

PRESIDENT'S REPORT

Cold Spring Harbor Laboratory enjoyed a highly successful year in 2013, despite uncertainty about how a political logjam in Washington, D.C., would impact the ability of our scientists to obtain federal grants. In the 20 years since I was appointed Director of the Laboratory, our faculty has grown from 39 to 52 and our federal grant income has increased more than 2.5-fold. Even so, it is clear that federal funding is not keeping pace with the cost of doing science. Federal grants now cover only about 40% of our \$119 million research budget, down from approximately 60% support of the \$30 million research budget in 1994. In the past decade, federal R&D funding has decreased by about 22% when corrected for inflation, and the fraction of grant applications funded by the National Institutes of Health (NIH) and the National Science Foundation (NSF) has declined alarmingly, to about one in seven of all applications. In forging a political compromise in early 2014 to fund government operations through 2015, Congress failed to engage in a full-scale budget debate about the role of American science in promoting economic development. Although the success rate of CSHL scientists in obtaining NIH grants is more than twice the national average, the funding situation is increasingly tight. Cultivating new sources of private philanthropy is therefore a high priority.

Uncertainty about funding notwithstanding, laboratories of the principal investigators at CSHL made impressive progress in 2013. Elsewhere in these pages are capsule summaries that demonstrate the breadth of our scientific achievements during the year—in cancer research, research on the brain, and in the genetics of plant development. Basic science discoveries continue to drive advances that are increasingly having an impact on medicine and food production.

As our friends and supporters know, CSHL takes pride not only in research achievements, but also in our extraordinary educational programs. These serve a unique range of target audiences, from professional scientists attending one of the world-famous CSHL Meetings or Courses, to a doctoral candidate matriculating in our Watson School of Biological Sciences, to 5th graders at the DNA Learning Center (DNALC) getting their first hands-on exposure to the tools that scientists use to study DNA. In this Report, I focus on our programs that reach young people.

The DNALC was founded 26 years ago to help children and their parents and teachers “thrive in the genome age.” The vision that guided the founders was notably democratic and pragmatic: “We envision a day when all elementary students are exposed to principles of genetics and disease risk, when high school students have the opportunity to do hands-on experiments with DNA, and when all families have access to genetic information that they need to make informed health care choices.”

The central achievement of the DNALC program, as developed by David Micklos, Executive Director of the Center since its inception, has been to educate all students, not just those who profess and display at an early age an interest in science. My main purpose here is to propose that, in the coming years, the DNALC’s hands-on learning model be emulated and reproduced across the sciences and throughout the nation, to the greatest extent possible. We have a winning formula, and it can do much good if scaled up.

What has worked on Long Island and to date has impacted half a million students can work in every major American city and in outreach programs organized for children at every major American university. The Learning Center concept is one that has legs. The more extensively it reaches across the United States, the better prepared Americans will be to make informed health care choices and compete internationally in science and technology fields.

Scientific investigation is a defining feature of our civilization and a prime basis of our hopes for a better future. There is strong evidence that the American people are well aware of this. Year after year, more than 80% of American adults tell pollsters from the University of Chicago’s National

Opinion Research Center that “scientific research that advances the frontiers of knowledge should be supported by the federal government, even if it brings no immediate benefits.” But the same set of annual surveys, published in *Science and Engineering Indicators* and available online,¹ reveal that Americans score poorly when asked nine questions about basic scientific facts. Many Americans don’t understand what radioactivity is, many don’t understand that antibiotics do not target viruses that cause illness, and more than 50% agree when asked if the following statement is true: “Ordinary tomatoes don’t contain genes, while genetically modified tomatoes do.”

Adult scientific literacy in the United States is far below a level befitting a nation leading the world in scientific research and technological development. If we expect to continue leading the world in these areas, we must be serious about investing in science education for the rising generation. The need is all the more acute when one considers the rapid emergence of new centers of scientific and technological activity, notably in China and other East Asian nations that are devoting an increasing share of their GDP to science and science education while we are reducing our share of GDP that supports research. It is worth mentioning that the government of Singapore, when planning the city-state’s economic future, chose medical and biotechnology as new areas of focus and accordingly came to CSHL for permission to license our model of high school scientific education. They now teach as many students each year as we do on Long Island, but since the population of Singapore is 2 million less than Long Island, one can safely assume that every child in Singapore is taught science using DNALC methods.

It is possible that in relative terms, tiny Singapore may benefit more from our education model than we will—unless, that is, American academic and political leaders, as well as leaders in industry, support better hands-on science education throughout the nation. It is ironic that although our public schools, with federal and state encouragement, have made commitments to stressing education in the so-called STEM fields (science, technology, engineering, and math), Congress has not seen fit to increase funding for scientific research or for science education. The advancement of science may be one of our highest national priorities, but support of educational programs remains stuck in neutral as debates over spending priorities are put off year after year.²

My enthusiasm for the “hands-on” concept central in all DNALC programs—which can be adapted to work in every major scientific field—is grounded in years of watching it succeed in real-world educational situations right here on Long Island and in our satellite facilities, notably in our Harlem DNA Learning Center in Manhattan. There, we have been able to serve students and teachers across the largest and most complex school district in the United States.

The ability of the DNALC to reach public and private school students in all five boroughs of the City from a single Harlem school demonstrates its scalability. The programs are scalable by design: Dave Micklos and members of his very talented team have devised various labs and modules that are fully compatible with the New York school system’s State-mandated curriculum. These modules take students on journeys of discovery that make elements of the curriculum literally come alive before their eyes. For instance, the DNALC’s pioneering lab on mitochondrial DNA has enabled tens of thousands of New York students to learn by doing—by sampling some of their own mitochondrial DNA and later learning how to interpret the DNA sequences that these generate. The children learn something about themselves—about their own genetic heritage and the extent to which it is shared, and not shared, with their fellow students, other members of their species, and indeed with distant species. Ostensibly abstract knowledge in this way becomes personally relevant.

¹<http://www.nsf.gov/statistics/seind14/>; see especially “Science and Technology: Public Attitudes and Understanding,” Chapter 7.

²“Wild Wild Cards Remain After Proposed Reshuffle of STEM Education,” *Science*, 19 April 2013, 258–259; “NIH Swears Off Science Education,” *Science Insider*, 27 September 2013; “Congress and NIH Don’t See Eye to Eye on Science Education,” *ibid.*, 28 January 2014.

Another of the DNALC's great successes is in using the hands-on approach to inculcate the single most important take-away skill from any K–12 science class: the ability to understand scientific reasoning. In the same respected national survey I have already cited, 58% of American adults in 2010 failed to demonstrate a basic understanding of scientific inquiry (regarding the use of evidence to test theories and the concept of “controls”). The figure balloons to 77% among those with a high school education or less.

Two years ago, the DNALC introduced an educational program that has worked marvelously to demonstrate that high school students are perfectly capable, and often brilliant, at understanding how to use science to ask a question and how to design an experiment using the scientific method to try to answer it. The new program, called the Urban Barcode Project, or UBP, involves teams of competing students, many from ethnic groups underrepresented in science. Importantly, these students were not cherry-picked from “gifted” classes; quite the opposite, for many, this experience is their first exposure to science. In 2013, 53 teams used DNA barcoding technology to identify living things in the local environment. They discovered 35 DNA sequences that did not match existing data in GenBank, an international database of DNA information. These new sequences were then published to the database with the students as authors. Teams presented their results at the American Museum of Natural History, with the grand prize awarded to students who investigated ant diversity in the Bronx. In 2012, 65 novel DNA sequences were discovered, and winners of the competition proved that many herbal Ginkgo products contained little or no *Ginkgo biloba* DNA—a lesson learned about science as well as marketing practices.

Each of the DNALC programs is scalable. A grant from the Howard Hughes Medical Institute (HHMI) enabled Micklos and his team to train 835 New York City teachers in lab techniques over a 5-year period. With minimal backup, readily provided by teaching mentors at the DNALC, these teachers have gone back to their schools and taught DNALC lab modules, captivated thousands of children with a hands-on approach, and have been able to build upon lab modules with some of the DNALC's prize-winning websites that extend the lessons from the lab setting and deepen student involvement during much longer periods of time. There are 22 such websites now freely available for use by teachers anywhere who want to use them. The DNALC also has devised “DNA Footlocker” kits that can be rented by mail and provide all the needed materials to do any of their current offering of six different lab modules. This is another aspect of the approach that is infinitely scalable, given proper organization and funding.

A small contingent of teaching experts from the DNALC thus has succeeded in markedly enhancing science education in a school district of more than 1 million students. The multiplier effect of each DNALC-trained teacher is hard to measure, but we do know that more than 40% of the 835 teachers trained under the HHMI grant and 133 additional teachers trained to lead UBP projects have subsequently booked field trips to one of our DNALC facilities; others have explicitly indicated that they felt self-sufficient as a result of their DNALC training and could now introduce students to concepts at their own schools, with the help of rented Footlockers. Students who take our labs appear to do better as well: Approximately a full letter-grade improvement was noted in our most recent attempt to document impact of the labs on students' grades.³

I want to make a final point about why this model is ready to be replicated across America. The DNALC has solved a problem that over decades has befuddled other innovative developers of science education curricula. Typically, the creation of programs such as the UBP or the mitochondrial DNA lab is supported by an initial government or foundation grant. When the grant expires, the program is left to succeed or fail on its own. Usually, funds dry up and programs are discontinued. The DNALC has had the insight to charge school districts that can afford to pay a nominal amount, typically a few thousand dollars a year, for the services it provides. Rather than

³2011 Annual Report, Cold Spring Harbor Laboratory, “DNA Learning Center Executive Director's Report,” p. 448.

hiring a teacher with a Ph.D. in biological science, a high school or middle school knows it can rely on our program to reach large numbers of students, at a tiny fraction of the cost of new faculty.

We annually host more than 20,000 students from Long Island schools for laboratory-based field-trips to our Cold Spring Harbor DNALC facility and its satellites, each of which has dedicated lab space manned by our instructors. Ten thousand more are reached in other programs, including DNA summer camps, a major plus—especially for students in resource-poor urban school districts. Separately, we provide training classes for teachers. No school that is unable to pay is prevented from benefiting from our programs. But many can pay a nominal fee, and the revenues generated make the entire DNALC enterprise economically sustainable, year after year.

Other cities, if they are motivated to do so, can use a similar model to kindle and sustain DNALC-like programs in biology, indeed, all of the physical sciences, as well as engineering. In 2013, we opened a new DNALC at the University of Notre Dame in Indiana, and we have started DNALCs in other areas of the United States, Australia, and Europe. We will open a new, larger DNALC in Manhattan and a new center in Suzhou, China in 2015. It is my dream that one day there will be as many science, technology, and engineering Learning Centers across this nation as there are McDonald's restaurants. It is a lot to hope for, but such a program will immediately make an impact, particularly if we have partners to help. The need is real and, in my view, urgent. By the time they graduate high school, we can prepare our young people to know—every student, not just the highly motivated—how scientists think, how they approach and answer problems, and a bit about how the natural world works. The long-term benefit is to allow more of our citizens to form opinions about subjects grounded in science, including those affecting their own health and well-being.

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