

Shaping Long Island's Bioeconomy:

THE ECONOMIC IMPACT OF
COLD SPRING HARBOR LABORATORY





This report was prepared by Appleseed, a New York City-based consulting firm, founded in 1993, that provides economic research and analysis and economic development planning services to government, non-profit and corporate clients.

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EXECUTIVE SUMMARY

- Cold Spring Harbor Laboratory – a private not-for-profit research and educational institution located on the north shore of Long Island in New York State – is a leading global center for pioneering work in molecular biology and genetics.
- CSHL contributes to the vitality of the New York State and Long Island economies – as a major regional enterprise, through its dual mission of biomedical research and education, and through the development of cutting-edge technologies, spin-off businesses and science, technology and support jobs, all derived from research conducted at the Laboratory.
- New initiatives position CSHL to shape the future of biology and genetics worldwide.
 - » The recently established Simons Center for Quantitative Biology brings together computer science, statistics and mathematical prowess to advance biological research in disease, develop alternative fuels and enhance crop yield to feed a hungry planet.
 - » The recently built Pre-Clinical Experimental Therapeutics Facility and the proposed Center for Therapeutics Research provide state-of-the art facilities and equipment to support CSHL's work in accelerated drug development and novel approaches to diagnostics and therapeutics for genetic diseases.
 - » Development of a new DNA Learning Center facility in New York City and expanded partnerships with school districts across the metropolitan area will significantly increase the number of elementary and high school students who benefit from the Lab's hands-on science education programs.
- CSHL's innovative science education programs that train professional scientists, confer Ph.D. degrees, inspire undergrads to pursue biomedical careers, and help prepare elementary through high school students to thrive in the genome age all put Long Island at an advantage in attracting and retaining intellectual capital for a robust biomedical economy.
- CSHL's efforts to strengthen the ability of its scientists to compete successfully for external (especially Federal) funding represent a critical investment in Long Island's economy and workforce. These efforts include supporting innovative early-stage research on projects that might not be sufficiently "mainstream" in technology or methodology to compete for external funding, but that have the potential to attract funding in the future. By working with early-career investigators who need training and guidance to identify Federal funding opportunities and prepare grant proposals, CSHL is planning and preparing for the long-term success of Long Island's economy.
- CSHL's research enterprise, with the potential for hiring of additional employees and creating spin-off companies and technologies, will generate additional jobs on Long Island and throughout New York State through increased spending on goods and services, and through the multiplier effect.

The impact of CSHL as an enterprise

- In 2013, CSHL had an operating budget of \$141 million (including depreciation), and employed 1,062 people – about 90 percent of whom worked full-time, and 89 percent of whom lived on Long Island. In addition to those employed directly by the Lab, 44 researchers employed by the Howard Hughes Medical Institute and other partner organizations worked full-time at CSHL, for a total of 1,106.
- In 2013, CSHL spent \$10.6 million on purchases of goods and services from New York State companies, including nearly \$9.4 million spent on purchases from Long Island companies.
- CSHL spent \$4.77 million on facility construction and renovation in 2013, of which nearly \$3.76 million (79 percent) was paid to Long Island contractors.
- In 2013, CSHL's spending on goods, services and construction directly supported 95 FTE jobs with Long Island suppliers and contractors, and 11 additional jobs with businesses elsewhere in New York State.
- Taking into account both the direct and indirect (or “multiplier”) effects of the Laboratory's spending, we estimate that on Long Island, CSHL in 2013 directly and indirectly accounted for:
 - » \$139.5 million in economic output in Nassau and Suffolk counties;
 - » 1,591 jobs; and
 - » \$89.0 million in earnings.
- Statewide, we estimate that CSHL directly and indirectly accounted for:
 - » \$149.2 million in economic output in New York State (including Long Island);
 - » 1,629 jobs; and
 - » \$92.9 million in earnings.
- In 2013, CSHL's operations directly generated nearly \$3.08 million in state income taxes, local property taxes and fees, and other payments to local governments.



Research and commercialization

- Research revenue at CSHL totaled \$104.3 million in 2013 – an increase of 65 percent since 2003. Federal grants and contracts provided 40 percent of the Laboratory’s research funding in 2013, and private contributions about 26 percent.
- Research at CSHL focuses on five broad areas: cancer, neuroscience, genomics and bioinformatics, plant biology and quantitative biology. In all of these areas, the Laboratory’s scientists conduct research that regularly leads to new breakthroughs, and that drives progress in the life sciences around the world.
 - » In 2013, Thomson Reuters *Essential Science Indicators* ranked CSHL among the top 1 percent of all research institutions worldwide, in terms of the frequency with which the work of its scientists was cited by others. In molecular biology and genetics, CSHL was ranked first in the world, ahead of MIT, the Salk Institute and other leading research centers – a ranking that helps CSHL scientists compete successfully for and bring to Long Island both public and private research funding.
- The impact of CSHL’s research in New York State is multiplied through its collaborations with other New York institutions and companies – with Stony Brook University and Brookhaven National Laboratory in neuroscience, biofuels and several other areas, and with several New York-based biomedical institutions and members of the Starr Cancer Consortium. Partnerships with biotechnology and pharmaceutical companies such as GlaxoSmithKline, Pfizer, Boehringer Ingelheim, Dart Neurosciences, Isis Pharmaceuticals, Merck and Syngenta similarly enable the Lab to speed the process of turning the results of its research into tangible benefits to society.
- CSHL is actively engaged in commercializing the results of its research – through licensing of technologies first developed in its labs – for commercial use by companies around the world, and by incubating and spinning off new businesses engaged in the further development of such technologies.
- New York State companies that were founded based on research conducted at CSHL include ASOThera, Certerra, Clarapath, DepYMed, Envisagenics and Mirimus. Long Island’s home-grown blockbuster cancer drug manufacturer OSI Pharmaceuticals, acquired by Astellas Pharmaceuticals in 2010, was a CSHL spin-off incubated at Broad Hollow BioScience Park (BHBP). CSHL is a founding member of the BHBP.



A destination for biologists worldwide

- Cold Spring Harbor Laboratory is a leading global venue for scientific conferences and meetings. Each year CSHL hosts approximately 45 large conferences and smaller meetings on current topics in genetics, molecular biology and related fields. In 2013 these programs drew about 8,000 participants to Cold Spring Harbor from throughout the U.S. and around the world, and 3,000 more to programs offered in China through a CSHL subsidiary (described below).
- CSHL also offers about 25 intensive two-to-three-week post-graduate courses each year on the latest life sciences technologies and methods, which draw a total of about 500 students.
- Approximately 16 percent of all Meetings and Courses Program participants are from New York State institutions and companies. The program is thus a valuable resource for the New York scientific community, and a magnet that attracts scientists and students to the region.
- In 2010, a new CSHL subsidiary – Cold Spring Harbor Conferences Asia – began offering a series of CSHL-style conferences and courses at the new Dushu Lake Conference Center in Suzhou, China (about 60 miles west of Shanghai). This new venture allows CSHL to export its services to China, and strengthens relationships between New York and the world's most rapidly developing center of science and technology.

Educating the next generation of scientists

- In 1998, CSHL established the Watson School of Biological Sciences, which offers an innovative Ph.D. program designed to prepare students to work at the cutting edge of scientific research. Enrollment in this highly selective program averages about 50 students.
 - » In 2013, eight students were awarded PhD's from the Watson School, and 10 new students (out of 274 applicants) were admitted.
- CSHL also provides graduate training through a long-standing collaboration with Stony Brook University. In 2013, 50 SBU graduate students in genetics, molecular and cellular biology, neurobiology and related fields conducted research under the guidance of CSHL scientists.
- CSHL's Undergraduate Research Program is a ten-week summer program that for 50 years has given undergraduates hands-on access to the latest techniques of modern biology.
 - » In 2013, 27 sophomores and juniors from around the world were selected from 738 applicants to participate in the program, including 11 who attended colleges and universities in New York State.
- CSHL's DNA Learning Center (DNALC) – with state-of-the-art facilities in Cold Spring Harbor and teaching laboratories in Lake Success and East Harlem – provides opportunities for hands-on learning in genetics, molecular biology and related fields for elementary and high school students on Long Island and in New York City.
 - » In 2013 more than 32,800 students participated in DNALC programs. CSHL has also partnered with school districts across Nassau and Suffolk counties and throughout the tri-state area to enhance public and private school biology curriculum, preparing today's youth for life in the genome age.

A center of New York's bioeconomy

- During the next several years CSHL's impact on New York's economy is likely to increase, for several reasons.
 - » New facilities such as the Pre-Clinical Experimental Therapeutics facility and the proposed Center for Therapeutics Research facility will significantly enhance CSHL's research capabilities, and its ability to compete successfully for Federal and other external research funding. Similarly, a new DNA Learning Center facility in New York City will increase the number of students who benefit from the Lab's education programs.
 - » To an extent that few other institutions can match, CSHL's strengths address the demands of what the National Research Council (NRC) calls "the new biology."
 - According to the NRC, this requires a more integrated approach to conducting (and funding) life sciences research, and a sharper focus on research aimed at finding solutions to some of this century's most significant challenges, including improving existing and developing new food crops, developing alternative sources of energy, adapting to climate change and creating the basis for new forms of personalized medicine.
 - » CSHL's growing strengths in commercialization will accelerate the translation of its world-class research and technologies into new businesses and new jobs, and new solutions to challenges in health care, energy, agriculture and the environment.
- » Expanded collaboration between CSHL and its regional partners – Stony Brook University and Brookhaven National Laboratory – will enable these institutions to achieve more in terms of scope and quality of their research, their ability to compete for Federal funds, private investment and talent, and their effectiveness in translating their research into economic growth, than they could individually. Leveraging each others strengths, the three institutions are exploring:
 - Brain disorders such as autism, schizophrenia, ALS and depression
 - Biofuels development
 - Genetic diseases and metabolism as they relate to obesity/diabetes
- Cold Spring Harbor Laboratory is a substantial and sustainable science- and technology-based enterprise. It plays a leadership role in expanding the frontiers of knowledge in genetics, molecular biology and related fields that far transcends its size. Through a growing web of collaboration with other New York institutions, CSHL acts as a "force multiplier," helping to create both scientific and economic value that exceeds the sum of each partner's contributions.
- In all of these ways, Cold Spring Harbor Laboratory is shaping the future – both for the new biology, and for New York's new economy.



PART ONE

Cold Spring Harbor Laboratory – An Overview

Cold Spring Harbor Laboratory (CSHL) is a private, not-for-profit research and educational institution located on the north shore of Long Island that specializes in molecular biology and genetics. The Laboratory traces its history to 1890, when it was founded by the Brooklyn Institute of Arts and Sciences as a biological laboratory for training high school and college teachers. A few years later, the Institute added a second mission – genetics research. In the early years of the twentieth century, research conducted at Cold Spring Harbor on the cross-breeding of varieties of corn revolutionized the science of agricultural genetics, laying the groundwork for a century of progress in agriculture in the U.S. and around the world.

For 125 years, CSHL breakthrough discoveries and innovative education programs have contributed to advances in health care, agriculture, energy development and environmental sustainability.

During the past sixty years, the Laboratory has played a leading role in the emergence and continuing development of molecular genetics. CSHL has been home to eight Nobel Prize winners. In 1951, for example, Barbara McClintock first discovered the mobility of certain genetic elements; the identification of these “jumping genes” proved to be a major breakthrough in understanding how genes function. She won the 1983 Nobel Prize.

Lecturing at Cold Spring Harbor in 1953, James D. Watson gave the first public presentation on his and Francis Crick’s Nobel prize-winning discovery of the double-helical structure of DNA. Watson later served for 36 years as the Laboratory’s director and then its president.

Since the 1950’s, CSHL scientists have continued to advance the field of biology. Notable achievements have included:

- Developing techniques for separating and visualizing DNA fragments that have made possible a wide range of advances in molecular biology
- Discovery of the phenomenon of RNA splicing, leading to the development of new treatments for a variety of diseases (1993 Nobel Prize)
- Pioneering research on the role of genes in causing cancer
- Understanding the protective role of telomeres at the ends of chromosomes (2009 Nobel Prize)
- Developing technologies for studying the structure and functioning of individual neurons within the brain
- Deciphering animal and plant genomes, including the entire genome of rice, the world’s most important food crop

With revenues of \$164 million in 2013, the contemporary Cold Spring Harbor Laboratory is a world-renowned center for life sciences research, focusing on cancer research, neuroscience, genomics and bio-informatics, plant genetics and quantitative biology. CSHL’s Meetings and Courses Program, which each year draws thousands of researchers from around the world, has also made it one of the world’s leading venues for exchanging ideas and for presentation of the latest research in the life sciences.

True to its origins in education and training, CSHL continues to educate both scientists and the public. In 1998, the Laboratory established the Watson School of Biological Sciences, a Ph.D.-granting program in molecular biology. Through the DNA Learning Center, founded in 1988, CSHL has provided hands-on educational programs in genetics to elementary and high school students on Long Island and New York City.

Cold Spring Harbor Laboratory’s facilities include:

- A 116-acre main campus located in the Village of Laurel Hollow
- A 65,000 square-foot Genome Research Center, located on an 11-acre site in Woodbury
- The 12-acre Uplands Farm Field Research Center in Cold Spring Harbor – the site of fields, greenhouses and labs that support CSHL’s research in plant biology
- The Banbury Center – a 55-acre site in Lloyd Harbor used for conferences and courses
- The Dolan DNA Learning Center – a renovated former elementary school in Cold Spring Harbor that is the principal site for CSHL’s educational outreach programs, offered in partnership with local school districts throughout the metropolitan area
- Two additional DNALC teaching laboratories – the DNA Learning Center West, in Lake Success, and the DNA Learning Center in Harlem
- Administrative offices and a warehouse in Syosset

Figure 1: **Location of Cold Spring Harbor Laboratory Facilities**





About this report

In the scope of its engagement with the scientific community, its reputation and the impact of its work, Cold Spring Harbor Laboratory is a global institution. And as one of New York's leading research institutions, it is an asset of particular value to New York State. In order to promote a clearer understanding of the multiple ways in which the Laboratory contributes to the life of New York State and its people, CSHL President & CEO Bruce Stillman, Ph.D. asked Appleseed – a New York City-based economic development consulting firm – to assess the Lab's impact on the state's economy – and in particular, on the economy of Long Island.

This report presents the results of Appleseed's analysis. Part Two highlights the impact of CSHL as an enterprise – as an employer, a buyer of goods and services from New York companies and a sponsor of construction projects. Part Three explores several ways in which research conducted at CSHL contributes to the growth of the state's and the region's economy.

Part Four of the report describes CSHL's Meetings and Courses Program, which each year brings thousands of the world's leading scientists to Long Island to discuss their work. Part Five describes the Lab's public education programs, which offer a wide range of opportunities for elementary and high school students, and for undergraduates and graduate students as well – covering everything from basic scientific concepts and techniques to the latest advances in the life sciences.

Finally, Part Six highlights several reasons why CSHL's impact on New York's and Long Island's economy could be even greater during the next five to ten years than it is today.



PART TWO

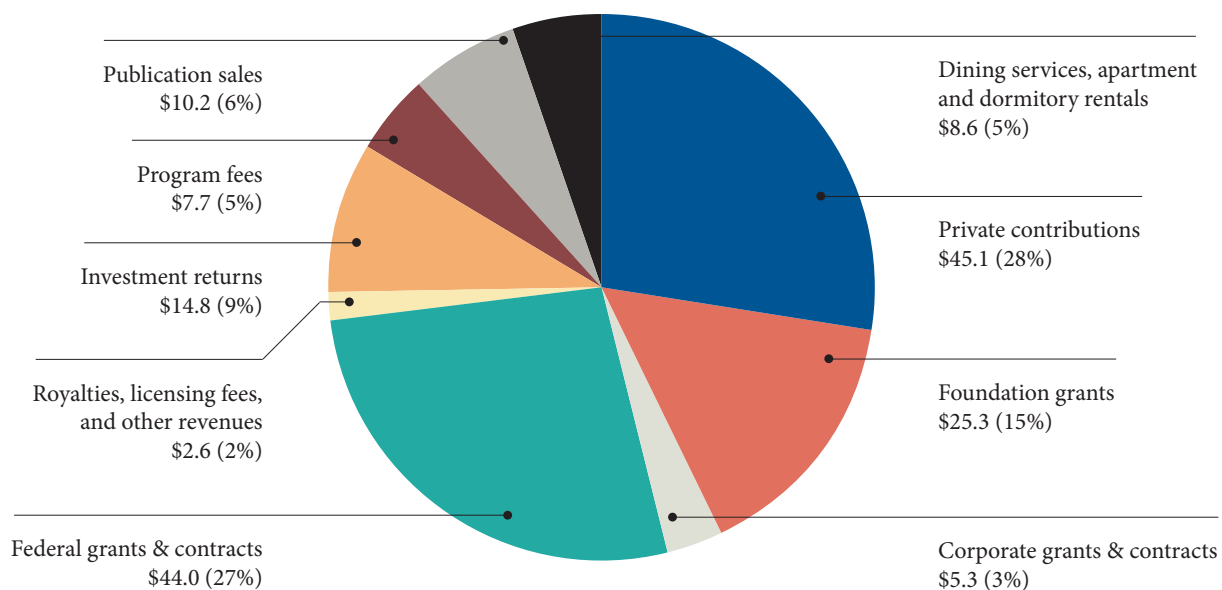
CSHL as an Enterprise

In addition to being a leading center of research and education, Cold Spring Harbor Laboratory is a major regional enterprise – contributing to the economic vitality of Long Island and New York State as an employer, a buyer of goods and services from New York companies, a sponsor of construction projects and a generator of tax revenues. This part of the report addresses the Laboratory's impact in each of these areas.

In 2013, CSHL's revenues totaled \$164 million. As Figure 2 shows:

- Private contributions totaled \$45.1 million – 28 percent of all revenues;
- Federal grants and contracts accounted for \$44.0 million (27 percent);
- Foundation grants (\$25.3 million) accounted for 15 percent;
- Investment returns generated more than \$14.8 million (9 percent);
- Sales of CSHL publications accounted for nearly \$10.2 million (6 percent);
- Dining services and apartment and dormitory facilities generated \$8.6 million (5 percent);
- Program fees generated \$7.7 million (5 percent);
- Corporate grants and contracts generated \$5.3 million (3 percent); and
- Royalties, licensing fees and other revenues generated \$2.6 million (2 percent).

Figure 2: Cold Spring Harbor Laboratory Revenues, FY 2013 (\$ millions)

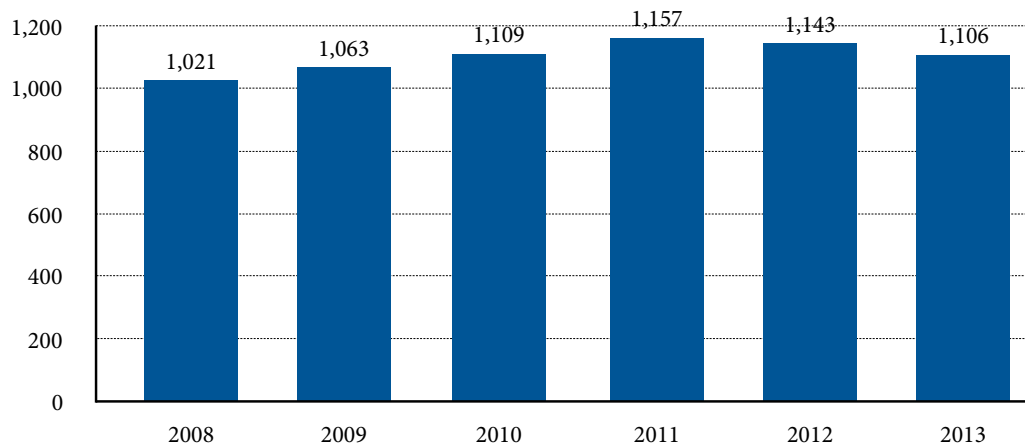


Cold Spring Harbor Laboratory as an employer

As of June 2013, 1,106 people were employed at Cold Spring Harbor Laboratory, 90 percent of whom worked full-time. This total included 1,062 people employed directly by CSHL, and 44 who worked full-time at the Lab while on the payroll of partner organizations such as the Howard Hughes Medical Institute and the U.S. Department of Agriculture.

Wages and salaries paid to CSHL employees during 2013 totaled \$56.1 million; and wages and salaries paid to those employed at CSHL by other organizations totaled an estimated \$3.8 million.

Figure 3: Cold Spring Harbor Laboratory Employment, 2008-2013

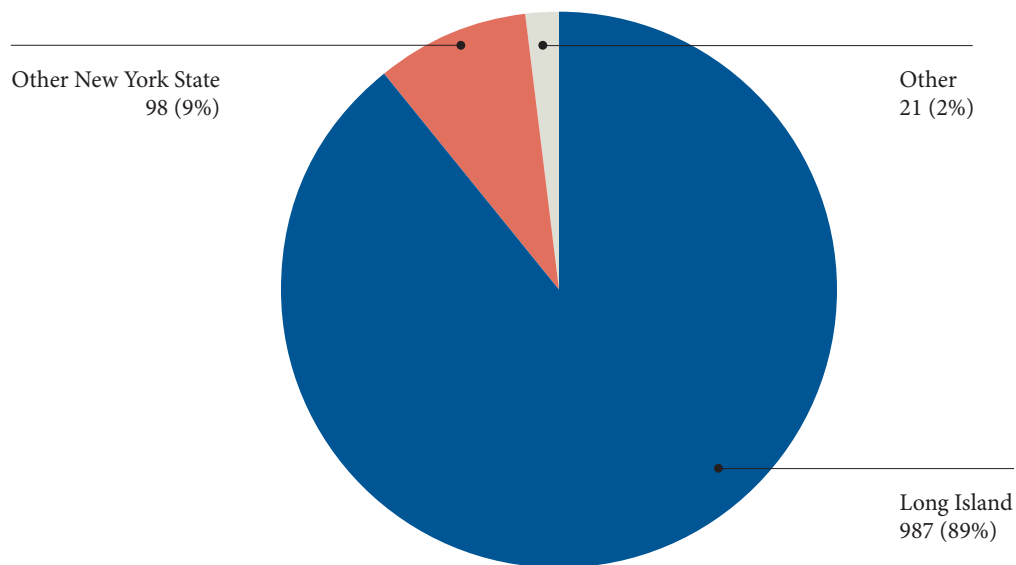


Where Cold Spring Harbor Laboratory employees live

As Figure 4 (below) shows, as of June 2013, 987 (89 percent) of all those employed at CSHL lived on Long Island. Salaries and wages paid to these employees totaled \$52.3 million.

Another 98 of those employed at CSHL lived elsewhere in New York State – about 9 percent of the Laboratory’s workforce.

Figure 4: Cold Spring Harbor Laboratory Employees by Place of Residence, June 2013



Diversity and quality of employment at CSHL

Cold Spring Harbor Laboratory offers a wide variety of high-quality jobs for residents of Long Island. Scientists and post-docs account for 27 percent of total employment; administrative and other laboratory professionals, 18 percent; clerical and technical support staff, 45 percent; and graduate students 10 percent.

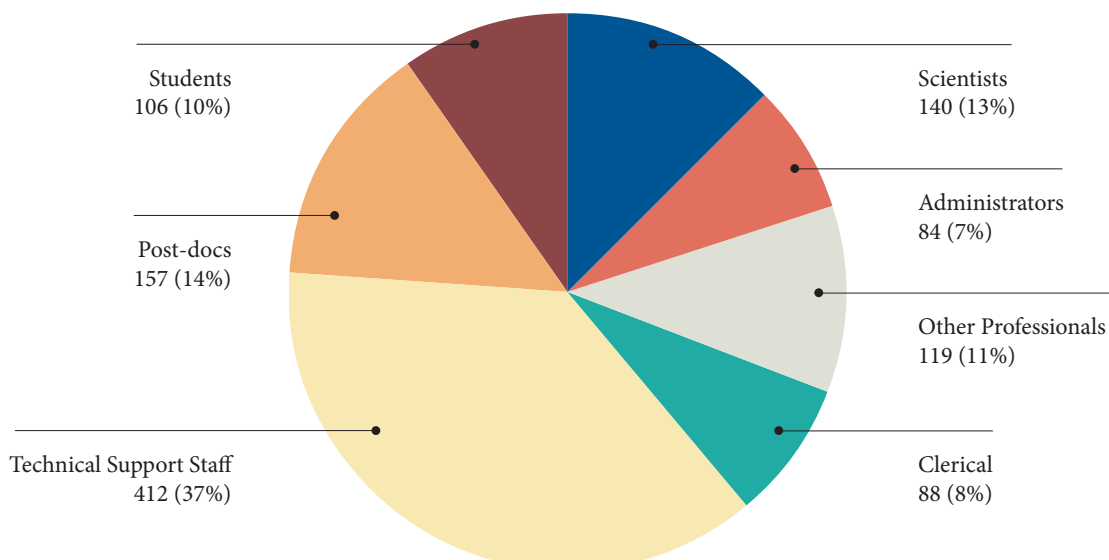
In addition to employing a diverse set of skilled workers, CSHL also provides a wide range of benefits to its employees. They include:

- Health, dental and vision insurance
- A pension plan
- Flexible spending accounts
- Life, disability, and long-term care insurance
- A prepaid legal plan
- An on-site gym, Wellness Center and health-related seminars and programs
- A on-site day care center with sliding-scale tuition

Cold Spring Harbor Laboratory also provides limited assistance to faculty in the purchase of a home as well as a housing allowance to post-docs and graduate students based on eligibility requirements. The Laboratory provides a family allowance for post-docs whose spouses are unable to work due to visa issues and provides stipend incentives for post-docs who apply for grants.

CSHL offers on-site training for faculty and post-docs, including leadership training and grant writing classes.

Figure 5: Cold Spring Harbor Laboratory Full- and Part-Time Employment by Occupation, June 2013



The impact of purchasing and construction

In addition to the people it employs directly, Cold Spring Harbor Laboratory generates jobs on Long Island and elsewhere in New York through its purchases of goods and services from local companies, and through construction and renovation of the Laboratory's facilities.

Purchasing goods and services

Cold Spring Harbor Laboratory spent approximately \$65.3 million on the purchase of goods and services during 2013. Of this total, about 16.2 percent – more than \$10.6 million – was spent on goods and services provided by New York companies, including:

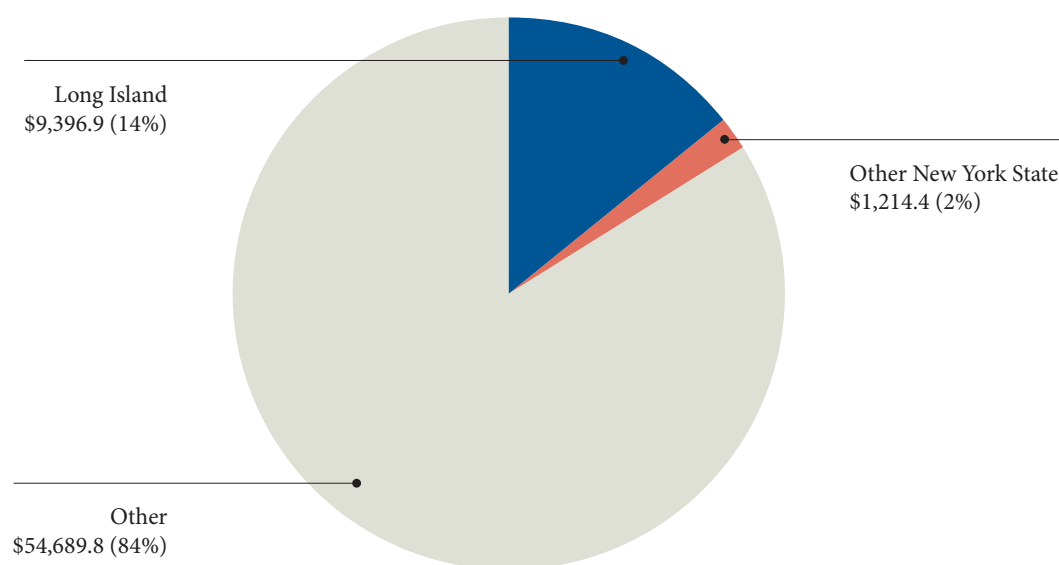
- Nearly \$9.4 million (14.4 percent of total spending) for goods and services bought from companies located in Long Island, and
- \$1.2 million (1.9 percent) spent with companies located elsewhere in New York State.

CSHL purchases a variety of goods and services from businesses located in Long Island. The leading categories of purchases from Long Island companies include utilities, professional services, research-related expenses and building maintenance contracts.

In addition to these direct purchases of goods and services from Long Island suppliers, CSHL's spending on employee health benefits is treated for purposes of this analysis as a purchase of services from health care providers in the areas where employees live.

Using the IMPLAN modeling system, we estimate that the Laboratory's purchases of goods and services from local companies (including health care providers) directly supported 71 full-time equivalent jobs with Long Island businesses, and 11 additional FTE jobs with businesses located elsewhere in New York State.

Figure 6: Cold Spring Harbor Laboratory Purchasing by Location of Vendor, 2013 (\$000s)



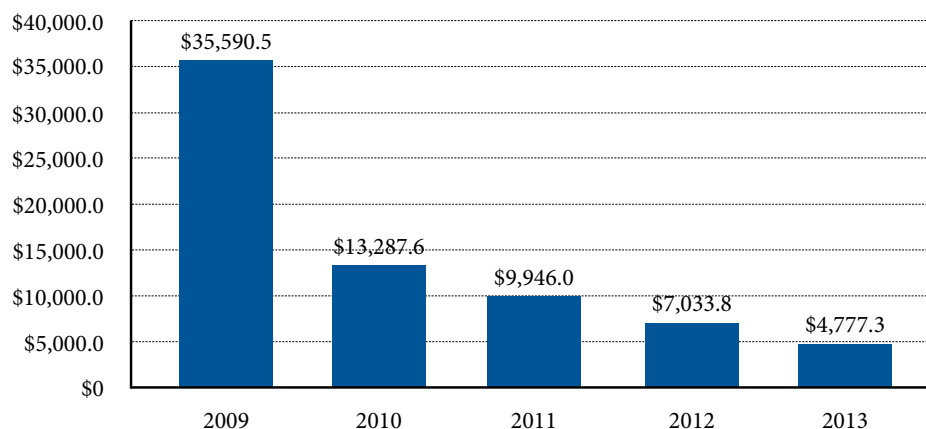
The impact of construction at CSHL

In addition to generating jobs and economic activity through its purchases of goods and services, CSHL also does so through its investments in Laboratory facilities. From 2009 through 2013, CSHL invested a total of \$70.6 million in facility construction and renovation. More than half of this total was spent in 2009, the peak year for spending on construction of the Hillside Campus (described below).

In 2013, CSHL spent approximately \$4.77 million on construction and renovation of campus facilities, of which nearly \$3.76 million (nearly 79 percent) was paid to contractors located on Long Island.¹ We estimate that in 2013, CSHL's spending on construction directly supported 24 FTE jobs with Long Island contractors in construction and related industries.

1. The remaining \$1.02 million was spent with contractors located outside New York State.

Figure 7: Cold Spring Harbor Laboratory Annual Construction Spending, 2009-2013 (\$'000s)



From 2014 through 2019 the Laboratory is planning to invest approximately \$64 million in new construction and renovation. Major projects under way, planned or proposed during this period include the following:

- In 2014 CSHL demolished a dilapidated nineteenth-century building on its main campus, and in its place constructed a new residential building, to be used as faculty housing. The cost of the project totaled \$1.389 million.
- In 2014 CSHL began construction of a 10,000 square-foot, \$15 million addition to its Woodbury Genome Center. When completed in 2015, the new space will house a new Pre-Clinical Experimental Therapeutics Facility, providing advanced pre-clinical testing of new drugs.
- Nicholls Biondi Hall is a multi-purpose building that will provide space for presentations by conference and meeting participants. Construction began in 2014 and will be completed in the spring of 2015, at a total cost of \$2 million.
- In 2015 CSHL is planning to invest \$2.6 million in renovation of a space in Manhattan to serve as a permanent teaching laboratory facility for expanded DNA Learning Center programming throughout the NY metropolitan area (described in Part Five).
- CSHL is currently working to secure financing for a major reconstruction of its sixty-year-old Demerec Laboratory building. When completed, the rebuilt 26,000 square-foot facility will house a new Center for Therapeutics Research, described on page 29.

The impact of Cold Spring Harbor Laboratory's construction spending goes beyond the opportunities it creates for contractors and construction workers on Long Island. CSHL's investment in construction and renovation of facilities enhances its ability to conduct research on state-of-the-art equipment as well as expand its areas of research, which in turn enhances its capacity to attract funding and contribute to the economic vitality of Long Island and New York State.

CSHL's Hillside Campus

In 2003, Cold Spring Harbor Laboratory began a \$200 million capital campaign to raise money for the construction of new laboratory facilities and fund new research and education programs. After a successful campaign, construction on the new research complex, the Hillside Campus, began in 2006. Completed in 2009, the Hillside Campus added 100,000 square feet of research space at CSHL – a 40 percent increase. The complex is designed so it appears to be six separate lab buildings, but all six are interconnected, and supported by a single system of below-ground infrastructure.

The Hillside Campus was designed to minimize its environmental impact, with high levels of energy efficiency and an award-winning stormwater management system that naturally filters runoff from the hillside before it flows into Cold Spring Harbor. The project also included the planting of 700 trees to replace trees that had been removed to make way for construction.

The \$107 million complex was financed with a mix of private funds raised through the capital campaign, a \$20 million grant from New York State, and tax-exempt bond financing. It has provided space for growth of CSHL's work in quantitative biology, human genetics, cancer and neuroscience.



Building and growing a new research center

As noted above, CSHL is seeking to secure financing for a \$25 million reconstruction and equipping of the 60-year-old Demerec Lab. The rebuilt facility would provide a home for CSHL's new Center for Therapeutics Research (CTR), which will conduct research aimed at identifying and understanding new therapeutic targets and pathways, and developing and testing new therapies. Appleseed estimates that constructing and equipping the building would directly and indirectly support approximately 157 FTE jobs on Long Island.

Once construction is completed, CSHL estimates that during its first five years, CTR will spend \$50 million on research and related activities, financed through a combination of Federal grants and contracts, private donations and the Lab's own internal resources. Appleseed estimates that during this five-year period CTR will generate at least \$10 million in annual revenues, and that this funding will directly support approximately 55 jobs at CSHL and (through the multiplier effect) another 60 FTE jobs elsewhere on Long Island.

The Center will also provide a focal point for collaboration with partners in the region, including Stony Brook University, the Brookhaven National Laboratory and North Shore-LIJ in both lab-based and clinical research.

Indirect, induced and total impact

The jobs and economic activity generated by CSHL's spending for payroll, purchasing, and construction are not limited to the direct impacts cited above. Some of the money that the Laboratory pays to its local suppliers and contractors is used to buy goods and services from other local companies; and the latter companies in turn buy goods and services from still other local businesses.

CSHL employees, and the employees of its suppliers and contractors, similarly use part of their earnings to buy a wide variety of goods and services – housing, utilities, food, personal services, and other household needs – from local businesses; and the employees of those businesses do the same.

Using the IMPLAN input-output modeling system – a modeling tool commonly used in economic impact studies – we can measure these indirect and induced (or “multiplier”) effects of CSHL spending. Table 1 summarizes the direct, indirect, and induced impacts of Cold Spring Harbor Laboratory's spending on Long Island and throughout New York State. In 2013, we estimate that on Long Island, CSHL directly and indirectly accounted for:

- \$139.5 million in economic output in Nassau and Suffolk counties;
- 1,591 jobs; and
- \$89.0 million in earnings.

Statewide, we estimate that CSHL directly and indirectly accounted for:

- \$149.2 million in economic output in New York State (including Long Island);
- 1,629 jobs; and
- \$92.9 million in earnings.

Table 1: Direct, Indirect, and Induced Impacts of Cold Spring Harbor Laboratory's Spending, FY 2013 (\$ millions)

	Jobs	Earnings	Output
Long Island			
<i>Direct spending:</i>			
Employment and payroll	1,106	\$59.924	\$59.924
Purchasing and construction	95	\$8.175	\$20.655
<i>Indirect and induced</i>	390	\$20.918	\$58.966
LI Total	1, 591	\$89.017	\$139.545
New York State (including LI)			
<i>Direct spending:</i>			
Employment and payroll	1,106	\$59.924	\$59.924
Purchasing and construction	106	\$9.103	\$22.706
<i>Indirect and induced</i>	417	\$23.885	\$66.565
NYS Total	1,629	\$92.912	\$149.195

Contributing to state and local revenues

Despite Cold Spring Harbor Laboratory's tax-exempt status, its operations generate revenues for state and local governments in several ways. CSHL withholds New York State income taxes from wages and salaries paid to its employees and pays into the state's unemployment insurance pool.

CSHL also makes payments to local governments. Like other non-profit institutions, the Laboratory does not pay property taxes on its campus properties as a tax-exempt institution. CSHL does, however, pay property taxes on off-campus properties in Cold Spring Harbor and makes annual payments in lieu of taxes (PILOT) to the Village of Laurel Hollow, the Village of Lloyd Harbor and the Cold Spring Harbor School District. In 2013, the Laboratory paid \$154,675 in real property taxes and \$403,821 in PILOT payments.

Table 2 details taxes, fees, and payments paid by Cold Spring Harbor Laboratory to state and local governments in 2013.

In addition to the fees it pays directly, CSHL contributes indirectly to local government revenues on Long Island through the real property and sales taxes paid by CSHL employees and by the Lab's local contractors and suppliers.

CSHL's contributions to the vitality of New York's and Long Island's economy are not limited to the impact of its spending on payroll, purchasing and construction. Part Three of the report discusses the growth of the Laboratory's research enterprise – highlights several examples of research conducted at CSHL during the last few years – and discusses the commercialization of new technologies first developed at CSHL.

Table 2: State and local taxes, fees and payments paid by Cold Spring Harbor Laboratory, 2013

Type of tax	Amount
Taxes paid to New York State	
NYS income taxes withheld	\$2,489,952
Taxes and fees paid to local governments	
Real property taxes paid on taxable property	\$154,675
Payments in lieu of taxes	\$403,821
Fees	\$30,921
<i>Subtotal, payments to local governments</i>	<i>\$589,417</i>



PART THREE

Research and Business Development

The heart of Cold Spring Harbor Laboratory's mission is research. The research conducted at CSHL contributes to the vitality of New York's economy in several ways:

- CSHL's research attracts financial support from a variety of outside sources, most of which is spent locally.
- Research conducted at CSHL often results in new discoveries or the development of new technologies with significant potential for commercial use – which can lead to the creation of new products, new businesses and new jobs.
- Research conducted at CSHL can advance the search for solutions to some of New York's, the nation's and the world's most pressing problems in healthcare, food security, energy and the environment.

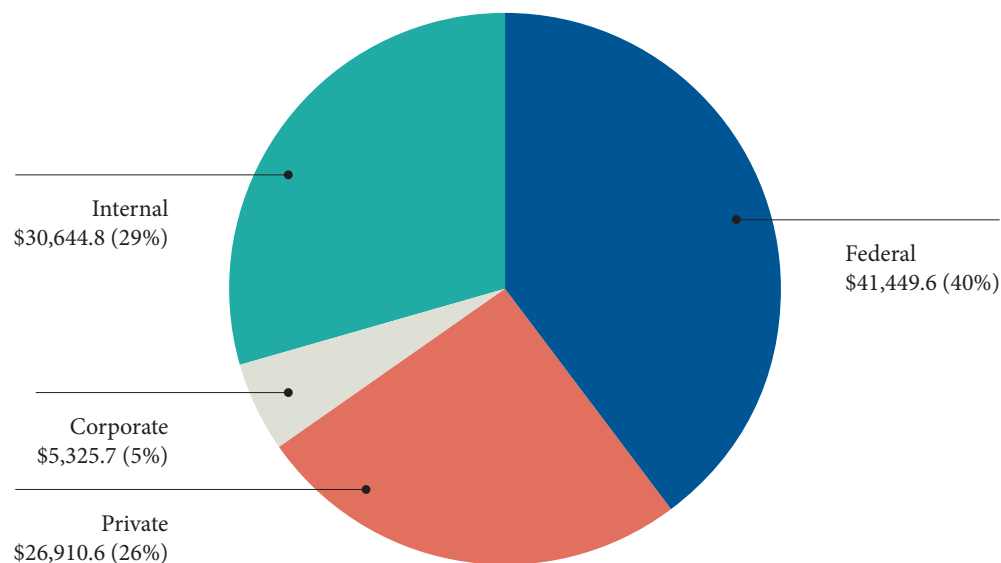
A growing research enterprise

In 2013, research funding at CSHL totaled \$104.3 million – an increase of 65 percent since 2003. Research activity accounts for 83 percent of the Lab's total spending.

As Figure 8 shows, Federal agencies provided 40 percent of the Lab's research funding – private contributions, 26 percent – corporate sources, 5 percent – and the Lab's internal resources, 29 percent.

CSHL thus generates much of its research funding from sources outside Long Island, most of which is then spent locally.

Figure 8: Cold Spring Harbor Laboratory Research Funding by Source, FY 2013 (\$000s)



Research at Cold Spring Harbor Laboratory: Selected examples

Research at CSHL is a multidisciplinary endeavor, with collaborations that span five areas of expertise – cancer, neuroscience, genomics and bioinformatics, plant genetics and quantitative biology. Below we highlight just a few examples of research conducted in these areas in 2013 and 2014.

In their research on cancer and cell biology, scientists at CSHL:

- Demonstrated that a protein called PTP1B plays a critical role in the growth of a type of breast cancer called “HER2-positive,” and identified a candidate compound called trodusquemine that appears to be effective in inhibiting HER2-positive tumor growth, and preventing its spread to the lungs in pre-clinical models. Based on this evidence, CSHL has partnered with Ohr Pharmaceuticals to pursue clinical trials with this potential new drug at North Shore LIJ.
- Developed the first 3-D culture system for growing both healthy and cancerous pancreatic tissue. Until now, scientists have been unable to culture normal human ductal pancreatic cells under standard laboratory conditions. The work changes the way pancreatic cancer research is done, allowing scientists to interrogate the pathways driving this devastating disease while searching for new drug targets.
- Catalogued the repertoire of interactions between breast cancer cells and 42 factors released by just one normal cell type in the tumor environment, many of which were found to encourage cancer growth. Drugs that block these signals and those released by other normal cells might have a powerful therapeutic effect.
- Demonstrated a potentially more effective way to administer a drug now in Phase 3 clinical trials to treat children with the often fatal genetic illness spinal muscular atrophy (SMA). The drug, based on discoveries made at CSHL about how messages encoded by genes are edited and mis-edited, might be possible to inject directly into tissue and not via the central nervous system.

In neuroscience, CSHL researchers:

- Determined that de novo gene mutations – mutations that are not found in either parent but occur “spontaneously” in their children – cause at least 30 percent of all autism spectrum disorder (ASD).
- Obtained the first atomic-level map of the NMDA receptor, essential in learning and memory, and dysregulated in schizophrenia, major depression, Parkinson’s and Alzheimer’s diseases. The full-length view of the receptor will guide the design of new drugs to selectively modulate its activity.
- Traced at the neuronal level pathways in the mammalian brain that help regulate depression and fear, illuminating potential new targets for antidepressants and therapies to counter anxiety and post-traumatic stress disorder (PTSD).
- Demonstrated that confidence is not a subjective state but rather a property of brain activity that can be objectively measured in rodents, and likely humans as well. It is an example of the power of modern neuroscience to understand in biological terms aspects of brain activity long thought to be fundamentally elusive.
- Discovered that a class of DNA elements called transposons or “jumping genes” become more numerous and more active as the brain ages. CSHL scientists are now pursuing the role that transposons may play in age-related neurodegenerative diseases.
- Conducted high-resolution sequencing studies of a gene called DISC1 (for “disrupted in schizophrenia”) that is implicated in a number of psychiatric disorders, including depression, bipolar disorder and schizophrenia.

In plant biology, researchers at CSHL:

- Identified a gene mutation that increases the length of ears of maize, and increases the number of kernels per ear by as much as 13 percent. This advance opens the door to increasing yields from maize plants – one of the world’s most important food crops.
- Identified a gene mutation that affects the production of florigen – a hormone that plays a key role in determining the number of tomatoes that tomato plants produce. This provides a basis for potentially doubling yields from commercial tomato plants by tweaking florigen levels.
- Identified a single gene, called Shell, that regulates yield of the oil palm tree. The fruit and seeds of the oil palm are the source of nearly one-half of the supply of edible vegetable oil worldwide, and provide one of the most promising sources of biofuel. The discovery has major implications for agriculture, energy and the environment.

In quantitative biology, CSHL scientists:

- Performed highly sophisticated mathematical and statistical analyses of vast datasets obtained from thousands of “simplex” autism families – those in which there is a single affected child, but neither parent nor siblings are affected. These indicate that males, while they are much more often affected, usually have less devastating gene mutations than females, and thus are more often higher-functioning.
- Developed a mathematical method called CORE to simplify data from the genome based on variations in DNA sequences, which are one of the hallmarks of cancer. CORE is helping researchers interpret messy and overlapping data sets, revealing a rich structure underlying the clutter. It can be used to assist in calculating patient prognosis and in making treatment decisions.
- Invented an algorithm called SCALPEL to identify and analyze where precisely in the human genome tiny variations called “indels” – insertions and deletions of DNA – “cut” into the reference genome sequence. Indels can cause catastrophic errors in the process by which genes instruct cells to make proteins, causing or contributing to many serious diseases from cancer to autism.



Using the tools of math and statistics to solve problems in the life sciences

Biological research today generates huge data sets. Future progress in biology will depend in large part on the development of complex computer programs, algorithms and statistical tools needed to analyze and exploit the data. CSHL's **Simons Center for Quantitative Biology** was established in 2014 with \$50 million donated by Marilyn and Jim Simons. Faculty use the tools and talents of mathematics, computer science, physics and engineering to explore basic questions in the life sciences. Current areas of research include genomic analysis in the context of serious diseases and studies in population genetics. The Center is located in CSHL's Hillside Campus (described in Part Two).

A collaborative enterprise

As several of the examples cited above suggest, research in the life sciences is increasingly a collaborative enterprise. One of the ways in which CSHL contributes to New York's strength in this sector is by collaborating with other New York institutions on research projects that go beyond what the partners could do individually.

- The **Starr Cancer Consortium**, was established in 2006 with an initial grant of \$100 million from the Starr Foundation. The Consortium's goal is to develop new platforms for research into the genetic and molecular bases of cancer, and to use the results as a basis for developing new approaches to diagnosis and treatment.

Four of the Consortium's five member institutions are based in New York – CSHL, Memorial Sloan Kettering Cancer Center, Weill-Cornell Medical College, and Rockefeller University, along with the Broad Institute, a joint MIT-Harvard research center located in Cambridge, Massachusetts. Starr funding is used only for collaborative projects involving at least two of the five institutions. By bringing to this collaboration its strengths in genetics, molecular biology and related areas, CSHL is not only helping the Consortium work toward its goal, but is also helping to build a foundation for New York's continued leadership in cancer research.

- CSHL is a founding member of the **New York Genome Center**, a consortium of research and medical institutions that in 2012 opened a new genome sequencing facility in New York City. Other consortium members include the Albert Einstein College of Medicine, Columbia, Cornell, the Jackson Laboratory, Memorial Sloan-Kettering Cancer Center, Mount Sinai, New York Presbyterian Hospital, NYU, North Shore LIJ, Rockefeller University and Stony Brook University.
- CSHL is also a member – along with NYU, the American Museum of Natural History and the New York Botanical Garden – of the **New York Plant Genomics Consortium**, an NSF-funded collaboration in genomic research on hundreds of species of plants.



Research with world-wide impact

CSHL researchers work closely with colleagues at other Long Island institutions including Brookhaven National Laboratory and Stony Brook University. For example, in developing a non-invasive technique for tracking the activity of neural progenitor cells in living patients, CSHL researchers drew on BNL scientists' strengths in brain imaging technology. This breakthrough would not have been possible without the work of Stony Brook researchers, who developed an algorithm that allowed them to identify and track these cells more clearly by filtering out background "noise" from the images they were creating.

CSHL's partners include not only other institutions, but also companies that have an interest in the Laboratory's work. As noted above, about \$5.2 million of CSHL's research spending in 2013 was funded from corporate sources. The Lab is, for example, collaborating on a wide range of projects with GlaxoSmith Kline, Pfizer, Boehringer Ingelheim, Dart Neurosciences, Isis Pharmaceuticals, Merck and Syngenta.

Research conducted at Cold Spring Harbor Laboratory has a major impact on the course of biological and biomedical research throughout the U.S. and around the world. In 2013, Thomson Reuters *Essential Science Indicators* ranked CSHL among the top 1 percent of all research institutions worldwide in terms of the frequency with which the work of its scientists was cited by others. The Laboratory's influence was especially strong in molecular biology and genetics, where CSHL ranked first in the world in citations per paper – ahead of other leading institutions such as MIT, the Salk Institute, the European Molecular Biology Lab and Memorial Sloan Kettering Cancer Center.

Table 3: Leading research institutions worldwide in molecular biology and genetics (measured by average number of citations per paper for all papers published from 2002 through 2012)

Rank	Institution	Citations per paper
1	Cold Spring Harbor Laboratory	96.94
2	Massachusetts Institute of Technology	87.82
3	Salk Institute for Biological Studies	70.85
4	Wellcome Trust Sanger Institute	70.27
5	Massachusetts General Hospital	67.50
6	Rockefeller University	62.46
7	Dana Farber Cancer Institute	62.22
8	European Molecular Biology Laboratory	59.41
9	Brigham and Women's Hospital	59.03
10	Memorial Sloan-Kettering Cancer Center	58.16

Source: Thomson Reuters *Essential Science Indicators*

Bringing the results of CSHL's research to the marketplace

The impact of research conducted at CSHL can be measured from several perspectives. As noted above, the Lab is one of the most productive scientific institutions in the world, in terms of the frequency with which its scientists' work is cited by others. This means, in effect, that work done in recent years at Cold Spring Harbor Laboratory is shaping the work of life science researchers – at universities, in corporate research centers and at other research institutions – far beyond its campus.

The new knowledge created through research conducted at CSHL may have more immediate practical and commercial implications. In these cases, the Laboratory has several options available for putting the results of its research to work for the benefit of society.

The most frequently-traveled route for bringing the results of CSHL research to the marketplace is through licensing agreements, under which private companies pay a fee in exchange for the right to use the Lab's "intellectual property" for commercial purposes. In some cases, the Lab's research may provide the basis for creation of a specific product, such as a new cancer drug. In these cases, the Lab typically grants an exclusive license to one company for the further development and use of the Lab's property. Between 2008 and 2014, CSHL entered into 64 licensing agreements.

While many of its licensees have been larger, established companies, the Laboratory has also entered into licensing agreements with new ventures created specifically for the purpose of further developing and bringing to market technologies first developed at CSHL. Since 1981, the Laboratory has concluded licensing agreements with 25 start-up companies, including five that were launched in 2014 – the largest number of start-up companies spun out of CSHL in any single year in the Lab's history.

Table 4: Cold Spring Harbor Laboratory Technology Transfer, FY 2008-2014

	2008	2009	2010	2011	2012	2013	2014
Gross licensing income	\$2,202,059	\$1,033,419	\$1,223,171	\$1,048,138	\$1,229,957	\$1,161,187	\$10,141,761
New patent applications	33	21	19	23	24	18	15
U.S. patents issued	1	3	4	4	7	4	6
Licenses/options executed	3	6	5	6	9	19	16
Start-up companies formed	0	0	0	2	1	0	5

New York companies recently started at CSHL include:

- **Certerra Inc.**, a contract research organization founded in 2011 and located in Cold Spring Harbor. Certerra provides high-resolution, cellular-level screening of the effects of potential new drugs on the brains of mice. Its services are used by pharmaceutical and biotechnology companies engaged in the development of new drugs for the treatment of brain disorders.
- **Mirimus, Inc.** founded in 2010 and located in Cold Spring Harbor, develops genetically engineered mouse models for use in pre-clinical testing of new drugs and in other RNAi research.
- **ASOThera**, founded in 2014 and located in Cold Spring Harbor, is developing new therapies for orphan diseases.
- **Clarapath**, founded in 2014 and located at the NY Genome Center in New York City, provides a range of services for the use of tissue samples for both research and clinical purposes. The company's services include sectioning, slide preparation, high-resolution digital imaging, digital analysis and storage.
- **DepYmed** is a joint venture of CSHL and New York City-based Ohr Pharmaceuticals, created in 2014 for conducting pre-clinical research on potential treatments for obesity, diabetes and certain types of cancer, based on research conducted at the Laboratory. DepYmed is pursuing clinical trials in collaboration with NSLIJ.
- **Envisagenics**, located in Huntington, is using the tools of "big data" to streamline drug discovery and development, by more quickly and accurately identifying the most promising candidate genes to be targeted in the development of new treatments. Envisagenics was founded in 2014 by a Watson School alumna and a CSHL post-doctoral fellow.

- **Protifi**, based in Huntington, was founded in 2014 to commercialize the results of research in genomics and proteomics conducted at CSHL.

CSHL has also supported the translation of life sciences research into new businesses and new jobs through its collaboration with SUNY Farmingdale in the development of **Broad Hollow Bioscience Park (BHBP)**. First opened in 2000, the 20-acre research park, located on the Farmingdale campus, currently includes two buildings with a total of 102,500 square feet that is available to start-ups and growth-stage bioscience companies. Long Island's homegrown blockbuster cancer drug manufacturer OSI Pharmaceuticals, acquired by Astellas Pharmaceuticals in 2010, was a CSHL spin-off incubated at BHBP.

While Cold Spring Harbor Laboratory's impact – on science, on society and on the region's economy – is founded on its role as a research center, it is also a function of CSHL's special role as a place where scientists gather to present, discuss, and learn about the latest advances in the biological sciences. The next part of the report highlights this aspect of CSHL's impact.



PART FOUR

Scientific Conferences and Courses

In addition to contributing to advances in the biological sciences through the work of its own researchers, Cold Spring Harbor Laboratory administers an extensive Meetings and Courses Program. Since it began in the 1930's, the Program has made Cold Spring Harbor one of the world's leading venues for the presentation of research and exchange of ideas among leaders in both basic and applied life sciences. CSHL scientific conferences and meetings attract more than 8,000 scientists annually from across the United States and throughout the world.

Conferences

Since 1933, CSHL has been organizing conferences on a wide array of topics in the life sciences. In 2013 CSHL hosted 27 large conferences, each usually lasting three to six days, and drawing anywhere from 100 to 500 participants. Examples of topics addressed during 2013 included:

- The biology of genomes
- 78th Annual Symposium: Immunity and tolerance
- Nuclear receptors & disease: bench to bedside
- Dynamic organization of nuclear function
- Neurodegenerative diseases

Attendance at CSHL conferences in 2013 totaled more than 7,300. About half of all participants are practicing scientists, from either academic institutions or industry; and half are graduate students or post-docs.

Two important features of CSHL conferences are the open submission process and level of participation by young scientists. The majority of meeting topics are chosen from openly submitted projects and programs that are put together by CSHL organizers on the basis of these abstracts. The Program is also notable for the number of young scientists presenting unpublished works – providing an opportunity for graduate students to speak for the first time and present to world-class investigators.

In addition to these large conferences, the Lab also organizes smaller, invitation-only meetings, which are held at the Banbury Center. CSHL's unique think-tank on science and public policy, the Banbury Center serves a variety of purposes, such as:

- Promoting early discussions among specialists in an emerging field, such as a three-day conference in May 2013 that explored the feasibility of redesigning photosynthesis;
- Providing a forum for discussion of more immediate practical questions, such as a 2013 meeting that focused on organizing a new neuroscience data consortium;
- Informing a broader cross-section of participants about the social, ethical, economic and public policy implications of recent developments in the life sciences – such as a 2013 meeting that focused on the need to strengthen privacy protections in genomic research.

Depending on the specific topic, these meetings are typically limited to 20 to 30 participants. In 2013, the Banbury Center hosted 25 meetings, with a total of more than 700 participants.

CSHL's large conferences are generally funded through fees paid by participants. Banbury Center meetings, in contrast, are funded entirely from Federal funds, foundation grants and corporate sponsorships.



Courses

Cold Spring Harbor Laboratory also offers advanced technology training courses covering a wide range of topics in the biological sciences. These are typically intensive, two- to three-week courses, generally designed for late-stage PhD candidates and post-docs. To ensure a high level of interaction between instructors and students, courses are usually limited to 20 students per class. Topics of the 28 courses offered during 2013 included:

- Quantitative imaging
- Computational cell biology
- The biology of learning and memory disorders
- Synthetic biology
- Advanced bacterial genetics

In addition to these courses, CSHL also offers a series of shorter workshops, such as a seven-day workshop for young researchers on autism spectrum disorders that was held in 2013.

Tuition and fees paid by students generally cover about 35 percent of the cost of courses, with the remainder covered by Federal funds or foundation grants. CSHL also maintains relationships with more than 100 companies that provide sophisticated equipment and technology for use by students.



Extending CSHL's reach through publications

Since 1933 – the same year that CSHL held its first symposium – Cold Spring Harbor Laboratory Press has supported the Laboratory's mission of promoting the advancement of science and sharing scientific knowledge through the publication of books, textbooks, journals, technical manuals and lab handbooks, conference proceedings and videos on the biological sciences. CSHL publications are a valuable resource for scientists and students around the world – and are also seen as an important venue for the publication of scientific findings.

Net revenues from the sale of CSHL's publications are used solely to support the Lab's research. In 2013, revenues from the sale of publications totaled nearly \$10.2 million.

National and international visitors

The Meetings and Courses Program at Cold Spring Harbor Laboratory provides an easily-accessible way for Long Island and New York scientists and students to learn about and discuss the latest discoveries in the life sciences. The Program also attracts scientists from throughout the U.S. and from around the world. Approximately half of all participants in conferences and courses come from other U.S. states, and one-third from other countries.

Conference and course attendees reside at the 230-bed dormitory operated by Cold Spring Harbor Laboratory. Since many of the conferences have registrants greater than the maximum occupancy of the dormitory, CSHL also arranges accommodations at Long Island hotels, and provides transportation to and from the CSHL campuses.

Since the cost of the conferences meetings or courses is an all-inclusive package – covering all accommodations, meals and transportation, if necessary – most spending by visitors is accounted for in our analysis of the impact of CSHL's purchases of goods and services (discussed in Part Two). The program no doubt generates some additional off-site spending – for example, in local restaurants – but we have not attempted to calculate the impact of such spending.



ATION MODELS OF CODON SUBSTITUTION ACCOUNTING FOR SPECIFICITIES OF AMINO ACID FITNESS PROFILES

University of Ottawa, Canada), Hervé Philippe and Nicolas Lartillot (Université de Montréal, Canada)

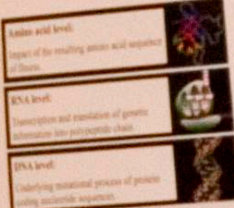
RESULTS

SELECTION COEFFICIENTS

In order to estimate site-specific results across all sites, we calculated the proportion of the proportion of the model, as shown in the distribution of

FUTURE DIRECTIONS

We need to extend our analysis to more data sets, and explore other forms of models for heterogeneity across sites. Further extensions of the model could be used to study the impact of selection, as well as to account for selective effects having an (symmetrical) codon preference (Yang & Nielsen, 2008).



Other extensions that could be explored include variable population sizes across the tree, as well as variable nucleotide preferences. The resulting model would provide a better reflection of these biological understanding, incorporating different features during the evolution of protein-coding genes, with future extensions in population genetic theory.

ACKNOWLEDGMENTS

We thank the following for their assistance. We also thank



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Evolution of ECG

Barbara Rosati, Qinghong Yan, Shuan-Ken Liao, Molecular Cardiology Institute, Department of Neurobiology, Stony Brook University

Scaling of a Complex Trait: Ventricular Action Potential Duration



Introduction

We have examined the relative importance of regulatory versus structural evolution in the scaling of a complex physiological system: the electrophysiology of mammalian cardiac ventricular myocytes. Two related phenomena were examined: changes in action potential morphology and the scaling of action potential duration.

Scaling of Heart Rate and Ventricular Action Potential Duration

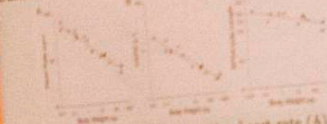


Figure 1. Relationship between resting heart rate (A), inverse ventricular action potential duration (B), fraction of the cardiac cycle taken up by the action potential (C) and body weight for terrestrial mammals.

Scaling of a Simple Trait: Ventricular Action Potential Morphology

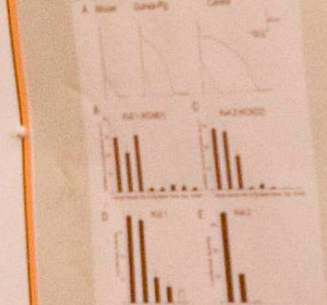


Figure 2. A comparison of ventricular action potentials recorded from mouse, guinea pig and human ventricular myocytes. Addition of a mathematically modeled (red) component to the experimental data (black) is shown in red. Comparison of (B) and (C) Kv4.2 mRNA expression in the left ventricle was also examined in these species. (D) Comparison of action potential morphology in mouse and human. (E) Comparison of action potential morphology in mouse and human.

Figure 3. A. Current-voltage relationships for KCNQ1 channels co-expressed with KCNH2 channels in guinea pig (left) and human (right) ventricular myocytes. B. Activation curves for KCNQ1 channels co-expressed with KCNH2 channels in guinea pig (left) and human (right) ventricular myocytes. C. Comparison of action potential morphology in mouse and human. (D) Comparison of action potential morphology in mouse and human. (E) Comparison of action potential morphology in mouse and human.

Bringing Cold Spring Harbor conferences to the world

The worldwide reputation of and growing demand for CSHL's scientific conferences and courses has led during the past decade to increasing internationalization of the program. In 2001, the Laboratory began organizing conferences in the U.K. in collaboration with the Wellcome Trust. CSHL and Wellcome now hold four or five such meetings each year.

Building on the success of its U.S. and U.K. programs, the Laboratory in 2006 established a subsidiary called Cold Spring Harbor Conferences Asia (CSHCA), to hold symposia, conferences and summer schools in Asia similar to those offered on Long Island.

CSHCA's home is a newly-built 600,000 square-foot hotel and conference center located on a 25-acre site on Dushu Lake in Suzhou, an ancient city 60 miles west of Shanghai. The Dushu Lake Conference Center was built by the Suzhou Industrial Park (SIP) – a nearby science and technology-based industrial complex that is being developed with financing from the governments of China and Singapore. SIP manages the Conference Center's facilities, while CSHCA owns and manages the meetings, conferences, courses and other programs offered at the site.

CSHCA's first Banbury-style conference, held in November 2009, focused on "Large-Scale planting of Transgenic Crops in Asia: Policy Issues, Scientific Advances, Regulatory Considerations and Economic Benefits." In April 2010, Dushu Lake Center hosted its first major international conferences – the first James D. Watson Cancer Symposium, and the first Francis L. Crick Neuroscience Symposium, each drawing hundreds of scientists from Asia, the U.S. and elsewhere.

In 2013, CSHCA sponsored seventeen conferences and a summer school, with a total of approximately 3,000 participants.

Cold Spring Harbor Asia has not only enabled the Laboratory to franchise its expertise globally, but also serves as a forum for sharing knowledge and ideas between U.S. and Chinese scientists, and a springboard for developing collaborative relationships.



PART FIVE

Educating the Next Generation of Scientists

Since its beginnings as a laboratory for the training of high school and college teachers, Cold Spring Harbor Laboratory's educational programs have grown in scale and in depth. The Laboratory's training and education programs now include courses designed for elementary and high school students, teachers, undergraduate and graduate students, as well as opportunities for post-doctoral fellows.

Watson School of Biological Sciences

In 1998, Cold Spring Harbor Laboratory became a degree-granting institution for the first time in its history with the establishment of the Watson School of Biological Sciences. The Watson School offers an innovative program in which students can take advantage of the Laboratory's strengths in genetics, molecular biology, neuroscience, cancer, plant biology, genomics and bioinformatics, and quantitative biology.

In designing the Ph.D. program, CSHL aimed to create a unique program tailored to the institution's strengths, while addressing a widespread problem in graduate education – the increasing number of years required for students in the sciences to complete the PhD degree. The Watson School offers a demanding program, in which students progress rapidly from intensive course instruction to doctoral research – going from matriculation to Ph.D. in four to five years.

During their first year, students combine intensive course work with rotations through several labs at CSHL. These rotations give students an opportunity to work with a range of faculty members, and to engage in research on a variety of topics. At the end of their first year, students prepare and sit for the Ph.D. qualifying exam. When the qualifying exam requirement is satisfied, students begin to focus on their doctoral research.

In addition to their doctoral research, students in years two through four participate in a series of week-long courses on “topics in biology,” and each year participate in one of the postgraduate courses offered at CSHL (described in Part Four). Students also gain teaching experience by working as instructors at the DNA Learning Center (described below).

Since starting with a first class of six students, the PhD program has gradually expanded, with total enrollment of about 50 students each year. In 2013, 8 PhD students graduated from the CSHL program and 10 new students were admitted (out of 274 applicants).

Stony Brook University collaboration

For more than twenty-five years, graduate students from Stony Brook University have come to Cold Spring Harbor Laboratory to conduct doctoral research and to work with CSHL faculty. Students enrolled in the following programs at Stony Brook University are eligible to take advantage of the University's collaboration with CSHL:

- Genetics
- Molecular and cellular biology
- Molecular genetics and microbiology
- Neuroscience and behavior

Most CSHL faculty members work with Stony Brook students in one or more of these areas.

Brookhaven National Laboratory, located in Suffolk County, plays a similar role in Stony Brook University's graduate program. The collaboration among Stony Brook University, Cold Spring Harbor Laboratory and Brookhaven National Laboratory allows Stony Brook University students to complete their course work at SUNY Stony Brook and perform laboratory rotations and doctoral research at any of the three institutions.

Each year, about 50 Stony Brook University students take courses or conduct dissertation research at CSHL. The Lab's collaboration with Stony Brook University and Brookhaven National Laboratory thus makes available to New York graduate students a range of opportunities for learning and high-level research to which they might not otherwise have access.

Undergraduate Research Program

Established in 1959, the Undergraduate Research Program is a 10-week summer program that gives undergraduates an opportunity to learn first-hand the techniques of modern biology while being immersed in a scientific community. Approximately 25 sophomores and juniors from around the world participate in the program each year, working with senior staff members on independent research projects in:

- Cancer Biology
- Neuroscience
- Plant biology
- Cellular and molecular biology
- Genetics
- Macromolecular structure
- Bioinformatics

While conducting original research at a world-class institution, students learn about scientific reasoning, laboratory methods, theoretical principles, and scientific communication. In addition, students attend seminars and special events at CSHL, and are also able to attend the Lab's postdoctoral courses. At the end of the summer students present a summary of their research to peers and advisors.

During 2013, 27 students were selected from 738 applicants to participate in the Undergraduate Research Program, including 11 who were attending colleges and universities in New York.

The DNA Learning Center

In order to participate fully in the ongoing revolution in the life sciences – and in the economic growth to which that revolution gives rise – Long Island and New York State need a critical mass of workers and citizens who have a basic knowledge of the field. Cold Spring Harbor Laboratory was one of the first research institutions in the world to recognize the importance of introducing school-age children to biotechnology – not only as a resource for education, but also as an investment in human capital. CSHL's leadership in science education for the public has enhanced Long Island's strength in education.

The DNA Learning Center in the Village of Cold Spring Harbor opened in 1988 to educate primary and secondary school students in genetics, molecular biology and related topics, and provide educational programs for science teachers and the general public.

The first DNALC location is housed in an elementary school purchased from the Cold Spring Harbor School District, about a mile from CSHL's main campus. CSHL's DNA Learning Center was the first program of its kind dedicated to genetics education. The Laboratory renovated the building to include 5,000 square feet of useable space – including a 32-seat lab, exhibition space and classrooms.

Over time, the DNALC program outgrew the original building and in the spring of 2001, the Laboratory completed a two-story addition, increasing the size of the building to 15,000 square feet. The DNALC facility in Cold Spring Harbor is now equipped with three laboratory classrooms, a computer laboratory, 104-seat auditorium, nearly 2,000 square feet of exhibition galleries, visitor lunchroom, office space for more than 25 staff members, prep lab, video studio, conference room and staff lounge. This facility is named the Dolan DNA Learning Center.

Based on the success of the first DNA Learning Center facility, Cold Spring Harbor Laboratory in 2002 established the DNA Learning Center West in Lake Success, New York. In collaboration with the North Shore–Long Island Jewish Health System, DNALC West provides the same high-quality genetic and biochemistry laboratory space as the DNALC, but in a more accessible location for middle and high schools in Nassau County and Queens. The proximity of DNALC West to the Clinical Core Laboratory, home of one of the largest robotic machines involved in diagnostics, provides students the opportunity to tour these facilities.

In 2008, Cold Spring Harbor Laboratory opened its first educational laboratory space in New York City, located in the John S. Roberts Educational Complex in East Harlem. Operating in partnership with the New York City Department of Education and with foundation support, the Harlem DNA Lab offers middle and high school students courses and laboratory experiments in topics such as bacterial transformation, DNA restriction analysis, forensic DNA profiling, and human mitochondrial DNA sequencing. The Lab serves students from Harlem and from other New York City neighborhoods as well. About 80 percent of the participating students are African-American or Latino.

CSHL is now planning to develop a second, larger DNALC facility in Manhattan, with sufficient capacity for more than 25,000 student visits per year. The Harlem DNA Lab will continue to operate in tandem with the new center.

Programming at DNALC facilities includes:

- **Teacher Training Workshops and Fellowships** for secondary and college faculty covering RNA interference, cancer biology, and neuroscience research, as well as professional development for NYC teachers in genetics and biotechnology; and
 - **Saturday DNA!**, classes that provide learning experiences available to the general public.
- In 2013, DNALC directly reached more than 32,800 students – 20,962 who participated in field trips to Dolan DNA Learning Center, DNALC West, or the Harlem DNA Lab, about 10,200 who benefited from in-school instruction by DNALC staff, and 1,621 who were taught by teachers trained by DNALC. Since the Center began operating in 1988, approximately 500,000 students have participated in its programs.
- DNALC has also licensed its programs to several organizations elsewhere in the U.S. – including, for example, the University of Notre Dame, which in 2013 opened a DNA learning center in a new science building on its South Bend campus.



DNA Learning Center – Digital Resources

Since 1993, the DNA Learning Center has been developing and managing websites and other resources with content and tools designed for scientists, students and the general public. The DNALC's websites fall into two categories:

- **Educational Sites** – educational, content-based Internet sites for the general public, ranging from middle school students to adults, covering topics that include basic heredity, genetic disorders, eugenics, the discovery of the structure of DNA, DNA sequencing, cancer, and plant genetics.
- **Lab and Bioinformatics Sites** – professional sites built around laboratory experiments and bioinformatics to address shortages and inefficiencies in the tools that are generally available to analyze large amounts of scientific data.

In 2013, the 22 websites administered by the DNALC collectively had more than 4.86 million visits, and its YouTube videos were viewed 823,400 times.

The DNALC also develops and distributes educational apps for smart phones and tablets. In 2013 these apps were downloaded 579,165 times. From its launch in 2009 through the end of 2013, the Center's 3D Brain app was downloaded more than 1.6 million times.



PART SIX

A Center of New York's Bioeconomy

As this report has shown, Cold Spring Harbor Laboratory has a significant impact on the New York State and Long Island economies. During the next five to ten years, its impact could be even greater.

1) New facilities, new capabilities

As noted in Part Two, the completion of CSHL's Hillside Campus in the spring of 2009 increased the Laboratory's supply of research space by nearly 40 percent. During the past five years this new complex has allowed CSHL to recruit additional scientists, and has provided space for new initiatives such as the Simons Center for Quantitative Biology (described in Part Three), and the Laboratory's expansion into new areas of cancer research.

The new Pre-Clinical Experimental Therapeutics Facility and the proposed Center for Therapeutics Research will similarly provide the additional space and state-of-the art equipment needed to support the continued growth of CSHL's research enterprise.

Similarly, development of a new DNA Learning Center in New York City and expanded partnerships with metropolitan area school districts will significantly increase the number of elementary and high school students who can participate in the Lab's science education programs.

In addition to developing new facilities, CSHL has in recent years taken several steps to strengthen its ability to compete successfully for external (especially Federal) funding – for example, by supporting early-stage research on projects that are not yet ready to compete for external funding, but that have the potential to attract such funding in the future; by working more systematically to identify Federal funding opportunities; and by providing more assistance to investigators in preparing proposals. All of these efforts will pay off over time in increased outside support for research at CSHL.

Expansion of CSHL's research enterprise, and the hiring of additional employees, will generate additional jobs on Long Island and throughout New York State through increased spending on goods and services, and through the multiplier effect.

2) Leading the way to “a new biology”

The biological sciences today are rapidly evolving in ways that just a few decades ago would have been almost impossible to foresee. The changes that are now

occurring could in the future yield enormous benefits – for our society, for our economy and for the environment. But if the promise of what a committee of the National Research Council has called “a new biology for the twenty-first century” is to be realized, significant changes in the way scientific research is conducted – and how it is used to solve some of our most pressing problems – will be needed. The NRC committee cited above called for a stronger emphasis on research that is organized around the search for solutions to some of the nation's and the world's most critical problems, and that integrates into the biological sciences the work of physicists, chemists, mathematicians, computer scientists and engineers.²

The NRC committee highlights four major challenges that the new biology can help to address:

- Developing food plants that are adapted to, and can be grown sustainably in, changing environments;
- Sustaining ecosystem function and biodiversity in the face of rapid change;
- Developing sustainable alternatives to fossil fuels; and
- Developing health monitoring and diagnostic systems – and when needed, treatment regimens – that are specifically tailored to the individual.³

To an extent that few other institutions can match – in New York or elsewhere – Cold Spring Harbor Laboratory is especially well-equipped to respond to the demands of the new biology, and to the opportunities it presents. CSHL has already-established strengths in many areas that provide a foundation for the new biology, including plant biology, genomics, genetics and quantitative biology; and scientists at CSHL are already deeply engaged in efforts to address at least three of the four major challenges cited by the NRC committee – more adaptable and more sustainable agriculture, new biofuels and personalized medicine.

2. National Research Council, Committee on a New Biology for the 21st Century, *A New Biology for the 21st Century: Ensuring that the United States Leads the Coming Biology Revolution* (Washington: National Academies Press, September 2009), p. 2

3. Ibid, pp. 3-4.

Moreover, as an institution, CSHL already embodies many of the characteristics that will be conducive to success in the new biology:

- A flat, non-hierarchical organization;
- Absence of the departmental and disciplinary boundaries that characterize many large research institutions;
- An intensely collaborative culture; and
- A strong commitment to recruiting and nurturing highly talented young scientists.

3) *Technology transfer and new business development*

During the past few years CSHL has greatly strengthened its support for commercialization of the results of its research and technology development – for translating new knowledge developed at the Lab into new products, new businesses and new jobs. The payoff from this effort is evident in the growing number of CSHL-related start-up companies doing business in New York State. The Lab's strengths in this area are critical to competing for Federal and private funding. CSHL is poised to achieve the goals of the NRC's "new biology" – ensuring that the nation's strengths in basic and applied research can be successfully harnessed to solve some of its most pressing problems.

4) *Collaboration with other New York institutions*

CSHL is building on its established (and in some cases, emerging) strengths, by working in collaboration with neighboring institutions on Long Island – Stony Brook University and Brookhaven National Laboratory – and elsewhere in the New York City area. CSHL already has a long history of collaboration with these institutions. A robust Long Island bioeconomy will result from broader and deeper scientific research and education partnerships.

These Long Island partners in scientific research and education complement each other in areas critical

to addressing major challenges facing society today: improving food production, developing new bio-fuels, adapting to climate change and personalized medicine. Together, CSHL, Stony Brook University and Brookhaven National Laboratory also bring complementary strengths to the task of accelerating the translation of research into new products, new businesses and new jobs – which New York State has identified as one of the principal elements of its economic development strategy.

Creating the future at Cold Spring Harbor

Cold Spring Harbor Laboratory is a substantial – and increasingly powerful – science and technology-based enterprise. It plays a leadership role in expanding the frontiers of knowledge in genetics, molecular biology and related fields that far transcends its size. Through a growing web of collaboration with other New York institutions, CSHL acts as a "force multiplier," helping to create both scientific and economic value that exceeds the sum of each partner's contributions.

In all of these ways, Cold Spring Harbor Laboratory is shaping the future – both for the new biology, and for New York's new economy. A strong CSHL can help lead the growth of the region's life sciences economy, and bring the results of its research to bear on some of society's most important challenges in health care, energy, agriculture and the environment.



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