By John E. Kelly III, Timothy Lance, and Edward Reinfurt

Intellectual Fusion

If you believe that the Large Hadron Collider at CERN in Switzerland, scheduled to begin pummeling protons later this year, is a purely scientific experiment, think again. By all accounts, this may be one of those landmark moments in scientific history, an opportunity to finally prove elusive but crucial principles of physics—such as why subatomic particles have mass. If all goes as planned, the experiment could yield the astonishing ability to create physical matter seemingly out of thin air. With particles colliding at unprecedented energy, we expect surprises—perhaps some that could even help explain the mysterious origins of the universe. However, the CERN collider project is a great social experiment as well. Not only might fundamental properties of matter revealed by the collider help us to derive energy from fusion, but we might also produce "intellectual fusion"—the explosive potential of collaboration on a grand scale. The experiment could easily serve as a model for large and small scientific projects that likewise require the close cooperation of people and organizations, both public and private, with expertise in a myriad of disciplines.

Those of us who hail from academia, government, and business should pay close attention to this model, because it will validate the collaborative approach we've already taken on projects involving nanotechnology, fundamental biology, and much more. It may also provide a path forward as we undertake grander challenges and place bigger bets. But to do so successfully, we need to reprioritize—not necessarily eliminate—our parochial and particular interests. This means we need to share financial resources, pool intellectual property, and blur bureaucratic boundaries.

As we in New York State know well, success does not follow a single, linear path. For instance, the basic chip created for the Blue Gene supercomputer was originally designed to assist Columbia University researchers working on quantum chromodynamics. But it turned out that these massively parallel machines work as well on analyzing computational fluid dynamics, protein folding in genetics, and even financial modeling.

The resources required for these collaborative projects can inspire advances in their own right. For example, the Federal Communications Commission has begun a $417 million experiment in rural health care; to achieve its full potential, this experiment will require advances in remote instrumentation, extended communication networks, and computational tools. Similarly, the CERN collider project will require new ways of sharing and crunching enormous quantities of data. Planned and improvised solutions will surely inspire corresponding breakthroughs in disciplines and enabling technologies that we never contemplated.

Naturally, the people, companies, academic institutions, and government agencies that have the most to contribute are often the most driven and competitive. And yet they are beginning to recognize that they can accomplish so much more in an environment of sharing. For instance, the scientific community mapped the three billion base-pairs of the human genome with two competing, yet complementary, collaborative efforts: the Human Genome Project, begun by the National Institute of Health and initially directed by Nobel Laureate James Watson in 1990; and the parallel industry-sponsored work by Celera Genomics established in 1998.

But how do we reliably and repeatedly build a cross-disciplinary, cross-institutional framework within which we can work to find answers? How do we motivate, enable, and sustain cross-institutional, cross-disciplinary collaboration? These questions are at the forefront of agencies such as the National Science Foundation, the National Institute of Health, and the National Institute of Standards and Technology and should be an active topic of discussion in government at multiple levels.

In January, a group of about sixty distinguished New Yorkers from across the state—junior and senior researchers, research administrators, and high-performance computing and networking experts—joined the three of us and our senior staff at the New York Academy of Sciences for a day-long discussion pondering these questions of integration, collaboration, and cooperation. We considered a half-dozen sectors for our areas of inquiry, including energy and environment, nanoscale materials and electronics, health care, government, and finance. We then linked them with various scientific disciplines—mathematics, physics, biology, chemistry, computational science, economics, and so forth—whose tools are needed to solve some of the grand challenge problems. And then we considered the cyberinfrastructure tools—education, hardware, operational support, secure networking and computing, and scalability—necessary for conducting scientific inquiry.

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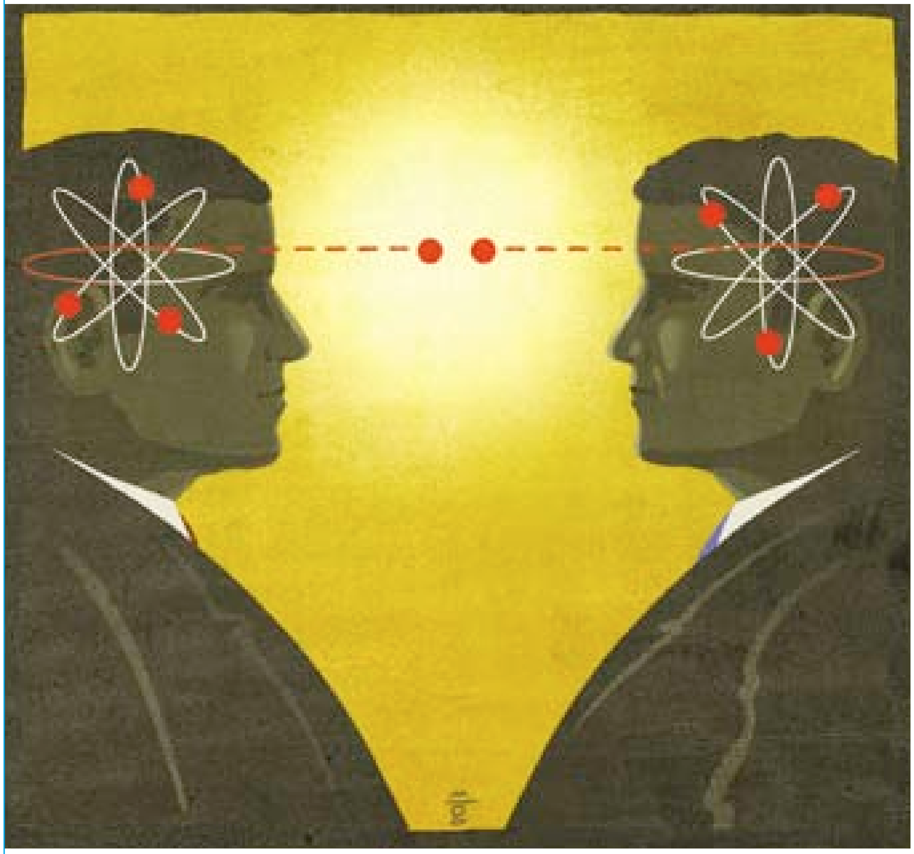
Our three working groups reached startlingly similar conclusions (http://www.nysernet.org/projects/cyberinfra.php) about how we need to build sustainable and repeatable collaborative efforts. The first urgent need was people: domain experts who understand, say, high-performance computing and can bridge the gap between the physicists receiving data generated by experiments and the computing and memory resources needed to analyze that data. Perhaps the greater overarching challenge here is reversing the sharp decline of people going into the science, technology, engineering, and mathematics (STEM) disciplines. If we are to sustain and grow our nation's enviable record in science and technology over the long term, we need to be advocates to motivate people of all ages, genders, ethnicities, and socioeconomic backgrounds.



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A second major conclusion is that big problems cannot be solved by one institution or even by one sector. Close linkage among the research and education community, the corporate sector, and state and federal governments is critical. All sectors need to contribute intellectual capital and computing, communication, and technical expertise. We need to gather, physically or virtually, the best talent with access to all the necessary technical tools—telemetry, computing, memory, networking, and network tools—to create the white heat of colliding, competing perspectives and to contain and sustain this milieu so that fundamentally new ideas will emerge. This is intellectual fusion—collaboration at its best.

Of course, this is easier said than done. The people, companies, institutions, and government agencies that have the most to contribute are also staffed by driven, competitive people, in the best sense of those words. No one said that producing intellectual fusion would be easy. However, government, academia, and private industry sectors are realizing that they can work together for the common good while also extracting what they need for their own missions.

As with nuclear fusion, containing the energy of the intellectual fusion we've described is delicate. Certainly, government research funding agencies can help to create and nurture the collaborative environment. To sustain such partnerships, we must wrestle with such things as intellectual property: what is individual or group discovery, what is legitimate trade secret, and what intellectual property is that of the entire project? Those helping to fund such an enterprise must likewise enable and respect these boundaries. In the end, all participants in these large-scale projects must commit to support the collaboration; if they do not, the containment wall will fail, and intellectual fusion stops.

Think about it: the CERN collider project is uniting 7,000 scientists from 80 nations. The physicists alone number 2,000, from 34 countries and hundreds of universities and laboratories. Rarely have we seen such a coordinated, multinational, truly global effort. Although the average scientific project may not require even a fraction of such resources, we will have demonstrated the capacity to tap large numbers of experts representing a huge spectrum of complementary interests, missions, and motivations.

Surely the implications will reverberate throughout a galaxy of disciplines, potentially leading to breakthrough medical therapies, more efficient manufacturing processes and "smarter" products, greater control over the earth's climate, and more efficient and renewable energy. History gives us reason for such optimism. The remarkable theoretical work of Einstein and his colleagues around the world at the start of the twentieth century led to astonishing developments in the hundred years that followed: radio, television, transistors, lasers, supercomputing, and high-speed communications, to name just a few.

We do not know precisely what the CERN collider project will reveal, but we do know one thing for certain: the value of the intellectual fusion generated by collaborative innovation can be a force more powerful and enlightening than the most immutable of scientific principles. Although smashing, splitting, colliding, and accelerating particles may suggest discord and chaos, we know that there is really nothing random about it at all.

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