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    A Region on the Verge of Discovery
When he was a teenager growing up in Brooklyn, his parents and teachers recognized that he had unusual talents in math and science. Lacking money, they sent him to the renowned public magnet school, Stuyvesant, which, in those days, was just east of 2nd Avenue on Stuyvesant Square. Because he was tall and gangly, he made first-string center of the not-very-competitive school basketball team. And that was his dream. As he plied the subway back and forth from Brooklyn each day, he didn’t dream of getting into Harvard or MIT, of winning a Nobel Prize, or saving humanity from a dreaded disease, he just wanted to sink a game-winner as time ran out on the scoreboard clock.

One eventful day, this Brooklyn boy found himself up against another local Brooklyn student with the same dream. But that boy was shockingly tall, nearly a foot taller, and he dominated the game from the first buzzer. Then came a bizarrely astute taunt from his opponent: “What’re you gonna do now, Einstein?”

It was more than 40 years before the two met again, and I was the fortunate witness. It was at a Cold Spring Harbor Laboratory Gala at the Mandarin Oriental. The truly tall boy—originally from Power Memorial High—was by now well-known for the longest winning streak in college basketball, six MVPs in the pros, and, now, to his pleasure, his philanthropy in support of Parkinson’s research. His name had been Lou Alcindor when the boys first met. But now the world knows him as Kareem Abdul Jabbar.

The other boy—who was too small to head to the pros—had gone on not to Harvard, but to Columbia. And he had certainly exceeded the expectations of his parents and his teachers. Richard Axel approached Kareem to remind him of their previous meeting—as two skinny kids on the basketball court. Now here they were, a winner of the Nobel Prize in Physiology and Medicine and a man known as one of the greatest basketball players of all time, and it seemed safe to say, each had achieved his dreams.

New York has always been a place for dreamers. It has been the embodiment of what America wants to believe it can be at its best.

This special issue is devoted to the transformation of New York that has taken place in the first decade of the new millennium. As every reader will see from the pages to follow, in the face of some of the most daunting challenges ever to confront a city—9/11, the worst financial implosion since the Great Recession, a devastating hurricane—New York’s institutions are flourishing as never before—and they are particularly flourishing in the realm of science and technology.

Universities and academic medical centers are on fire with novel ideas to overcome outdated traditions of disciplinary silos and seniority and create Big Dreams that will not merely transform their campuses but meaningfully contribute to the world through research and development.

Similarly our companies—large and small—are taking the boldest steps imaginable to reinvent themselves so that they can better address the global challenges of health and education, of poverty reduction, of urban growth and sustainability.

A third factor: the most generous benefactors on the planet. We in New York have always been blessed by this. Edison and Bell saved the journal Science from bankruptcy. Andrew Carnegie gave a million dollars to the five principal engineering associations so they could come together in New York to create synergies that would make our city the world’s hub of engineering. And today, science-focused philanthropy is even more inventive, more exciting—with philanthropists focused on transformational giving.

This too is the decade of institutions built to overcome the old zero-sum-game, dog-eat-dog mentality that held us back for so long. There is collaboration not only amongst individual institutions, but also on the part of established organizations to create entirely new institutions that are not about ownership, but about results.

And last but not least, our own New York Academy of Sciences, which changed the culture in its own unique way. First, we created a home for 15,000 scientists who come annually from all of our institutions (academic and industry) to meet, to be mentored, to exchange ideas, and to build joint projects. Second, we broadcasted our collective strength to the world on the Internet and in print so that scientists and students the world over started to see the unmatched scale and power of New York in the biomedical sciences. Then we assembled—at the request of others—global public-private partnerships in cutting-edge areas like Alzheimer’s disease, nutrition, smart cities, and more. These activities attracted leaders of governments across the globe to want to partner with New York as a center of gravity in a world full of questions and challenges that only science and technology can answer.

But key to it all is the quality of young people trying to come to our city to achieve their dreams…and ours. The dream of New York as the science capital of the world is not merely achievable. As the articles in the rest of this publication demonstrate, the dream is becoming reality as we come together. I close with one more story:

In 2011, I was invited to participate in China’s version of the World Economic Forum on Hainan Island. My guide was a Chinese student who had adopted the American name Lily. On the last day of the event, as she was escorting me to a meeting with the man who would become the next Premier of China, she said: “I will be in New York in September.” When I asked why, she answered with great excitement: “I have been accepted to study at NYU.” I congratulated her and asked whether she had applied to other schools as well. “Yes,” she said with special pride: “And I got into all of them: Duke, Boston College, the University of Toronto.” I was impressed. “So why did you choose NYU?”

Her eyes lit up: “New York: It’s where dreams are made.”

Ellis Rubinstein
President & CEO
Special thanks to the New York City Economic Development Corporation for providing facts and figures on S&T in NYC.
NEW YORK: A SCIENCE STATE OF MIND

An introduction to New York’s newest role: that of an undisputed scientific powerhouse.

BY SHARON BEGLEY
Come, New York has long beckoned: come achieve your dreams and create what has never existed before—come build America’s first department store and largest stock exchange, her first pizzeria and first public brewery. Come make New York City the nation’s capital of finance and media and fashion, and come invent the inventions that change the way we live (air conditioning, toilet paper), the way we remember (photographic film), and the way we sing (folk rock). Come immerse yourself in neighborhoods filled with other artists and writers and thinkers who will nurture and challenge your ideas, producing the critical mass that will enable you to achieve what you cannot in isolation. Come change the way an entire nation thinks, as when the abolition movement put down roots in Rochester in the mid-1800s.

Even as New York City and State have called the world’s doers and dreamers to their shores for centuries, scientists became almost an afterthought by the mid-20th century. Yes, Nikola Tesla did pioneering experiments on alternating current in lower Manhattan during the Golden Era for New York science in the late 19th century; biologists at The Rockefeller University discovered in the 1940s that DNA is the molecule of heredity; and physicists using particle accelerators at Brookhaven National Lab on Long Island in the 1960s, 1970s, and 1980s discovered some of the basic building blocks of the universe and the magical rules that govern them.

But by the post-war era, science and technology had become less central to the life, commerce, and the very identity of New York than the rising commercial behemoths of advertising, finance, law, and business.

Now, New York is exulting in a science renaissance. You can measure it in glass and steel, like the $350 million Advanced Science Research Center that The City University of New York is building on St. Nicholas Park in Upper Manhattan and which, when it is completed next year, will house scientists whose work will be driven by a revolutionary new way of organizing research. You can measure it in bold new collaborations, such as the New York Structural Biology Center in Harlem or the $50 million New York Genome Center in SoHo, both of which attract researchers from around the country and around the world.

You can measure it in the ways that long-established institutions are expanding their research footprint: in West Harlem, Columbia University is building an entirely new campus, allowing it to increase the size of its engineering faculty by 50%. “Never before in our city’s history has there been...so much scientific investment,” said Mayor Michael Bloomberg in his 2013 State of the City address.

And you can measure it in the ways that New York is hanging up “Science Wanted” signs, such as its offer of land on Roosevelt Island and up to $100 million to induce world-class institutions to build a state-of-the-art applied sciences and engineering campus. Welcome, Cornell Tech, a collaboration between the Ithaca, NY, university and Technion-Israel Institute of Technology, which has been hailed as “the most exciting economic development project our city has ever undertaken.”

Only a decade ago, New York, the city as well as the state, were behind other regions with relatively well-educated populations and leading universities in attracting scientists and research funding. That began to change when Mayor Bloomberg vowed that the city would rise from the ashes of the 9/11 attacks with a more diversified economy, one in which science would take its rightful place alongside other creative, forward-looking fields. The city’s “ultimate goal,” Bloomberg said in a 2009 speech, is “reclaiming our title as the world’s capital of technological innovation.”
Just as Wall Streeters and Mad Men, as well as denizens of the diamond and garment districts, draw much of their energy and hone their competitive instincts from sheer proximity to one another in the neighborhoods where they cluster, so too have scientists formed a critical mass in New York, both upstate and downstate.

New York City is home to more students than any other city in the country. Attracted by the city’s dynamism and culture, to say nothing of the access to capital, ideas, and the growing presence of others like them, young people are streaming into New York to study, to invent, and to start technology companies; welcome, Silicon Alley. For sheer creative and intellectual energy, Paris in the 1920s has nothing on New York City in the 2010s.

In Upper Manhattan, CUNY’s Advanced Science Research Center will be welcomed to the neighborhood by the five-year-old CUNY Energy Institute, the new CUNY Hub for Innovation and Entrepreneurship, and a new City College science building. A subway ride away is Columbia University’s new Mortimer B. Zuckerman Mind Brain Behavior Institute.

Continue downtown to the three-year-old Alexandria Center for Life Science on the East River, which has already drawn such tenants as Kadmon Pharmaceuticals, ImClone Systems, and Pfizer’s Centers for Therapeutic Innovation, and has spawned dozens of life sciences start-ups. With NYU Langone School of Medicine and Bellevue Hospital close by, Midtown East is as dense with biologists and physician-scientists as 6th Avenue in the 20s is with wholesale florists.

Global organizations that could have chosen headquarters in Beijing, Boston, Baltimore, or anyplace else with an abundance of science talent are lately choosing New York, including The Global Alliance for TB (tuberculosis) Drug Development and the International AIDS Vaccine Initiative’s (JAVI) AIDS Vaccine Design and Development Lab. Both leverage New York City’s status as the crossroads of the world—and the international hub of finance and communications—to carry out their ambitious missions.

New arrivals have long brought new energy and new ideas to the city, starting well before a soaring copper-and-wrought-iron lady with a torch welcomed them in its harbor. The scientific groups putting down stakes today are doing the same, igniting a research renaissance that is rejuvenating well-established institutions. The Rockefeller University, established in 1901, recently launched a Center for Genomic Medicine—which is barely two years old. And Mount Sinai Medical Center, whose roots go back to the 1850s, expanded its clinical and research space by nearly 30% last year with the completion of the Hess Center for Science and Medicine, which promotes a trans-disciplinary approach to patient-centered care.

The research renaissance doesn’t peter out once you leave the five boroughs. New York State, spurred in part by the need to replace lost manufacturing jobs, is making its own big bets on science and technology, and drawing national support. A dozen years after its founding in 2001, the College of Nanoscale Science and Engineering (CNSE) of the State University of New York (SUNY) has attracted more than 3,100 scientists, engineers, students, and faculty to its world-class labs, drawing researchers from IBM, Intel, Samsung, Toshiba, and many others.

Albany has not only CNSE but, as of 2010, The RNA Institute, also part of SUNY, which in turn taps the expertise of faculty at the University at Albany School of Business to develop and commercialize new biotechnology in the Capital Region. On Long Island, the Advanced Energy Research and Technology Center is leveraging $45 million from the state to bring together 14 universities, Brookhaven National Laboratory, and telecom companies—among others—to accelerate and commercialize research on solar and wind energy, fuel cells, and the efficiency and security of the electric grid.

In a collaboration that fuses upstate with downstate and medicine with engineering, the Icahn School of Medicine at Mount Sinai Medical Center in Manhattan and Rensselaer Polytechnic Institute (RPI) in Troy signed an agreement last May to build on the institutions’ respective
strengths—Mount Sinai’s in biomedical research and patient care, and RPI’s in engineering and invention prototyping.

It’s clear from just a quick dive that New York has indeed reclaimed its place as a scientific powerhouse. In the following pages, many of New York’s major research institutions have highlighted some of their most exciting new initiatives, those which they expect to further shape the New York science community over the coming decade. They are truly astounding—and will no doubt have implications far beyond the local area.

Articles exploring other facets of New York’s science ecosystem—from inter-institutional collaboration to corporate research, philanthropy, global partnerships, and tri-state area innovations—round out this publication, which is dedicated to the researchers and technology professionals, the universities and academic medical centers, the corporations, and the funders who are driving this renaissance. We guarantee you’ll be astonished at how New York has indeed become a science state of mind.

Sharon Begley is a science journalist and author in New York.

Did You Know?
NY Tech Meetup now boasts more than 34,000 members, gathering monthly to hear from groundbreaking tech start-ups.

Did You Know?
A new College of Nanoscale Science and Engineering initiative relocates part of the U.S. Department of Energy’s SunShot initiative, which aims to make solar power economically competitive with other forms of energy, from Silicon Valley to upstate New York.

Did You Know?
New York City counts 124 institutions of higher learning within its borders.
Poor RNA. It has never managed to attract the scientific spotlight that DNA has, and the molecule seems destined to be forever considered a mere supporting player in the great drama of the molecular biology of life.

Not if The RNA Institute at the University at Albany, part of the State University of New York (SUNY), has anything to say about it, however. The Institute was founded in 2010 on the conviction that RNA is not a mere errand boy for DNA, but is a promising target for therapies that might treat diseases ranging from cancer to depression.

Genetic dogma holds that DNA, found in cell nuclei, contains the genetic code—the book of life and the blueprint for a human being. In less soaring rhetoric, however, DNA is simply a twisting staircase of a molecule (a double helix) that holds instructions, called genes, for the production of proteins, including structural ones like the actin and myosin that make muscles move as well as enzymes like pepsin that digest food and others that regulate cell development.

A century of pharmaceutical development has focused on proteins, such as by providing the protein insulin to diabetics. More recently, genetic medicine has targeted DNA to treat hereditary diseases, such as by replacing the faulty gene that causes thalassemia or by blocking the effects of mutated genes that underlie cancers. Nothing therapeutic targeted RNA. Its job seemed to be merely to carry DNA’s instructions to cellular structures called ribosomes that produce the proteins. Why shoot the messenger?

The RNA Institute, directed by Paul F. Agris, professor of biological sciences and chemistry, is premised on a paradigm that sees RNA as much more important than a mere messenger. Scientists have recently shown that cells make countless RNAs that control protein production, a feat they manage by acting as the on/off switch for genes. Since disease results when proteins are not made correctly or in the quantity required by the cell, it might be possible to target RNA, inducing it to shut off disease-causing genes, for instance, or rev up laggard ones in order to provide proteins in the quantities a cell needs.

RNA, since it is involved in multiple steps leading to protein production, therefore has the potential to be the target of a novel class of therapeutic agents. Scientists at The RNA Institute are working to develop RNA-based medications, vaccines, and diagnostics for breast cancer; for drug-resistance in bacterial and viral infections, including MRSA (Staphylococcus aureus), drug resistant tuberculosis, and HIV; neurodegenerative and neuromuscular disorders such as amyotrophic lateral sclerosis (Lou Gehrig’s disease) and neurofibromatosis (“elephant man disease”); depression; orphan diseases such as mitochondrial diseases and Sjögren’s syndrome; and neuropathies.

RNA-based drug discovery begins with RNA target identification, characterization, and validation; moves on to predictive modeling of the target of intervention; drug design; and virtual screening; and culminates in the development and implementation of screening methods for potential therapeutics.

“The RNA Institute is an incredible establishment,” says University at Albany senior Kathryn Fanning, whose research at the Institute led to a paper in the prestigious Journal of Neuroscience examining the effects of antibiotics known as aminoglycosides on hearing loss. “My work primarily focused on finding evidence that the antibiotics were binding to a specific section of ribosomal RNA to cause the damage.”

Since current technologies, instruments, and methods were conceived and designed for DNA and proteins, the Institute—with $1.5.4 million in funding from the University at Albany and $2.5 million from New York State—is developing, adapting, and re-purposing technologies specifically for their use in RNA-based
science. In addition to university and state support, the Institute received $5.37 million from the National Institutes of Health under the 2009 American Recovery and Reinvestment Act (better known as the stimulus bill) to build the physical structure housing the Institute, which was completed in June 2013; $8.13 million in NIH research grants; and $1.3 million from industry partners Sigma Aldrich, Krackeler Scientific, Dell, Bruker Daltonics, and Thermo Fisher Scientific.

The exciting promise of RNA-based therapeutics has enabled the Institute to attract a stellar group of scientists to its advisory board, including Nobel Laureate Ada Yonath of the Weizmann Institute in Israel, and seven members of the National Academy of Sciences, including Dieter Söll and Ron Breaker of Yale University and Gregory J. Harmon of Cold Spring Harbor Laboratory. Researchers at The RNA Institute collaborate with some 350 researchers in more than 50 laboratories worldwide. As New York’s national research resource for RNA-based biomedical research, the Institute is committed to initiating and fostering collaborative public-private partnerships, including those involving biotechnology and pharmaceutical companies. It will be a resource for small, medium, and large businesses and aims to spur the development of start-up companies, new R&D centers, and other business operations in New York State.

In collaboration with UAlbany School of Business faculty, The RNA Institute is providing researchers with the tools and strategic know-how to assess the marketplace and successfully develop and commercialize technology in the Capital Region. The RNA Institute will become an economic engine for the state, putting New York at the forefront of cutting-edge RNA technology and fostering unique therapeutic, diagnostic, and technology start-up companies.

“My work primarily focused on finding evidence that the antibiotics were binding to a specific section of ribosomal RNA to cause damage.”
In the digital age, no one has time to wait for data. When an Amazon customer searches for a book, or a Facebook user clicks to see the next picture in an album, he expects his query to be answered immediately. Likewise, a physician pulling up an electronic medical record expects vital patient information, instantly. Failed connections lead to dissatisfaction, no matter who the customer may be. To safeguard against even the briefest service outage, the tens of thousands of data centers in the United States have devised extremely resilient systems of redundancy—keeping businesses running smoothly, but at the cost of untold amounts of energy. Perhaps tech is not always as green as it seems.

A 2012 report in the *New York Times* found that 90% of energy pulled off the grid by data centers is wasted, and as big data gets ever bigger, and more and more information is stored on the cloud, energy demands are going to escalate. On an already overburdened national energy grid, data centers currently account for 2.7% of total national electricity consumption.

“It’s staggering for most people, even people in the industry, to understand the numbers, the sheer size of these systems,” data designer Peter Gross told the *Times*. “A single data center can take more power than a medium-size town.”

At Binghamton University, State University of New York, a team of researchers is committed to slowing the pace of data center power usage. The university is one of several founding members of the Center for Energy-Smart Electronic Systems (ES2), a collaboration of universities and businesses whose long-term goal is to create green systems in a range of disciplines, from computer chips to smart buildings. For now, though, the men and women of ES2 are focusing on data centers, in hopes of helping the Internet live up to its green potential.

The National Science Foundation provided the infusion of funds necessary for Binghamton to join ES2, extending the university’s long commitment to innovation in the field of electronics. The initiative is unique in its macro/micro approach—attacking long-term, industry-wide goals with smaller steps, like the reform in data center technology.

To better understand industry practices, the Binghamton arm of ES2 will soon make the leap into a new facility, a state-of-the-art home in upstate New York, designed to serve as a “living laboratory” for efficient server management.

“The center will address energy efficiencies in a way that has not been tackled before,” says Bahgat Sammakia, director of ES2 and vice president for research at Binghamton. “By looking at energy-efficiency problems from all angles and across many disciplines, the center will provide the kind of answers that leaders in the electronics industry are looking for. Each of the center’s academic partners has expertise in a particular area, and by tapping into these individual strengths, we will collectively find the answers to some of the industry’s most challenging practical problems.”

Although part of ES2’s approach to data center improvement is technology based, there is more to saving energy than building a better microchip. Just as important as the guts of a server is the way it is used, which means looking for ways to improve job scheduling, waste heat recovery, and resource management.

“The center takes a holistic approach,” says Kanad Ghose, site director for ES2 Binghamton, “when it considers computing, thermal, and other challenges.”

But such innovation is useless if these more efficient practices are not adopted by industry. Binghamton’s business partners, including IBM, Microsoft, Bloomberg, and Facebook, represent the supply
chain for data centers, from those who make the machines to those who fill them. As ES2 produces advances in data storage, those groups have pledged to adopt the new technology as quickly as it becomes available.

Ghose says the group’s goal is to improve energy efficiency and productivity of the country’s data centers by 20% to 35%, a reduction that, if successful, would reduce the need for new power plants by as many as two every three years, while still meeting the nation’s demand for data.

Once that goal is accomplished, the lessons learned in the data center campaign will be applicable in ES2’s future endeavors, allowing researchers to find ways to increase energy efficiency across all areas of the electronics industry—from cell phones and tablets to gaming consoles and e-commerce.

“The whole,” says Ghose, “is bigger than the sum of the parts.”

“"A single data center can take more power than a medium-size town."
Of all the casualties of the 2008 recession, few are more serious than the evaporation of federal support for scientific research. Impatience in Washington has shifted what little federal dollars are available to short-term projects, whose benefits can be seen in the first year or so, at the expense of more ambitious work whose results are years or even decades away.

The creation and manipulation of nanomaterials falls into that second category. But though the materials involved in this exciting new field may be minute, the possible gains are immense. Researchers at the University at Buffalo (UB), State University of New York (SUNY), consider nanomaterial synthesis vital, and have not let the recession slow them down.

UB has proven nimble in the face of economic adversity, taking advantage of the recently-signed NYSUNY 2020 legislation, a statewide initiative designed to reinvigorate scientific research in the SUNY system. The initiative, inaugurated in 2011, will allow UB to hire 300 new faculty members, building on a reputation as a high-profile destination for great scientific minds at a time when other institutions are being forced to cut costs and lay off staff.

“New York State’s universities are the jewel of our state’s educational system, and with this bill the SUNY system will now be perfectly positioned to become the engine of economic growth across the state,” Governor Cuomo said, upon signing the legislation. “The $140 million in new capital funding will build these schools into America’s leading institutions of research and innovation, while also creating jobs for New Yorkers and improving our state’s economic competitiveness.”

In Buffalo, some of the most striking innovation is coming at the microscopic level, as the Institute for Lasers, Photonics and Biophotonics, led by Paras N. Prasad, makes unprecedented advances into the fabrication and manipulation of nanomaterials. Prasad is an expert in photonics—the study and development of new technologies based upon manipulation of light—and his latest endeavor applies that experience to the construction of remarkable nanostructures for applications in alternative energy, healthcare, and sensor technology.

Prasad and colleagues are attempting to fabricate nanocomposites—micron-scale structures made up of organic and inorganic materials. Such structures are naturally occurring—consider mother of pearl, or human bone—but they form very slowly. Once they finish growing, they are stubborn substances—resistant to external stimuli, and unwilling to be reconfigured to meet multiple or changing needs.

Prasad’s team hopes to change both of those things. They want to create nanocomposites quickly, and they want these materials to be cooperative, responding to external stimuli such as light, temperature, pH, or electromagnetic fields. The result will be endlessly useful—micron-scale structures that can be reconfigured according to need.

The research team includes Aidong Zhang, chair of UB’s Department of Computer Science and Engineering, and Mark T. Swihart, director of the UB 2020 Strategic Strength in Integrated Nanostructured Systems—one of eight areas of interdisciplinary scholarship in which the university is investing through the UB 2020 strategic plan.

The potential for the kind of material they’re creating is thrilling. By 2023, they could be used to create solar panels whose structures reconfigure themselves according to changes in weather, or medical devices that can diagnose and treat diseases ranging from influenza to cancer.

But 2023 is 10 years away, and with most federal organizations lacking the patience for such long-term research, Prasad found a willing supporter in the United States Air Force, whose Office of Scientific Research (AFOSR) awarded a $2.9 million grant...
to his international research team. The AFOSR’s Hugh Delong serves as the program manager.

To build their nanomaterials, Prasad’s team is using a varied palette of nanoparticles, including gold, silver, and silica. The endlessly varied combinations of materials would be impossible for human hands to test efficiently, so they will turn to high-throughput methods to test hundreds of combinations at once, and data mining techniques to help them make sense of it.

“One of our goals is to contribute to the fundamental understanding of how the spatial arrangement of nanoscale components in materials affects their optical, magnetic, and plasmonic properties,” Prasad says. “The high-throughput techniques and big data approaches we are using were pioneered in the field of bioinformatics, but also have extraordinary promise in the exploration of advanced materials.”

Just as these nanostructures are assembled from disparate types of compounds—natural and synthetic, organic and inorganic—this research effort has come about because of cooperation at various levels. Statewide support has bolstered UB’s science programs, and the cooperation of the Air Force has allowed Prasad and his team to reach out to researchers as far away as Australia for help with this research.

“This project is an example of the enormous research opportunities at the intersection of materials science and informatics,” says Alexander N. Cartwright, vice president for research and economic development at UB. “The scientists leading this project are experts in several different fields, and they are bringing their skills and expertise together to conduct materials research. This kind of collaboration is at the heart of what UB’s New York State Center of Excellence in Informatics strives to achieve—by drawing on the talents of researchers across disciplines, we can pursue advanced and complex research projects.” That’s a goal worth pursuing, even if it takes some time.

“The techniques and big data approaches we are using were pioneered in the field of bioinformatics, but also have extraordinary promise in the exploration of advanced materials.”
It is rising like an emblem of the quest for knowledge, perched on an elevated rock outcropping along St. Nicholas Park in upper Manhattan, its undulating curved glass facade enclosing laboratories, office space, and no less than a new vision for science in New York City.

The $350 million Advanced Science Research Center (ASRC) at The City University of New York, adjacent to CUNY’s City College, is the capstone of CUNY’s “Decade of Science.” Launched in 2005, the initiative has expanded science education and expanded the pipeline of students who graduate and enter the workforce with degrees or backgrounds in science, technology, engineering, and mathematics (STEM) fields, helping to address threats to the nation’s decades-long leadership in cutting-edge research and technology innovation.

In recent years, American students have lagged behind their international peers in science and math proficiency, a trend that saps the nation’s economic strength and, because of the lack of STEM talent at home, has caused American businesses to export hundreds of thousands of jobs. In New York State, there are nearly two open science-related jobs for every unemployed person in the state. Some three-quarters of CUNY’s students remain in New York and enter the local job market after graduation. That gives the university a critical role in the city and state’s economy, another key factor in its commitment to providing students with greater access to STEM programs and opportunities.

“No great university can truly claim to be at the forefront of knowledge unless it takes seriously its involvement with science” says CUNY Interim Chancellor William P. Kelly. The Decade of Science initiative has increased CUNY’s fulltime and parttime faculty in STEM disciplines by 25% since 2006, attracted talented graduate and doctoral students and postdoctoral researchers from around the world, brought hundreds of millions of dollars of investment in new or upgraded science buildings and laboratories, and spurred a near doubling of research funding, to more than $400 million, since 2000. Perhaps most importantly, it has stirred a rebirth of CUNY’s legacy as a university renowned for great science: ten CUNY graduates won Nobel Prizes in science between 1959 and 1988.

“When we designated 2005 to 2015 the ‘Decade of Science’,“ says CUNY Chancellor Emeritus Matthew Goldstein, “our goal was to elevate the importance of science across the University. It was a commitment to the future and a renewal of CUNY’s legacy of world-class science.”

The ASRC is the most visible expression of CUNY’s science push. To be completed in 2014, it is not the usual “here’s some lab space, tell us what you want to study” research facility. It is mission-driven, focusing on five of the most exciting and promising areas of research: nanoscience, photonics, structural biology, neuroscience, and environmental sciences. Though seemingly distinct, the fields intersect in many of the most significant research quests of our time, ranging from treating Alzheimer’s disease (neuroscience and structural biology) to securing the future of the global water supply (nanoscience and environmental sciences), and will enable CUNY to attract researchers working in biology, physics, neurology, and many other scientific fields.

Each of the five areas of focus will occupy a floor of the center and be linked with the others by open floor plans and a central stairway that encourages informal exchanges of ideas. Researchers from the five areas will also work side-by-side in the core facilities, reflecting the ASRC’s goal of breaking down traditional disciplinary walls in science and embedding a culture of collaboration. The ASRC, says Charles J. Vorosmarty, an expert in global water issues who directs the center’s Environmental CrossRoads Initiative, will serve as “an incubation vessel for ideas, for the gee-whiz stuff that we can turn on its ear and apply to the environment.”

Typically, research is siloed and conducted behind lab doors, says Gillian Small, CUNY’s vice
chancellor for research and a driving force behind the ASRC. “The very architecture of the ASRC will facilitate an informal exchange of ideas, with communal break rooms positioned to catch the eyes of passing scientists and entice them in to mingle, ideally fostering collaborations between scientists with divergent expertise but complementary interests.” The ASRC, says Small, will recruit scientists “who appreciate how the most complex problems can’t be solved by any one component alone.”

The ASRC will operate as the nucleus of a University-wide science enterprise. Twenty new researchers, including directors for each of the five initiatives, will form the Center’s core faculty. They will be joined by faculty, students, and postdoctoral fellows from CUNY’s colleges who will use the center’s facilities to advance their work. Unprecedented in scope and concept, the ASRC will be a beacon of science in the public interest, pursuing discoveries that benefit society and inspiring the next generation of scientists, engineers, and technicians.

Led by Vice Chancellor Small, the ASRC will position the nation’s largest urban public university at the vanguard of 21st century scientific exploration and education. It will raise CUNY’s profile as a major American research university, helping it compete for research dollars and science talent, and will be CUNY’s most high-profile effort to encourage young people in the City to pursue STEM educations.

The ASRC will also anchor an emerging research corridor in Upper Manhattan. The neighborhood is already home to the five-year-old CUNY Energy Institute, the new CUNY Hub for Innovation and Entrepreneurship, and a new City College science building that will bookend the ASRC. A block away is the New York Structural Biology Center, a partnership of institutions that includes CUNY. The center will fortify CUNY’s ties with industry, promote entrepreneurial activity, and expand CUNY’s capacity to commercialize its intellectual property, thereby spreading its influence far beyond campus and city boundaries.
As Willa Appel, chief executive officer of the New York Structural Biology Center (NYSBC), shares the story of the city’s first major collaborative life science research center, which opened in 2002, she still marvels at the good fortune that landed the NYSBC at the abandoned South Campus of the City University of New York on Convent Avenue in Harlem. The gymnasium’s lower level, complete with an empty swimming pool sunk deep into the Manhattan schist, turned out to be an ideal site for housing the city’s most advanced nuclear magnetic resonance spectrometers—exquisitely sensitive equipment unable to tolerate the nonstop vibration of millions of New Yorkers and the subways that move them.

The NYSBC—along with dozens of universities, research institutions, nonprofit organizations, and start-ups that comprise New York’s burgeoning science sector—is a true product of the city: wildly ambitious, visionary, and undaunted by the challenges of the island E.B. White called “the greatest human concentrate on earth.”

The major players in New York’s science industry almost universally view what most residents perceive as obstacles—population density, intense competition, and premium real estate—as assets. They’ve succeeded not in spite of, but because of, the city’s singular makeup and layout. The secret behind the success of what has become one of the world’s best funded and most productive multidisciplinary science sectors is the kind of mold-breaking collaboration that is uniquely possible in a place like New York.

Speaking from the new downtown headquarters of the New York Genome Center, Bill Fair, vice president of strategic operations, recalls a time when joining the terms “New York” and “science hub” was more likely to generate questions than answers. As recently as 2002—despite having the most advanced medical infrastructure and largest healthcare workforce in the country—New York City was struggling to attract science talent and the funding dollars that often followed. At the first meeting to discuss what would become the NYSBC, Appel remembers, one participant joked that “the best recruiting tool in New York was a subway token and a bus pass. People weren’t moving here to work in science.”

The town long known as the capital of finance, media, and fashion took a turn toward technology when Mayor Bloomberg zeroed in on life sciences and entrepreneurship as ways to revitalize and diversify the post-9/11 economy. What would transpire over the following decade would vault New York into an elite position among bioscience and technology hubs, uniting the city in a way that would draw the attention of the world.
“When we first proposed the idea of the Structural Biology Center in 1997, nobody believed this kind of collaboration could happen,” says Appel, describing the circumstances that prompted its nine founding institutions to put their competitive concerns aside and form a consortium. Structural biology—the study of the three-dimensional shape of biological macromolecules and how changes in shape can affect their function in both health and disease—was a hot field that required access to highly specialized research equipment no one institution could afford alone.

When we first proposed the idea of the Structural Biology Center in 1997, nobody believed this kind of collaboration could happen.

Pooling their resources, the consortium initially purchased four high-field nuclear magnetic resonance spectrometers at 800 megahertz—the most advanced instrumentation in the field—housing them at the renovated NYSBC facility and alternating access much like a time-share. On opening day, the NYSBC was the most advanced facility of its kind in the country, and it has since added cryoelectron microscopes, synchrotron beamlines for x-ray crystallography, and high throughput protein production facilities. Today, it’s the most advanced structural biology facility in the world.

A new and transformative paradigm for New York’s research institutions and universities was born.

Start-up Engine

At 29th street and the East River, sandwiched between NYU School of Medicine and Bellevue Hospital, is the Alexandria Center for Life Science—the largest biotech campus in New York City and the embodiment of the city’s efforts to bolster commercial development of bioscience breakthroughs.

Announced in 2005 after a competitive bidding process and opened in 2010, the Alexandria Center was founded with a twofold purpose—part one was attracting major biotechnology and pharmaceutical research activity to the city. Inaugural tenants like Kadmon Pharmaceuticals, ImClone Systems, and Pfizer’s Centers for Therapeutic Innovation are conducting translational research on site. Roche recently announced that it will relocate its headquarters—and nearly 200 employees—from New Jersey to the Alexandria Center’s new West Tower, currently under construction.

Alexandria is also home to some of the approximately 30 life science companies born in New York City each year, offering lower cost office and lab facilities and critical networking opportunities. It is one among more than a dozen small business incubators stoking the engines of entrepreneurship.

Making New York City friendlier to technology start-ups, both by tapping the financial and venture capital communities and removing a major operational barrier—costly office space—has unleashed a flood of innovative local businesses unimaginable just five years ago.

In 2009, the New York City Economic Development Corporation (NYCEDC) entered into a partnership with Trinity Real Estate and the Polytechnic Institute of New York University (NYU-Poly), founding the first city-sponsored business incubator at 160 Varick Street. A few hundred dollars a month bought young entrepreneurs desk space, business development mentoring, introductions to the venture capital community, and connections to other entrepreneurs. By 2012, 22 companies had graduated from Varick Street, trailing 300 newly created jobs and $38 million in funding in their wake.

In that same space, the tenants of the New York City Accelerator for a Clean and Renewable Economy (NYC-ACRE) were set to transform New York through wind, solar,
and water. Started by NYU-Poly with seed funding from the New York State Energy Research and Development Authority, NYC-ACRE was created to nurture clean technology and renewable energy companies. From smaller-scale wind turbines to harnessing energy from water distribution facilities to create clean power, NYC-ACRE companies are commercializing technologies for a cleaner urban future. Its nine graduate and 11 current companies have created 115 new jobs and raised $32 million dollars.

Since 2009, the city has expanded its incubator program to house more than 600 start-ups, and recently opened its first incubator in the Bronx. In November 2013, the first city-sponsored biotechnology incubator, Harlem Biospace, will welcome 24 fledgling ventures. The incubator will offer low-cost space in a field where the start-up costs—namely specialized equipment and wet lab space—are at a premium.

Some of the most exciting collisions of innovation and entrepreneurship in the city are in its most populous borough, Brooklyn. Amid the area’s famed brownstone blocks and artisan food shops are the three nodes of the Brooklyn Tech Triangle: The Brooklyn Navy Yard, DUMBO, and Downtown Brooklyn. Ten percent of New York’s start-ups are located in these few square miles, along with 12 universities and colleges. A consortium led by the Downtown Brooklyn Partnership is developing the area to support a projected 18,000 technology jobs by 2015.

One consortium partner, NYU-Poly, has made entrepreneurship an integral part of students’ experience. “We have imbedded the philosophy of entrepreneurship and innovation into our educational culture, from classrooms and labs to our start-up incubators that serve students, faculty, and the New York economy,” says Katepalli R. Sreenivasan, president of NYU-Poly and dean of engineering at New York University.

“Science Alliance teaches the kinds of skills that wouldn’t normally be taught in academic programs.”

Similarly, the Science Alliance program, now in its tenth year at the New York Academy of Sciences, has mentored more than 10,000 early-career scientists, complementing their technical training with “the kinds of skills that wouldn’t normally be taught in academic programs,” says John E. Kelly III, senior vice president and director of research at IBM and a member of the Academy’s Board of Governors. Science Alliance holds regular gatherings and courses, offering real-world lessons in entrepreneurship, interviewing, teaching, and grant writing, pointing young scientists on a path to success.

By 2004, the city was gaining competitive ground, garnering close to $1 billion in National Institutes of Health (NIH) funding. By 2007, New York’s colleges and universities would well surpass that number, leading the nation in NIH funding.

Despite that progress, the city was still home to, what one researcher quipped, “a lot of R, but almost no D.” Pharmaceutical giants like Pfizer had a presence limited to sales in New York City, but the crucial behind-the-scenes work took place in the kind of lab space that seemed unattainable in the five boroughs. Many researchers who made breakthroughs with commercial promise had to weigh the possibility of leaving academia to bring an innovation to market. Finding a solution that would allow them to translate local research into reality would be the next crucial step in New York’s transformation.
"A Complete Cultural Shift"

Private labs were one way to, as Susan L. Solomon says, “leave the politics at the door and take the science as far as the researchers were able to go.” Solomon, who founded the New York Stem Cell Foundation (NYSCF) in 2005 and serves as CEO, saw the potential for New York—with its 50 hospitals and diverse population—to become a leader in stem cell research. “Young researchers were being counseled out of pursuing stem cell work,” she says. “The thinking was that the real work wasn’t happening here.”

With a roster of healthcare luminaries as an advisory board and $1.1 million in private seed funding, Solomon and her team opened a lab in less than 4 months. “There was very exciting diabetes research coming out of Harvard, but too much red tape preventing it from moving forward. We brought the work here, and built the lab faster than the researchers could collect patient samples.”

Since then, NYSCF scientists, including 45 postdocs from New York’s elite research centers, have done “high-risk, high-reward” work, turning out five top medical breakthroughs including the first personalized bone intended for transplant. The organization has also designed software to automate the labor-intensive process of generating stem cell lines, producing a degree of uniformity that is key to advancing therapeutics. “We’ve saved years of time and millions of dollars through the openness of our scientists and partners, who go so far as to share pre-publication work at our conferences,” Solomon says. “It’s a complete cultural shift. At our first meeting, most of the researchers in the room—and they were the best in their fields—had never met each other.”

“We brought the work here, and built the lab faster than the researchers could collect patient samples.”

The shift Solomon notes is evidenced several dozen times a year at the lower Manhattan offices of the New York Academy of Sciences. Jennifer Henry, director of life sciences at the Academy, presides over a program for local scientists that tests—and often breaks—the barriers of convention. “We set out to create a more united community of scientists working in New York—to introduce them to each other before they meet at major conferences,” Henry explains.

For nearly 50 years, scientists from across the region and around the world have convened at the Academy to attend one-off conferences and recurring Discussion Group symposia. Formalized as Frontiers of Science 12 years ago, this program unites academia, industry, nonprofits, and government to discuss progress and challenges in science, medicine, and technology. The Academy hosts over 60 such events each year, each with a different focus. “Everyone is on equal footing at these events,” says Henry. “It’s a neutral environment where people who don’t typically get together can interact in a personal way. It’s also an incredible opportunity for younger scientists to network with major players.”

The Discussion Groups bring sought-after speakers and smaller gatherings of scientists together in New York throughout the year. “Networking is a major benefit, but these groups have become so much more than that,” Henry explains. “The Discussion Groups are now safe spaces where what are, essentially, competing researchers have been known to enlist the group’s feedback on their work in progress. Can you imagine?”

The success of New York’s academic collaborations continues to embolden and inspire new ventures, continually expanding the city’s science capabilities. Manhattan’s foothold in the emerging field of genomics and bioinformatics lies in SoHo at the New York Genome Center. Ten local institutions founded the facility, which operates as an independent nonprofit, to speed advances in genomics and commercialize breakthroughs. Researchers gain access to valuable wet lab space and latest generation sequencing equipment, along with technical support. Demand for the Genome Center’s services—which include full human genome sequencing, bioinformatics analysis, and data storage—has been so high that it had to establish a 3,000 square-foot temporary lab at The Rockefeller University during construction of the new headquarters.

The Genome Center’s founding institutions are reaping more than scientific benefit from their investment. It has been a powerful recruiting
Science on the Streets

Perhaps the most magical manifestations of New York’s efforts to advance science are the ample opportunities for people of all ages to see and touch science in classrooms, cultural institutions, and on the streets.

When Stephen Hawking and Yo-Yo Ma share a stage, robotic fish swim through Brooklyn’s MetroTech Center, and Darwin meets hip-hop in the first peer-reviewed rap performance, it can only be time for the World Science Festival. Each summer since 2008, the Festival, founded by author and Columbia University professor Brian Greene and journalist Tracy Day, has lured close to 1 million New Yorkers to dozens of live events, many of them hands-on, all of them inspiring.

Alongside programs exploring beer brewing—“humankind’s first biotechnology”—and an intimate study of insect music and mating—timed to the emergence of the 17-year Brood II cicadas—are days’ worth of programs aimed at the Festival’s youngest and most important attendees: children.

Sparking a love of science in the next generation is a responsibility that has taken on new importance as studies show U.S. students lagging in science and math. In New York, a host of homegrown programs, along with the city’s museums and schools, are making steady progress to reverse that trend.

This year, the New York Academy of Sciences and the Girl Scouts of America joined with the Clinton Global Initiative, committing to raise $3 million to pilot a program pairing professional scientists with Girl Scouts to provide hands-on science, technology, engineering, and math (STEM) lessons at the middle school level—exactly the age when girls’ participation in science and math tends to decline. The program is an expansion of the Academy’s successful Afterschool STEM Mentoring Program, which serves middle school students in low-resource areas of New York and New Jersey, thanks to a robust partnership with the State University of New York and community-based afterschool programs.

Such supplemental STEM enrichment programs, particularly those aligned with school-based efforts that engage teachers and students, have proven highly effective. The Central Brooklyn Robotics Initiative, pioneered in Brooklyn middle schools, pairs graduate engineering students with public school teachers to create engaging classroom STEM activities. In its first three years, 70% of its 3,200 participating students raised their STEM grades by a half or full grade.
Two of the city’s premier science museums, the American Museum of Natural History (AMNH) and New York Hall of Science collectively host more than a million pairs of exploring young hands each year, drawing school groups and families with programs that are now, more importantly than ever, helping turn curiosity into careers. AMNH’s much-lauded science-enrichment initiative, the Urban Advantage Network, started in New York middle schools and is now serving as a model for schools across the country to partner with local science institutions.

Taking in the many vibrant organizations comprising New York’s current science scene, it’s clear that what began as an experiment among an elite group of New York’s research institutions has spawned a contagious collaboration that has touched every sector of the city, changing it for the better. This drive toward togetherness has inspired members of the scientific community to see the limitless possibilities for invention in this extraordinary city.

Today, the subway token has been replaced by the Metrocard, and much like the transit system that runs beneath them, New York’s science players are more connected than ever. As Appel says, in a sentiment that also characterizes New York itself, “in science, you can’t sit still for half a second.”

Hallie Kapner is a freelance writer in New York City.

Beyond the Bridges

“If you visited 15 years ago, nobody would have been here,” remarks Dean Fuleihan, executive vice president for strategic partnerships at the College for Nanoscale Science and Engineering (CNSE) in Albany. Founded as an affiliate of the State University of New York in 2002 and recently authorized to become an independent entity, CNSE is many things—but underpopulated isn’t one of them. With 3,100 people on site and 140,000 square feet of clean room, the world’s only college devoted to nanoscience operates 24 hours a day, seven days a week doing some of the world’s most advanced semiconductor research and fabrication and revitalizing the manufacturing workforce in the Capital Region.

“If you visited 15 years ago, nobody would have been here.”

For a site engaged in proprietary work with some 300 corporate partners around the world, CNSE is surprisingly, literally, transparent. The clean rooms, home to new techniques that stand to dramatically increase chip efficiency, are surrounded by glass walls. Nothing is hidden to those who visit the facility, whether dozens of middle and high school girls who participate in the college’s five-year STEM enrichment program, or President Obama, who made his first-ever clean room visit shortly after taking office.

This openness is characteristic of the college’s approach to education. “We don’t have traditional departments,” Fuleihan says. “Our students see engineers working with physicists and biologists, and they witness real-world partnerships with industry and the private sector. The end users for the technologies we develop are all here. There’s no better way to learn.”

CNSE students have plenty of opportunities to do just that—in addition to serving as a research testbed for global nanotech leaders including IBM, Intel, GlobalFoundries, Toshiba, and Applied Materials, the college is engaged in its own projects. Among them is the largest Department of Energy grant ever awarded—$57 million over five years to advance the efficiency of solar cells. “You can see why we’re 24/7,” jokes Fuleihan.
CNSE has been touted as a model for other university-driven research enterprises, and the ripple effects can be felt 200 miles away, on Long Island. Inspired by the Albany campus, the founders of the Advanced Energy Research and Technology Center (AERTC), energy executive Robert B. Catell and Yacov Shamash, dean of the College of Engineering and Applied Sciences at Stony Brook University, created a similar partnership to spark innovation in the energy sector.

Several years, $45 million state dollars, and one LEED platinum-certified research facility later, AERTC has marshaled the support of partners including 14 universities; dozens of federal laboratories, such as Long Island-based Brookhaven National Labs; local and national utilities; and telecommunications companies. A leading priority, according to Catell, is educating the public on the importance of improving the country’s energy delivery structure. Catell believes that public education, combined with the development of compelling new energy solutions “starting with generation and moving down to the customer” will transform the industry.

AERTC’s facility fosters energy research including solar, wind, water, and fuel cells, and runs simulations of methods to improve the efficiency and security of the energy grid. It also has a stake in entrepreneurship, through the five companies in its in-house incubator, as well as its participation in Accelerate Long Island (ALI).

Founded in 2011 with a mission to commercialize research and establish an entrepreneurial hub on Long Island, ALI has connected with more than 100 local start-ups in 2013 alone. Together with the region’s universities, research institutions, and the business community, ALI supports entrepreneurs through funding and a free, intensive mentoring program for high-tech start-ups.
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Taking a Translational Approach to ‘Incurable’ Cancers

It’s called “the valley of death,” that gap between an elegant breakthrough in basic science and the arrival of a new therapy based on that breakthrough, and it is where brilliant ideas go to die. But not if the Cancer Therapeutics Initiative (CTI) at Cold Spring Harbor Laboratory (CSHL) has anything to say about it. For years, policy makers, patients, and even many scientists have lamented the disconnect between basic biomedical research, which the United States does superlatively, and the lower-profile work that turns discoveries into therapies. The barriers to such “translational” research aimed at moving discoveries from bench to bedside are legion, and they are why headline-making discoveries seldom become treatments, much less cures.

The goal of the Cancer Therapeutics Initiative is to discover new, non-toxic therapies for currently incurable cancers by designing drugs that will target the genetic mutations that drive a tumor and the pathways by which that mutation exerts its malignant effects. The CTI will do that through what it calls a “vertically integrated” approach—but the MBA-speak doesn’t do justice to how revolutionary the approach is.

In the standard model, molecular biologists might discover, say, a gene required for the survival of leukemic cells. Then, because the discoverers usually don’t have the expertise to design a molecule able to cripple that gene and test it in animal models of leukemia, it is up to many other teams to carry the discovery across the goal line to an FDA-approved drug. With the CTI, research teams will do it all, from rapidly identifying new therapeutic targets to performing the therapeutic development and initial validation required for human trials.

The process starts with the genetic analysis (profiling) of patients’ normal and tumor DNA samples to identify a given tumor’s Achilles heels. But while other labs might make that discovery and call it a day, CTI scientists will then identify and develop molecules with significant activity against these targets. Next, another team will churn out sophisticated mouse models of the particular cancer—that is, mice carrying the same genetic glitch identified in human tumors—on an industrial scale. Finally, researchers will validate in the mice both the targets and the molecules designed to “hit” them, gleaning clues to how cancer patients are likely to respond. The result should be a molecule ready to license to a biotechnology firm or pharmaceutical company for human testing.

This soup-to-nuts approach is a novel adventure in an academic setting. By taking it, CSHL is building a powerful translational engine that will convert academic knowledge about cancer into new targeted treatments. First up: prostate, pancreatic, breast, ovarian, liver, lung, and brain cancers, as well as melanoma and leukemias.

The CTI approach has already shown promise. CSHL’s Christopher Vakoc and colleagues, for instance, used RNA-interference technology developed in the lab of CSHL’s Greg Hannon to discover that a protein called BRD4 drives an acute, usually incurable form of leukemia called AML. Shutting down BRD4, the team confirmed, derailed a cellular process considered the hallmark of AML—the aberrant self-renewal of leukemic stem cells and their failure to mature. Scientists had previously found that a drug called JQ1 hits BRD4, so the CTI team then showed that JQ1 causes remissions of cancer in mice modeling human AML. Now, a variant of JQ1 is in clinical trials.

A single drug against a given form of cancer is unlikely to be sufficient, however. To turn lung cancer, for instance, into a chronically manageable illness rather than a frequently fatal one, therapies will have to anticipate and disable molecular pathways that evolving tumor cells develop to circumvent the first-line treatment, much as insects evolve resistance to pesticides. This will call for the development of combinations of targeted drugs, which will be taken in “cocktails” analogous to the multi-drug combinations...
used so effectively to overcome the resistance that develops in people infected by the HIV-AIDS virus.

The CTI was conceived and is led by CSHL’s President & CEO, the distinguished cancer researcher Bruce Stillman. It also benefits from the insights of James D. Watson, CSHL Chancellor Emeritus, co-discoverer of the double helix structure, and Nobel laureate; and the expertise of David Tuveson, a renowned clinician-scientist and director of the CTI.

“We seek to maximize the impact of what we in academia do best: discover functionally meaningful targets for new cancer therapies based on our deep knowledge of cancer biology,” says Stillman. “The CTI aims to deliver well-validated drug candidates to industry. Industry can then focus on what it does best: optimizing candidate molecules and testing them in cancer patients.”

CSHL envisions collaboration with other research and clinical centers as well as biotech and pharmaceutical companies that can both contribute to and benefit from the vertically integrated CTI pipeline. Collaborators include many New York-based institutions, including Memorial Sloan-Kettering Cancer Center, The Rockefeller University, Stony Brook University, Weill Cornell Medical College, Columbia University Medical Center, NYU Langone Medical Center, and North Shore-LIJ Health System.

New York and Cold Spring Harbor Laboratory, which began as a summer biology camp for city teachers in 1890, have been great partners in biomedical research and education for the last 120-plus years. The lab has been a magnet for the best and brightest biologists and geneticists, attracting more than 12,000 professional scientists from around the world each year to an internationally renowned program of scientific meetings and technical courses.

Proximity to New York City and a harbor-side site on the beautiful North Shore of Long Island makes
Uncovering the Neuroscientific Basis of Human Behavior and Disease

They are among the deepest and most challenging questions in science: how does the finite number of neurons in a human brain produce thoughts and feelings, generate desire and imagination, give rise to consciousness? More prosaically but just as challenging, how does autism arise? What can be done to treat Alzheimer’s or Parkinson’s diseases, depression, schizophrenia, or bipolar disorder?

Neuroscientists have made major strides in exploring the brain and its disorders, from discovering the molecular basis for memory to mapping the circuits involved in a wide range of behaviors. But with so much more to be learned, Columbia University in 2012 launched the Mortimer B. Zuckerman Mind Brain Behavior Institute, a transformational venture in neuroscience that will pursue cutting-edge research to gain deeper insights into human mental functions in both health and disease.

A key goal of the Zuckerman Institute, which will be one of the nation’s largest private academic research institutes dedicated to research on the brain and mind, is understanding the inner workings of the brain and the interplay between mind, brain, and behavior. The functions of the healthy brain are just as mysterious as its malfunctions, and neuroscientists are eager to understand such enigmas as how humans make decisions and how a particular pattern of neural activity becomes the subjective sensory experience of “red” or “sour,” of worry or fear or joy. The brain is the organ of behavior, so in theory every human behavior should be fair game for neuroscience, which means this field, perhaps more than any other in science, has the potential to interact with a broad range of intellectual endeavors.

With that in mind, the Zuckerman Institute will include an innovative mix of scientists and scholars from such fields as structural biology, chemistry, physics, psychology, psychiatry, engineering, law, business, political science, and economics. This interdisciplinary, collaborative approach, combined with the remarkable resources of Columbia University, make this a groundbreaking venture. The University has designed the Zuckerman Institute to link neuroscience with programs in other fields across Columbia, ranging from statistics and mathematics to business and the arts.

One of the Zuckerman Institute’s co-directors, Eric Kandel, says it, “places Columbia in a position to produce a paradigm shift in how brain science is practiced by connecting to the many facets of the academic enterprise that are concerned with mind and behavior, including law, economic decision making, sociology, psychology, and art.”

One has only to scratch the surface of those fields to see that many of the questions they pursue are, fundamentally, about behavior and thus about the organ of behavior. Why is saving money so much less pleasurable for most people than spending it? Why do people see beauty in some works of art and nature, but not others? What is the brain basis for creativity, inspiration, confirmation bias, xenophobia, and the myriads of other products and quirks of the mind? How is it that young children are sponges for language, learning their mother tongue effortlessly? Despite revolutionary advances in our understanding of the brain and its component neurons and circuits, precisely how brain networks do all of this and more is still one of the most poorly understood areas of modern biology.

The Zuckerman Institute will gain a dedicated physical space in 2016; planning for the Jerome L. Greene Science Center, a 450,000 square-foot structure on the University’s new Manhattanville campus in West Harlem is underway. However, the Institute’s work has already begun; it has assembled scholars who possess a record of accomplishment in the brain sciences which is unsurpassed at any other research university.

Its three founding co-directors are Thomas Jessell, the Claire Tow Professor in the Department of
Neuroscience and the Department of Biochemistry and Molecular Biophysics; Richard Axel, University Professor of Biochemistry, Molecular Biophysics and Pathology, who shared the Nobel Prize in Physiology or Medicine in 2004 for his pioneering research on the olfactory system; and Kandel, University Professor, Kavli Professor of Brain Science, director of the Kavli Institute for Brain Science, and a 2000 Nobel laureate for his work on the cellular foundations of learning and memory. Over the next several years, through carefully planned recruitment, the Institute’s core faculty—those based in the Greene Science Center—will grow to 65 members, plus a number of independent junior fellows, visiting scholars, and affiliate faculty who are based at the University’s Morningside, Manhattanville, and Medical Center campuses.

At a forum last year, Zuckerman said, “Eric Kandel is the visionary who convinced me that we stand at the edge of a new era of understanding of the human mind. He explained that for the first time we have the technology to measure extensively the real effects of drugs and treatment on the brain that would dramatically increase our capacity to deal with that very complicated part of our anatomy...Who could not be motivated by the potential benefits to this field of scientific research?”

For more than 250 years, Columbia University has been attracting the best minds to New York in pursuit of the highest quality research, teaching, and public service. With the Zuckerman Institute, Columbia will draw global attention to New York as a center of great neuroscientific innovation, continuing its rich legacy of enriching both the city’s culture and the economy.

“For the first time we have the technology to measure extensively the real effects of drugs and treatment on the brain that would dramatically increase our capacity to deal with that very complicated part of our anatomy.
“To be a leader in the 21st century, you have to be a leader in innovation,” said Seth Pinsky during his tenure as president of the New York City Economic Development Corporation. And, “an important part of innovation is technology.” But New York, a recognized leader in many industries, lacks the engineering and computing talent that other major economic centers have—talent that serves as a critical driver of industry growth and transformation.

Not a city to turn its back on such a problem, the Bloomberg administration instead created an opportunity: In 2010 Applied Sciences NYC was born. The competition invited top institutions from around the world to propose a new or expanded state-of-the-art applied sciences and engineering campus. The city’s offer of land and up to $100 million in capital to help with building and related costs was enough to lure 18 proposals from 27 world-class institutions from six U.S. states and eight countries. In December 2011, we had a winner: the proposal from Cornell University and its academic partner, Technion-Israel Institute of Technology.

Called Cornell NYC Tech, the program of graduate tech education aims to produce leaders who will advance technology and generate cutting-edge research that addresses critical issues, making significant contributions to the New York City community and economy by fusing educational excellence with real-world applications and a focus on commercializing technology rooted in the latest academic research.

Mayor Bloomberg, Qualcomm founder Irwin Jacobs (Cornell class of 1956, who with his wife Joan announced a $133 million gift to Cornell Tech last April), and Google Executive Chairman Eric Schmidt have signed on to provide guidance on the programmatic and physical development of the tech campus. Such guidance is welcome as Cornell Tech builds a new culture of innovation and entrepreneurship that marries technical excellence with real-world impact. Cornell Tech is “a startup inside a university in partnership with government,” says Dean and Vice Provost Dan Huttenlocher.

To this end, Cornell Tech ditches traditional academic departments in favor of interdisciplinary hubs and discipline-based programs that bring together different expertise centered on industries already established in the city.

“Hubs will allow us to focus on generating technology to serve particular industry sectors,” says Lance Collins, the Joseph Silbert Dean of the College of Engineering. “The objective is to yield businesses.” The first hubs are Connective Media, Healthier Life, and the Built Environment. For Healthier Life, think mobile health sensor-enabled smartphones (measure your glucose level while you text), improved electronic medical records, and human-implanted and biomorphic electronic chips.

“This is a singularly inventive graduate community fostering collaboration in an open-office setting with no departmental silos,” says Rajit Manohar, associate dean for academic affairs and professor at Cornell Tech.

The Joan and Irwin Jacobs Technion-Cornell Innovation Institute (JTCII), an academic partnership between Techion and Cornell, is a key component of Cornell Tech. Starting in fall 2014, JTCII will offer a unique two-year Master of Science degree where students will specialize in applied information-based sciences in connective media, earning dual master’s degrees concurrently, one each from Cornell and Technion. Also starting in 2014 is an innovative new MBA from the Johnson School, designed specifically for the tech sector.

Cornell Tech isn’t waiting for its Roosevelt Island campus (opening in 2017) to be finished before enrolling students. Its first “beta” class arrived in January at Cornell Tech’s temporary space in Google’s
New York building to work toward a one-year Master of Engineering program in computer science. Among the projects the students completed with industry partners was a fee-based interface called MOOOH (Massive Open Online Office Hours) intended to improve the dismal completion record of MOOCs (Massive Online Open Courseware), which only 10 percent of enrollees finish, by enabling online interaction with professors.

Another student project, called Adfilter, is a browser extension that lets users choose which Internet ads get through, while one in which students worked with Google engineers uses machine learning to improve severe weather alerts like those that warn residents of an approaching tornado. This fall there are nearly 30 students on the campus, about two-thirds in the computer science MEng program, and the remainder pursuing doctoral studies.

Looking ahead to 2023, Cornell Tech aims to hit several milestones: demonstrating that it is fueling the city’s tech economy, attracting and retaining the brightest faculty, engaging with leading edge businesses, and fostering startups. And by 2043? Up to 2,500 students and nearly 280 faculty members, boosting the city’s full-time engineering students at the graduate and PhD level by 70%—and making New York City a center of the world for applied science and technology.

“Cornell Tech aims to produce leaders who will focus on commercializing technology rooted in the latest academic research.”
Revolutionizing Disease Diagnosis with Multimodal Imaging

A woman finds a lump in her breast. She visits her doctor, who sends her to get a mammogram and biopsy. The diagnosis is an aggressive cancer. Will it respond to treatment? That’s a question mark today, but in the future, multimodal imaging may be able to provide an answer, sparing patients from unnecessary therapy and its harsh side effects. This noninvasive approach may even provide an alternative to biopsy.

Over the last decade, researchers across the country have pushed to make a new standard of multimodal imaging—the combination of elements of MRI and PET scans to provide richer, far more informative results. By combining optical, radioactive, and magnetic imaging techniques, this integrated approach is giving physicians information about a patient that, in the past, might have been hard to come by.

Albert Einstein College of Medicine has long been at the forefront of medical technology, and a recent gift from the EGL Charitable Foundation is allowing them to take multimodal imaging to the next level. Founded in 2012, Einstein’s Integrated Imaging Program (IIP) is making a radical step forward in breast imaging.

“Consider a woman who presents with a breast tumor,” says project co-leader John S. Condeelis. “Right now, using MRI in the conventional way, you can see a tumor but you don’t know whether it’s aggressive or nonaggressive.”

But images produced by the new technology will allow researchers like Condeelis to illuminate tissue across a tremendously wide imaging spectrum, from micrometers to millimeters. At this level of detail, an aggressive tumor and a nonaggressive one will not look the same, allowing a woman’s physician to prescribe the appropriate treatment without resorting to biopsy. Even more incredibly, Condeelis says, it may allow oncologists to know at a glance whether or not a tumor will respond to chemotherapy. This means far greater precision in cancer treatment—and greater precision means happier patients, with far better outcomes.

The IIP is fueled by input from across Einstein, and its benefits will be shared as well: Multimodal imaging will offer researchers and physicians at the College of Medicine unprecedented levels of detail. The Gruss Magnetic Resonance Research Center (MRRC) and the Gruss Lipper Biophotonics Center (GLBC) are already two of the finest imaging centers in the area, and they are about to become even more useful.

“Integrated imaging research is collaborative work by nature, and Einstein’s highly collaborative research environment makes it an ideal setting for such a program,” says Robert H. Singer, co-director of the GLBC, and one of the heads of the IIP.

Research at the GLBC and MRRC covers a wide range of pathologies and fields, including cancer, neurological disorders, liver disease, cardiology, traumatic brain injury, and hematology. The IIP promises to help Einstein’s experts in those fields not just treat diseases and conditions, but better understand them. The breast imaging investigation that is serving as the IIP’s test program is teaching researchers not just how to treat a tumor, but how they form. It is not difficult to imagine the same methodology being applied to tracking plaque build-up in a patient at-risk for heart disease, or monitoring the brain activity of a potential Alzheimer’s sufferer.

“Images obtained through the IIP will reveal—with an astonishing level of detail—how complex diseases get started and progress in the body,” says Singer. “This information will help scientists target the molecular glitches responsible for cancer, diabetes, Alzheimer’s and other major health problems.”

In making the IIP a reality, Singer and Condeelis’ biggest challenge was securing funding for their research—an ever-present difficulty in an era of...
reduced federal support, and strained private pocketbooks. The generosity of the EGL Charitable Foundation, which was founded in 2011 to provide support for outstanding young Israeli scientists, was just the latest in a long line of gifts given to the College of Medicine by the family of Joseph Gruss, a prominent philanthropist who died in 1993. The Gruss Lipper Foundation was responsible for the grants that made the GLBC and MRRC possible.

“We are extremely grateful to the EGL Charitable Foundation for helping us create this vital resource at the College of Medicine,” says Einstein Dean Allen M. Spiegel. “The family’s support has enabled Einstein to emerge as a leader in imaging research, and this latest investment places us among a select group of institutions that offer research scientists and clinicians the tools to bring about significant medical advances.”

At the MRRC, Einstein researchers continue to push the boundaries of what an MRI can do. The latest project? An MRI-guided high-frequency ultrasound system that, when focused on cancers or diseased tissue, heats it, and destroys it—completeing a chain of healing begun when multimodal imaging identified the tumor in the first place.

“Right now, using MRI in the conventional way, you can see a tumor but you don’t know whether it’s aggressive or nonaggressive.”
The year was 1924 and Albert Einstein was desperately in need of funding. And so he did what legions of scientists, emerging and renowned alike, would later do in his footsteps: he turned to philanthropists.

In his case, Einstein wrote a letter to the Rockefeller Foundation. The executive leadership had no guarantees of future breakthroughs from Einstein, but they took a chance on the “unknown scholar”—awarding him $1,000.

“He may be on to something,” John D. Rockefeller said when instructing his top lieutenant to double Einstein’s initial request of $500.

With that gift, comically small by today’s standards, the Rockefeller Foundation not only demonstrated its commitment to Einstein himself, but it solidified its place in the pantheon of powerful philanthropic institutions emerging in New York City at the time—a network fueled by a common desire to foster a better world; a network whose ripple effect would eventually extend well beyond the Big Apple.

This institutional mindset was arguably pioneered by the formation of the Carnegie Corporation of New York, which Andrew Carnegie seeded with $125 million in 1911 and 1912, making it the largest philanthropic trust ever established. Within a decade, the Corporation had begun channeling its resources to the natural and social sciences, part of a great effort to improve “scientific management” in the U.S.

This trend continues today, with foundations and individual philanthropists—whose potential beneficiaries are virtually limitless—placing a premium on furthering science through financial support. According to the most recent national report from the nonprofit Foundation Center, which tracks global philanthropic giving, the health industry was the number one recipient of foundation dollars in 2008, receiving nearly 23% of the pie.

The volume of philanthropic monies awarded today is staggering, and it is only logical that New York, an axis of power, wealth, and creativity—and the birthplace of large-scale philanthropy—remains the epicenter of targeted giving. Based on a list of the top donors in America—who each gave over $1 million—published by The Chronicle of Philanthropy, foundations and individuals in New York State gave close to $1.5 billion in 2012. So far in 2013, the amount from New York-based donors has already exceeded $2.2 billion.

**A Lean-Forward Approach**

Financier Sanford Weill, who endowed the Weill Cornell Medical College with a $250 million gift in 2007, is often near the top of The Chronicle of Philanthropy’s annual list. Continuing to break his own records for philanthropy—his total giving is now approaching $1...
billion—Weill and his wife Joan, and the Weill Family Foundation, gave an additional $100 million to Weill Cornell Medical College in the fall of 2013 to boost the school’s research endeavors.

With New York having become such a hotbed of health and technology-related innovation, Weill says there is no shortage of scientists who are “easy to give money to.”

“What they do is not based on how much money they’re going to make for themselves,” Weill explained recently in his office overlooking Central Park, “but how they’re going to help make the world a better place.”

And in that sentiment, Weill is hardly alone. In equally grand offices across Manhattan, moguls of finance, media, real estate, and investment are recognizing the profound importance, and future potential, of the scientific innovation that is emerging from New York. Like Weill, they are leveraging their great professional success and personal contacts to endow local laboratories, medical centers, and nonprofits with financial support that is unparalleled in science-centered philanthropic circles.

Many are firm believers, and pioneers, in “transformative philanthropy,” a more engaged, lean-forward approach in which donors seek out high-value ROIs while still allowing the scientific innovators to innovate the way they know best.

This new generation of funders, whose names now grace the facades of leading global institutions across New York and beyond, are furthering the health-related causes long championed by proven powerhouses like the Carnegie Corporation and the Rockefeller, Ford, and Alfred P. Sloan Foundations, each established before the Second World War. Together, they have created a robust philanthropic landscape that is quickly propelling New York toward achieving the city’s “ultimate goal,” as vocalized by Mayor Michael Bloomberg in a 2009 speech: “Reclaiming our title as the world’s capital of technological innovation.”

**Giving Back to Science**

It is only logical that Jan Vilcek would feel indebted to the field of science and to the institution that helped him turn his capacity for it into a wildly lucrative career.

After escaping the crushing grips of Czechoslovakian Communism in the mid-1960s, Vilcek, then a pioneering young researcher, was rewarded with a faculty post at New York University's School of Medicine, where he remains today. In the course of his research, Vilcek contributed to the development of Remicade, a blockbuster therapeutic drug that would treat untold multitudes of patients suffering from Crohn's disease, rheumatoid arthritis, and dozens of other inflammatory disorders.

“We expected the royalty income would grow,” Vilcek recently said, “but we had no idea it would become as successful as it actually has.”

And so Vilcek and his wife, Marica, formed the Vilcek Foundation as a way to support the sciences and the arts. And beyond their foundation, they decided to channel a portion of their Remicade earnings to NYU. One gift alone, donated to NYU in 2005, totaled $105 million. The funding has largely promoted basic research, which Vilcek sees as the building blocks of scientific discovery.

“A decade ago it seemed like there was much more going on in the Boston area and in California,” he says of scientific research outside of the five boroughs. But New York, he adds, is rapidly catching up, with charitable giving serving as a core driver of the innovation.

“Philanthropy is really essential, especially in the times we witness today, when government spending is down,” Vilcek notes. “Without philanthropy, there would be complete stagnation.”

Likewise, James (Jim) Simons built his financial career on the back of
science and technology and he, too, saw fit to pay it forward. His hedge fund, Renaissance Technologies, rose to the top of its field by using complex mathematical models to evaluate and execute trades.

"All the sciences have a beauty to them—a well-conceived experiment, a dramatic new finding," even intricate financial algorithms, Simons says. "And I think science needs all the help it can get."

About 20 years ago, Simons and his wife Marilyn formed the Simons Foundation, which focuses its energies on funding basic science and mathematics research. Among his proudest achievements is the foundation’s Autism Research Initiative, which, since 2007, has awarded grants to more than 150 researchers across the globe. Along with a myriad of other programs, the foundation created a novel initiative called Math+X to generate highly competitive challenge grants fostering collaboration between mathematicians and those in science and engineering.

The Simons Foundation is also devoting substantial resources to studying the overall functionality of the human brain and the origin of life.

Asked about his interest in the latter, Simons shrugs and smiles: "It’s interesting! Wouldn’t you like to know?"

"We look at the stars and wonder how this whole thing got here," he says. Indeed, in over a dozen interviews with leaders in business and science philanthropy over the summer of 2013, a common personality trait quickly emerged: visionaries like Simons, and those with names like Appel, Soros, and Allen, appear to possess an unbridled curiosity, which motivates them to channel their money to those capable of answering some of life’s greatest questions and solving some of its most dire challenges.

**Something Greater Than Me**

“When you’re in Wall Street everyone else looks good," Robert Appel likes to joke. "The Wall Street people make good money and if they’re smart they’ll support other things. But in the medical field, if you do good you’re saving somebody or you’re making them better, and that’s a very refreshing approach."

Appel, a private investor and financier at his namesake money management firm, Appel Associates, is a self-described futurist who believes that “technology will make it better for all of us." As Chairman of the Board of Jazz at Lincoln Center, he also sees a direct creative link between the arts and science.

Appel admits that philanthropists might initially support the science and medical fields out of a desire to care for their own families, should the need inevitably arise.

“But what happens is it becomes broader than that," he says, “once you meet these people and you see the work that they’re doing.” Philanthropists, Appel explains, quickly realize the immensity of change that their financial support can create for those well beyond their bloodline.

To that end, Appel was instrumental in raising the funds to build Weill Cornell Medical College’s new Belfer Research Building, which will become a hub, on East 69th Street, for translational research initiatives. He and his wife, Helen, also endowed Weill Cornell Medical College’s Appel Institute for Alzheimer’s Research, as a means to encourage cross-disciplinary research into the study of Alzheimer's disease and other neurodegenerative conditions.

"The things that are going on are extraordinary," Appel says. "And to be involved where extraordinary things are being done by extraordinary people is a very exciting way to spend your life."

**Kickstarting Silicon Alley**

Sanford Weill hates the sight of blood.

But in 1982, the financier and former chief executive and chairman of Citigroup found himself on the board of Cornell University with no time to commute to Ithaca for meetings.

“They had this operation in New York that was just a fair kind of a place,” Weill said of the University’s medical college, “so I figured that might be some fun.”

In 1998, Weill and his wife, Joan, endowed the medical school with a $100 million gift intended to “create the greatest medical complex in the world,” Weill said at the time.
And in a more recent quest to make New York the greatest technological center in the world, Weill helped orchestrate the newly formed partnership between Cornell University and the Technion-Israel Institute of Technology. Their collaboration will form the basis of the revolutionary Cornell Tech campus, set to open on Manhattan’s Roosevelt Island in 2017. The institute, born of a $350 million gift from Atlantic Philanthropies and its founding chairman, Charles Feeney, has been heralded as an NYC-Silicon Valley equalizer, with Mayor Bloomberg comparing it to an “Erie Canal of the 21st Century,” according to Weill.

“The best kind of philanthropy is when you get somebody to make a contribution and they see results…and they give again and again and again and again.”

Weill cites a “can-you-top-this?” attitude that he stresses is integral to philanthropic success. At the foundational level, such a strategy often takes the shape of so-called challenge grants—employed with great success by the Simons Foundation—which seek to inspire others to offer a matching gift.

“...The best kind of philanthropy is when you get somebody to make a contribution and they see results from what they’ve done, and they give again and again and again,” he says. “That’s how institutions get built up.”

Such a phenomenon is evident in the increasing number of business icons investing in the health sciences, from Facebook’s Mark Zuckerberg to retired hedge fund manager Julian Robertson and Carlyle Group co-founder David Rubenstein.

It’s all about “teamwork rather than individual superstars,” Weill explains. “Together, there’s no telling the good we can do.”

The ‘Ground Floor’ of Innovation

If anyone should be given a free pass to use a real estate pun at his leisure, it is Mortimer Zuckerman.

And the real estate and media tycoon does just that when he describes the sheer joy and sense of purpose he derives from giving, which he considers to be “another form of public service.” Zuckerman’s latest such service to make headlines was a $200 million gift to Columbia to endow the Mortimer B. Zuckerman Mind Brain Behavior Institute, which, upon opening in 2016, will become a nerve center for what Zuckerman believes is “the most exciting frontier in medicine.”

The institute sits at a crossroads of pure genius and talent, he says, “...and to be involved on the ground floor—pardon the pun—on something like this, for me, just an opportunity to make a contribution that might have a real consequence.”

“It’s certainly an opportunity to make a lot of medical science come to fruition a lot earlier,” he adds.

But despite Zuckerman’s hope for, and expectation of, a big impact, he explains that patience is a key factor in scalability. “The whole idea is to create a platform initially. It’s not going to be the be-all, end-all of everything,” he says.

An Obligation to Empower

What most people might not know about Carl Icahn is that he could have been a doctor.

His medical school stint may have been short-lived—“I didn’t like it,” Icahn says, bluntly—but his interest in science never left him. He would go on to become an enormously successful investor and today remains the majority shareholder of Icahn Enterprises, the diversified holding company.

Icahn’s strategy throughout his myriad of business and philanthropic endeavors has had one core principle in common: he looks for “secular change” in the industries and opportunities to which he devotes his attention and resources. One of those sectors is genomics, or the study of the human genome.

“The change that’s going on is amazing,” Icahn says of the field. “I wish I were younger so I could really enjoy watching what happens.”
But Icahn is doing all he can while he is still around, having recently endowed a genomics laboratory to Princeton, his alma mater. His financial support extends into other realms, too: the Mount Sinai School of Medicine was recently renamed in his honor based on gifts totaling $200 million, and Icahn has been a staunch supporter of charter schools in New York.

Through it all, he has learned to stay on the sidelines, cautioning that it would be “absurd and presumptuous” for a businessman like himself to tell the science or education experts how to do their jobs.

“Don’t think because you made a lot of money that you’re so damn smart and you can tell these guys what to do,” he says with a laugh. “That’s my advice. Don’t micromanage them.”

He continues: “People who make a lot of money start believing that they’re geniuses. But they’re not. I can attest to that one.”

Similarly, Kenneth Langone, the venture capitalist and financial backer of Home Depot—and chair of NYU Langone Medical Center—knows full well the value of a well-placed investment, and he emphasizes that he does not “believe in managed progress.”

He references Jonas Salk and Albert Bruce Sabin—“two Jewish kids that grew up in New York and New Jersey” and pioneered the first polio vaccines—as a powerful example of how young talent can flourish, and change the world, when uninhibited.

Of Salk and Sabin’s science descendents, Langone adds, “These kids who could be making lots of money as lawyers or in finance are making major sacrifices by going into science. Their treasure is time; mine is money. So I want to give my money to make their time well spent.”

In the same fashion, Daisy Soros, who together with her late husband formed the Paul and Daisy Soros Fellowships for New Americans, calls philanthropy her “raison d’être.” Paul, a shipping innovator, “defected to the U.S. with $17 in his pocket,” Soros says, in explaining their decision to support immigrant graduate students through their fellowship. Soros has been told by past awardees, many of whom have gone on to careers in science and medicine, that the fellowship she started with Paul “has heart.”

It was Soros’ personal eagerness to learn about the latest medical innovations that led her to agree to participate on the board of overseers at Weill Cornell Medical College 20 years ago. But for Soros, who once considered a career in medicine, simple interest in a cause is not enough: “I do my research and I want to understand where the money goes. I don’t want [to] waste money by giving it to organizations that don’t spend it on the people who need it. I believe in due diligence.”

On a more local level, Len Blavatnik, the founder and chairman of holding company Access Industries, places a similar emphasis on creating exposure, and financial support, for the challenges being tackled by young innovators in the New York area. Along with the New York Academy of Sciences, for which he serves as a board governor, his Blavatnik Family Foundation supports the Blavatnik Awards for Young Scientists, which provides monetary awards to scientists under the age of 42 who are performing groundbreaking research in science, engineering, and mathematics.

“Their exceptional discoveries represent our future and our hope for a better world,” Blavatnik says of the work done by emerging researchers—a belief that complements the mission of other Academy-affiliated programs, like The Sackler Institute for Nutrition Science. Generously supported by the Dr. Mortimer D. Sackler Foundation, the institute works to stimulate research in nutrition science, nurturing the next generation of thought leaders in the process.

Dr. Kathe A. Sackler and Mortimer D. A. Sackler, who serve as foundation trustees, recently addressed attendees at an event for The Sackler Institute for Nutrition Science, explaining how they’ve come to realize that nutrition plays a critical role in everything from individual health to political strife. As such, they are committed to playing their own role in mitigating malnutrition and its effects by supporting researchers working to solve major nutrition-related questions and challenges through evidence-based science.
As Carl Icahn says, “Give where your money does the most good.”

Success Breeds Success

To say that Larry Silverstein enjoys a world-class view from his office would be a gross understatement. The Manhattan-based real estate developer sits in a sprawling, glass-walled space on the 38th floor of 7 World Trade Center, a building he built in 2006 after the original structure collapsed following the 9/11 attacks. Silverstein can practically reach out and touch One World Trade Center, his most iconic, and important, creation to date, which soars past his office in a shimmer of shiny blue.

As one of the world’s most influential landlords, it is only fitting that Silverstein has a lofty perch from which to watch over the city of New York, his birthplace, which is currently undergoing what he considers a renaissance of ingenuity. Silverstein can tell you all about Wall Street’s forthcoming rebound and the plum opportunities for real estate development, but he’s just as bullish about science, which, he says, “is at the basis of everything.”

“I believe the city is going to experience enormous growth in the sciences, in research of all kinds, in technology, in creativity, in communications,” Silverstein said over iced coffee in his office recently. “The growth here is phenomenal today, and it’s going to become even more so tomorrow.”

Silverstein is a man with a seemingly endless list of philanthropic pursuits, from NYU’s Real Estate Institute and Medical Center to the United Jewish Appeal. But he grows most animated when talk turns to Cornell Tech and all it will do for the city that buzzes hundreds of feet below.

“What they’re going to create here in New York—wow!” Silverstein remarks. “Powerful, powerful draw, powerful magnet. The sciences, the scientists that will come here to participate in it—phenomenal. Absolutely phenomenal.”

“We put money where the talent is and the scientific talent in New York is staggering.”

Paul L. Joskow, who helms the Alfred P. Sloan Foundation—an organization that has been supporting science for the better part of a century—couldn’t agree more. Sloan gives $75 million annually in support of science, but Joskow says that because New York is home to so many world-class researchers, Sloan spends one out of every five dollars here.

“We put money where the talent is,” says Joskow, “and the scientific talent in New York is staggering.” Recently, Sloan has turned its attentions to the promise and perils of the data avalanche unleashed by information technology and the Internet, partnering with the Moore Foundation in a $7.5 million initiative to turn New York University’s Center for Data Science into a national leader in big data management.

But, perhaps surprisingly, Joskow says it’s New York’s influential role as a cultural center that may hold the most promise for research. “We won’t have a society that adequately funds research until we have a society that fully appreciates researchers.” Sloan acts on this insight by partnering with NYC artistic institutions—from the Metropolitan Opera to the Tribeca Film Festival—to raise the visibility of science and educate the public about the value of research.

“Science deserves a seat at the cultural table,” says Joskow. “New York can give it one.”

Of course a large part of the reason that science is becoming intertwined with New York culture like never before, is the city’s fortunate status as home to many of the world’s most active science-promoting philanthropists and foundations. Close to a century after Albert Einstein received that first auspicious check from the Rockefeller Foundation, it’s fitting that science-related philanthropy is reaching a groundswell moment in and around New York, hand-in-hand with groundbreaking research.

Noah Rosenberg is a journalist and the founder of Narratively.
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In Bosnia, a truck driver was crippled by rheumatoid arthritis. His joints inflamed, he was unable to work, drive, or play with his children. After years of disability and pain, he volunteered for a clinical trial of a vagus nerve stimulator being conducted by a start-up company, SetPoint Medical, Inc. Eight weeks later, his arthritis was in remission, and the man was able to return to work and to resume a normal life as a father for the first time in years.

Kevin J. Tracey, president of the Feinstein Institute for Medical Research and inventor of the vagus nerve stimulator to treat inflammation, traveled to Bosnia to meet the patient and see his remission in person. Tracey returned to the United States hoping that he had witnessed the first clinical results for an entirely new modality to treat inflammation. Devices like the vagus nerve stimulator, termed “bioelectronics,” may offer promise to those who, like the truck driver, have become prisoners to their own immune responses.

“To me, nothing is more fulfilling than meeting a patient who has benefited from a discovery made in the lab,” says Tracey. “This experience—of inventing a treatment and transforming someone’s life for the good—is a stark reminder that successful inventions require more than just the idea; they require solidarity, tenacity, dedication, and time.”

Founded in 1999, the Feinstein Institute for Medical Research is a nonprofit organization that provides a research base for the kind of life-altering scientific innovation Tracey pursues. As part of North Shore-LIJ Health System, the largest integrated healthcare network in New York, the Feinstein Institute is responsible for as many as 2,000 clinical studies at any given time, involving 15,000 patients each year. The president of the Feinstein Institute since 2005, Tracey has helped build the Institute into a leading center for the study of immunology and neuroscience.

After 20 years of targeted research, Tracey understands how the body’s natural response to disease can cause pain, further illness, and—in the case of sepsis, which Tracey has called “the killer within”—even death.

Tracey first discovered the role of the vagus nerve in suppressing inflammation while researching an experimental molecule called CNI-1493, which he hypothesized could be used to stop the swelling in the brain that occurs after a stroke. Tracey and his team found that CNI-1493 stimulated signals in the vagus nerve which traveled from the brain to the major organs and stopped inflammation in the body’s organs.

“The drug was stimulating the vagus nerve and turning the brake on the immune system,” Tracey told Wired earlier this year. “Once we understood that, it was a ‘eureka’ moment. We realized you didn’t need the drugs, you could just manipulate the nerve itself.”

It sounds like science fiction, but the idea has an undeniable elegance. Instead of introducing chemicals, why not electrically stimulate the nerves to produce the anti-inflammatory effect?

Tracey dove into the research of bioelectronics hoping to prove that if the neural signature of a disease can be mapped, the disease can be treated by electrical impulse alone. The treatment for the Bosnian man’s arthritis by SetPoint Medical was the first human trial of this theory, and Tracey is hoping for more, similar, successes.

While such treatment may not be able to rid the body of infectious diseases or cancer, it can help patients cope with their symptoms, and stimulate the immune system to better fight illness. Bioelectronics could have a direct impact on a range of inflammatory diseases—not just arthritis, but asthma, diabetes, and even neuro-psychiatric disorders like Parkinson’s and epilepsy. The field offers stunning opportunities for research across a wide variety of
disciplines, and a recent comment in Nature called for trans-disciplinary cooperation:

“To develop treatment devices in this field, bioengineers designing biocompatible interfaces will need to collaborate with electrical engineers to develop microchips for real-time signal processing; with nanotechnologists to create energy sources; and with neurosurgeons to ensure that these designs can be implanted and connected. Researchers will need to embrace the languages and tools of other fields, and perhaps even dream differently: much of the challenge lies in translating biological understanding into engineering specifications.”

Tracey’s research is being funded by the NIH, DARPA, and GlaxoSmithKline (GSK), which see bioelectronics as an incredible opportunity. The pharmaceutical giant GSK has committed to funding up to 40 researchers in up to 20 labs as the race to map disease-associated neural circuits heats up.

Of course bioelectronics are only one area of focus for Feinstein Institute researchers; they are conducting high-profile research projects in areas such as Parkinson’s disease, genomics, and schizophrenia management, hoping to impact patient’s lives throughout a range of diseases and conditions, as nearby as New York, and as far away as Bosnia.

“This experience –of inventing a treatment and transforming someone’s life for the good– is a stark reminder that successful inventions require more than just the idea; they require solidarity, tenacity, dedication, and time.”

TOP RIGHT: An outside view of The Feinstein Institute for Medical Research.
SECOND RIGHT: Vials line a lab bench at The Feinstein Institute for Medical Research.
THIRD RIGHT: Kevin J. Tracey (left) and a colleague collaborate in the lab.
BOTTOM RIGHT: Kevin J. Tracey (center) with a few of his lab members.
Founded in 1863, just two months before the Battle of Gettysburg in a Second Avenue brownstone, New York City’s Hospital for Special Surgery (HSS) is the oldest orthopedic hospital in the United States. Its first chief surgeon, James A. Knight, was a believer in “expectant treatment,” which recommended clean air, exercise, and sunshine as the best medicine. Although medical techniques have changed with the advent of germ theory, antiseptic surgery, and the advances of 20th century orthopedic science, the hospital that Knight founded remains just as committed to improving the lives of its patients as it was 150 years ago.

HSS is today known as one of the preeminent musculoskeletal hospitals in the world, ranked first in orthopedics and fourth in rheumatology in U.S. News & World Report “Best Hospitals” 2013-14. To continue making strides in the treatment of rheumatoid arthritis (RA) and lupus, this year the hospital has established the David Z. Rosensweig Genomics Research Center, endowed by a $5.6 million grant from The Tow Foundation.

“At HSS, all laboratory research is conducted with the goal of improving outcomes for patients,” says Chief Scientific Officer Steven R. Goldring, Richard L. Menschel Research Chair. “This is the mission of the new Genomics Center as well.”

Although genomics research has implications for many fields of medical research, its effect on autoimmune diseases such as RA and systemic lupus erythematosus has the potential to be truly groundbreaking. There are certain cytokines—tumor necrosis factor and interleukin 6, for instance—which are associated with RA. Better understanding that relationship has already led to dramatic improvement in the treatment of RA. The goal of the Center is to apply the new and powerful technologies of genomics research to identify more effective therapies for the treatment of RA, lupus, and the related disabling rheumatic diseases.

Lionel B. Ivashkiv, director of the Genomics Center and David H. Koch Chair in Arthritis and Tissue Degeneration Research, has been with HSS for 21 years, and has seen remarkable advances in rheumatology research that have led to the development of “cutting edge, state-of-the-art molecular-based therapies.”

“When I was a resident and decided to go into rheumatology,” he said in an interview in April, “people looked at me and said, ‘Why do you want to do that? They don’t understand anything and they can’t even help their patients.’ And I thought it was an opportunity to have an impact. Fifteen years later, there has been a quantum leap in both the understanding of the disease mechanisms and importantly in the development and application of new and effective therapies.”

Few of these new therapies have been as potentially revolutionary as the advances offered by genomic research. Epigenetic and genomic studies have shown that the genetic risk for autoimmune diseases like RA comes from an unlikely source: genetic sequences formerly known as “junk DNA.” The existence of these sequences has been known for decades, but because they do not code for proteins they were assumed to be non-functioning. “It turns out that what they do is regulate how genes are expressed, and they also mediate the response to environmental cues,” says Ivashkiv. “And the big surprise is that they are linked to diseases. So that the state-of-the-art understanding is that genetic susceptibility to diseases, including autoimmune diseases, is linked more to these regulatory regions... rather than to the traditional genes themselves.”

Scientists in Ivashkiv’s lab have discovered new mechanisms that regulate autoimmune-associated genes and identified new genes that encode “non-coding RNAs,” which he hopes to use to develop very specific therapies designed to treat the inflammation that makes life with RA so difficult. Today, patients
are prescribed drugs on a trial-and-error basis, testing one after the other in a painful, and often expensive, process. Ivashkiv predicts that in the next decade, improved therapies and so-called personalized medicine will eliminate that guesswork.

“We’d like to be able to select the best drug right from the get-go,” he says.

The David Z. Rosensweig Genomics Center at HSS was first proposed because of the sheer complexity of genomic research, which by its very nature requires an interdisciplinary approach. HSS is an associate founding member of the New York Genome Center (NYGC), where it will share research and resources with other local institutions. Partnership with the NYGC and the Advanced Bioinformatics Core at Weill Cornell Medical College will enable genomics research at HSS.

For all those institutions involved in the NYGC, personalized medicine is one of the chief goals. If the NYGC, with significant contributions from the new HSS Genomics Center, can help make personalized medical treatment routine, it could have life-changing effects, not just for sufferers of RA and lupus, but for sick people everywhere.

“That is a very complex undertaking,” says Ivashkiv, “but we think that would also have a very big impact on improving patients’ lives.”

“The big surprise is that [so-called ‘junk DNA’] is really linked to diseases.”
Ever since Scottish physician John Hunter performed the first modern cancer surgery in the 1760s, followed by the first radiation therapy for cancer in 1896 (by Emil Grubbe in Chicago), and the first chemotherapy (by Sidney Farber in Boston) in 1947, cancer treatments have been grounded in the familiar trio of slash, burn, and poison—surgery, radiation, and chemo. The fact that the treatments often leave patients disfigured or make them violently ill is only one reason they are considered unsatisfactory by many in the medical community. Infinitely worse is that they often fail to work: in 2013, projects the American Cancer Society, 580,350 Americans will die of cancer (almost 1,600 a day). And the chance of surviving metastatic cancer is hardly better in 2013 than it was half a century ago.

At Memorial Sloan-Kettering Cancer Center (MSKCC), researchers are convinced there’s a better way, one that lies in the body’s immune system. And although the 40-year “war on cancer” has become notorious for curing millions of mice while struggling for breakthroughs that help people, the approach pioneered by the MSKCC team has already kept alive patients who should, by all rights, have lost their battle.

The new form of therapy, designed by MSKCC’s Michel Sadelain and Renier Brentjens, genetically engineers white blood cells (specifically, a type called T cells), key players in the immune system. Despite their comic-book reputation for hunting down and killing any invaders, in fact T cells are able to find and attack only invaders they have been trained to recognize as foreign. Unfortunately, T cells have not learned to identify malignant cells as foreign invaders; most look like any other cell of the body. The scientists therefore trained T cells to recognize, make a beeline for, and destroy often-deadly leukemia cells.

Genetic engineering, of course, simply means inserting foreign DNA into a cell in such a way that the cells carries out the instructions, even though the orders come from a different individual or even a different species. In this case, the foreign gene is actually a Rube Goldberg-ian assemblage called a chimeric antigen receptor, or CAR. “Chimeric” refers to the fact that the molecule has several parts: one part trains the T cells to recognize homing beacons (antigens) called CD19 on leukemic cells—notably, those in B cell chronic lymphocytic leukemia (CLL), acute B cell lymphoblastic leukemia (B-ALL), and most B cell non-Hodgkin lymphomas. The second part of the chimera instructs T cells to kill any such cells they find. The third makes T cells survive longer than usual, allowing them to stay on the battlefield.

After a decade of research, the MSKCC scientists began translating their approach to people. In their first two clinical trials, they tried the engineered T cells in patients with CLL and relapsed B-ALL; the latter often proves resistant to chemotherapy and can kill in mere weeks. Current treatments are effective in only 30% or fewer of adult cases of B-ALL, says Sadelain. But “the T cells are living drugs, taken from a patient’s own cells,” he says. “They see the CD19, they kill the cancer cells, and they persist in the body.”

In the clinical trial of five patients with ALL (ranging in age from 23 to 66), leukemia became undetectable in four of them in 18 to 59 days. It was evidence that CAR-modified T cells are a potentially very powerful tool against B cell cancers, with life-saving potential.

CAR-engineered T cells might also be unleashed against solid tumors, which are responsible for the overwhelming majority of cancer deaths. Here, the idea is to genetically engineer a patient’s T cells to make receptors specific to the antigens on those tumor cells—if not CD19, then another antigen. The researchers are currently gearing up for clinical studies in mesothelioma, lung, breast, prostate, and ovarian cancers. CAR technologies could become a new pillar of oncology treatment for hematologic and solid cancers.

Genetic Engineering: Firing Up the Body’s Attack on Cancer Cells
MSKCC was a leader in immune therapies for cancer even before the CAR work. Ipilimumab, a treatment for metastatic melanoma that is marketed by Bristol-Myers Squibb as Yervoy, was developed at MSKCC and the clinical trials that led to its approval were led by Jedd Wolchok. The drug targets a protein called CTLA-4, which plays a role in preventing the immune system from attacking the body’s own tissues. By blocking CTLA-4, Yervoy helps the immune system recognize cancer cells as the enemy and was the first drug to improve overall survival for patients with metastatic melanoma.

Neither the CAR nor the Yervoy successes would have been possible without the unsung heroes of cancer research, those whose names never appear on a grant proposal or journal paper: patients who volunteer for clinical trials. New York City and the tri-state area provide a significant population of highly motivated patients willing to enroll in such trials.

Being in New York also allowed the projects to tap into the city’s incredible pool of philanthropists. Indeed, although the science of CAR and cancer immunotherapy in general is extremely challenging, the greatest hurdle was getting the research funded. In a time of dwindling federal spending on science, philanthropy provided a critical lifeline. This treatment is still experimental and requires further testing, which means additional, larger, and therefore costly clinical studies. “We hope,” Sadelain says, “these new cell therapies are poised to take their place alongside surgery, radiation, and chemotherapy as standards of cancer care in the next decade.”
On an inner city Johannesburg street, a new mother’s cell phone registers a text message. It reminds her to breastfeed her baby, and to give him antiretroviral syrup daily to reduce his risk of contracting HIV.

At a rural school in Kenya, the lights are on. It’s no small feat considering the scarcity of fuel, and the fact that most residents can’t afford to buy it. The school, along with a neighboring maternity clinic, runs on dung power—something that’s never in short supply.

Half a continent apart, the new mom and the school are connected by a thread that runs to the other side of the globe, to the place where the programs that are improving—and even saving—lives are created and supported: New York.

New York has rightfully been called the meeting place of the world—the United Nations alone justifies the title—but it is not only a city where people gather. It’s one of the greatest launching-off points in the world, home to dozens of nonprofits, universities, and foundations that export ideas, technologies, business practices, and innovative health measures to places as far as Madagascar and as close as Queens.

At any moment, tens of thousands of New Yorkers are addressing some of the most vexing issues around the globe. By leveraging the most developed medical infrastructure in the country, 110 local colleges and universities, and a highly developed network of donors, local citizens are creating synergies and implementing programs to improve health, strengthen cities, and expand education, globally.

Such is New York’s legacy as a truly global city; from the early, and continuing, contributions of immigrants and local foundations in shaping the city’s major industries, to the present, when its Mayor, Michael Bloomberg, is asked to chair a council of 40 cities interested in sharing best practices for sustainability, and its resident science academy—the New York Academy of Sciences—is asked by the President of Russia, the Prime Minister of Malaysia, and the Mayors of Barcelona and Mexico City to share wisdom around science and policy.

1,000 Days and Counting
For organizations engaged in solving global health problems, the clock is ticking. With fewer than 1,000 days left to achieve the United Nations’ Millennium Development Goals, many local institutions are turning up the heat on what has already been considerable progress. These days, New York isn’t known as a hotbed of tuberculosis (TB). Following an outbreak in the 1990s, local TB rates have been in steady decline. Yet in 2000, when global health stakeholders gathered in Cape Town to found a new organization dedicated to making treatment breakthroughs for a disease that takes a life every 25 seconds, the
A wonderful drug that’s too expensive for the developing world doesn’t do much good sitting on the shelf.

The Alliance currently has three drug candidates in clinical development and is awaiting results of Phase III clinical trials of a promising new multi-drug regimen.

“We’re bringing innovation to a field that’s been stagnant,” says TB Alliance CEO Mel Spigelman. “It’s possible in part because of our access to the incredible human capital in this area—the people, the intellect, the proximity to the pharma companies and the research groups. This couldn’t happen in Washington.”

What’s happening in Brooklyn—or more specifically, the Brooklyn Army Terminal—may change the world. The Terminal is the site of the International AIDS Vaccine Initiative’s (IAVI) AIDS Vaccine Design and Development Lab, a place where research outcomes from around the world are analyzed in the quest to design an effective, affordable vaccine for HIV.

Through partnerships with dozens of academic, pharmaceutical, and governmental institutions in 25 countries, IAVI is among the world’s leading forces advancing the ultimate solution in HIV prevention. Filling gaps in the drug discovery and development process, IAVI directs clinical trials and community engagement efforts in countries hardest hit by HIV/AIDS, as well as funds high-risk and proof-of-concept work of promising early-stage technologies.

In the late 1980s and early 1990s, New York City was the epicenter of the AIDS epidemic. More than 150 years before that, it was established as a major commercial center, a status that remains true to this day. Joining the two, and harnessing the power of the business community to impact the course of diseases like AIDS, is the work of the Global Business Coalition on Health (GBCHealth).

Since its founding in 2001 by former U.S. Ambassador to the United Nations Richard Holbrooke, GBCHealth has amassed a coalition of 200 companies in a mission to apply business practices to solve major global health threats. What started as a response to AIDS now includes campaigns against malaria, tuberculosis, and non-communicable illnesses including diabetes, cardiovascular disease, and cancer.

“There’s a public-private partnership behind most successful global health efforts, and every industry has a core expertise to apply,” says Eve Heyn, communications manager for GBCHealth. “In addition to the United Nations, New York also offers us the research and educational...
institutions to help our partners understand what’s needed, and the marketing and media firms who can help spread messages about medical compliance, sleeping under a net, or using condoms."

GBCHhealth in action looks like this: A declaration from 40 CEOs of major companies—Levi Strauss & Co., which spearheaded the campaign with UNAIDS, along with Kenneth Cole Productions, The Coca-Cola Company, The National Basketball Association, Thomson Reuters, and others—demanding that 45 countries lift arcane travel restrictions on those living with HIV. It provides support and promotion of innovative partnerships like the Mobile Alliance for Maternal Action (MAMA), which uses text messaging to deliver critical health information to pregnant women and new mothers in developing countries and underserved areas.

“Business skills are readily applied to global health,” says Heyn. “Have you noticed you can find a Coke anywhere in the world? The same isn’t true with TB medicines. Coca-Cola is the master of the supply chain, and they’re working with African governments to improve drug delivery.” Similar private sector efforts by GBCHhealth and its partners aim to save the lives of 4.4 million children and 200,000 mothers before the Millennium Development Goals clock winds down to zero.

Urban Testbed
More than half of the 7 billion people on Earth live in urban environments—a first in human history. As one of the world’s largest metropolitan areas, New York is the ultimate urban testbed for the engineers, ecologists, urban planners, and environmental health specialists developing solutions to strengthen the world’s cities.

When Edwin Torres, associate director of the Rockefeller Foundation, talks about Jamaica Bay, he doesn’t sugar coat matters. “It was basically a dumping ground for New York City for about a century,” he told a group at the Municipal Arts Society Summit for New York in 2012. Torres, who runs the Foundation’s NYC Opportunities Fund, is among those involved in a first-of-its-kind initiative to rehabilitate a damaged urban ecosystem, taking notes for the rest of the world’s coastal cities along the way.

“Solutions developed here will be shared for global gain.”

The Rockefeller Foundation is one of the founding supporters of the recently announced Science and Resilience Institute in Jamaica Bay, the 10,000-acre wetland estuary that touches parts of Brooklyn, Queens, and Long Island. The storm surge during Hurricane Sandy devastated both the natural environment and the densely populated neighborhoods surrounding the bay, highlighting the vulnerability of coastal cities as climate volatility increases. The Institute will ultimately serve as a hub for research on making cities more resilient—able to survive, adapt, and grow amid climate and population stress. “Eighty percent of the world’s coastal cities are on estuaries,” Torres says, mentioning some of the more populous places on the planet, like Mumbai, Tianjin, and Lagos. “Solutions developed here will be shared for global gain.”

Flooding is only one subject tackled by Upmanu Lall and his colleagues at the Columbia Water Center, one of the 30 research centers that comprise Columbia University’s Earth Institute. Powered by more than 850 scientists pursuing a sustainable future, the Institute’s global programs address poverty, health, energy, climate change, and, of course, water.

Founded in 2008, the Center’s approach “inverted the way people view water,” says Lall, the Water Center’s director and a professor of engineering at Columbia University. “Many water projects fail because people don’t look at the entire chain. If you can secure the resource itself and its quality, then you can impact access—not the other way around.” The shift in strategy has served the Water Center, and millions of people on four continents, well. Its engineers and scientists have taken on some of the world’s toughest water-related challenges, navigating fierce politics and life-or-death resource issues. They have achieved measurable, positive outcomes in a field often marked by failure.
In the Brazilian state of Ceará, a place Lall calls “the poster child for drought,” an advanced system of climate forecasting has helped stabilize a tug of war over water that put the region’s farmers at contentious odds with urban dwellers and the government. The Center designed algorithms for predicting rainfall and river flow levels, allowing the government to plan water allocation accordingly and helping subsistence farmers determine when—and if—conditions would be favorable for planting. Likewise, in India, where groundwater depletion from agriculture is so severe that no city gets more than a few hours per day of water flow, the Center devised a strategy to preserve farmers’ staple crops while dramatically decreasing water and energy usage. Working with local scientists, Water Center staff deployed soil moisture sensors at farms throughout the Punjab region. The results were significant—a 22% water and 24% energy savings. A project that began with 525 farms has more than quadrupled today.

Closer to home, the Water Center is training its expertise on New York’s water needs, conducting an in-depth study of the history of drought in the Upper Delaware River Basin. The team is eying the possible impacts of a series of droughts on the Northeast. “We’re trying to determine how much water New York City really needs, and how we should be managing supply today based on what we’re learning about the past,” says Lall.

A Global College Town
Forty miles south of Seoul, South Korea, is the Songdo International Business District in the Incheon Free Economic Zone. A “smart city” conceived and built by the Korean government, it is high-tech, sustainable, and designed to incorporate signature features of cities around the world. It’s also the site of the only outpost of an American university in Korea, SUNY Korea.

“Songdo is considered the global education city in the region,” says Samuel Stanley, president of the State University of New York at Stony Brook. “The innovative idea the Korean government had was to invite foreign universities to set up programs in their areas of excellence. In our case, it’s been more than just a program.”

SUNY has transported its nationally recognized expertise in computer science and engineering to SUNY Korea, with 84 graduate and undergraduate students—mostly in these two fields—enrolled for the spring 2013 semester. SUNY Korea is also home to a branch of the university’s Center of Excellence in Wireless and Information Technology, conducting state-of-the-art research at what Stanley attests is an equally advanced facility in Songdo. Students spend two years in Korea and one at SUNY’s home campus on Long Island. The first class from Korea will arrive on campus in fall of 2013.

If SUNY’s other campuses abroad will serve as level-setters for Korea, the outcomes will be impressive. Among other international centers, SUNY runs the Turkana Basin Institute in Kenya, home to Richard, Maeve, and Louise Leakey. Working alongside the renowned paleontologists and anthropologists—whose findings include such landmark discoveries as identifying new species of our own genus—are a team of environmental scientists applying new solar and wind technologies to solve local energy issues. The dung-powered school in Kenya is one of several facilities benefiting from the work of SUNY scientists to improve the energy applications of biogas generators.

New York’s university network abroad stretches from Africa, the cradle of human civilization, to the “cradle of modern Western society,” as David McLaughlin, provost of New York University, refers to the Middle East when he discusses the importance of having a presence in the region. NYU Abu-Dhabi (NYUAD) opened its doors in 2008, and has grown from a study abroad site into a full-fledged member of the NYU network of research campuses. The inaugural undergraduate class of students from 39 countries has given way to a spectacularly diverse student body hailing from 100 countries, and both the campus and its population are set to grow quickly in the coming years.

The advantages of expanding NYU’s presence abroad are numerous, according to McLaughlin. “We certainly think New York is the greatest city in the world, but not everyone of talent wants to travel here,” he says. “By having these campuses, we are able to recruit outstanding faculty and students who might otherwise have never been a part of our university.”

It also creates possibilities for collaborative research that couldn’t happen on anything less than a global scale. The Center for Global Sea Level Change, a joint project between NYUAD and NYU’s Courant Institute in New York, aims to produce quantitative estimates of future sea-level changes, combining the physical theory capabilities of Courant with observational data and new modeling techniques pioneered in Abu Dhabi. The multidisciplinary Neuroscience of Language Lab, straddling two major world cities where many languages are spoken, investigates the neural basis of language use and production.

This year also marks another major expansion in the NYU network—campuses in Shanghai, China, and Sydney, Australia.

The Grand Challenges
A synergy between New York and Qatar is yielding something more than results on paper—it’s creating doctors. New York’s Weill Cornell Medical College, which has a full campus in the state, taught the first students to ever attend medical school in Qatar in 2002. The initial class of 22 students and eight faculty members, housed temporarily at a
The Academy has similarly partnered with Malaysia, after being asked by the country’s Prime Minister to help form the country’s Global Science and Innovation Advisory Council (GSIAC) to bring best practices from around the globe to bear on Malaysia’s economic growth and sustainability efforts—with many of the meetings taking place at the Academy’s headquarters in New York City. The Academy, along with its GSIAC partners, made a series of recommendations to advance Malaysia’s goal of becoming a high-income country. One of the more exciting elements for Academy CEO Rubinstein is a program to boost science, technology, engineering, and math (STEM) education in Malaysia, modeled on the Academy’s own successful Afterschool STEM Mentoring Program.

“We’re going to improve the pipeline of kids going into STEM in Malaysia, and we’re starting similar programs in other countries, including Spain, thanks to Barcelona’s forward-looking Mayor” says Rubinstein. “What’s great is that we’ll be able to connect exceptional students from around the world, and ultimately bring them together for workshops here in New York.”

“The major global challenges facing our world today will require a global response.”

Another way the students will be connected—not only to each other but to Nobel laureates, working scientists, and teachers worldwide—is through seamless telepresence technology, provided through a generous new gift from Cisco Systems Inc. By bolstering local resources and talent, and then connecting them with other local resources around the globe, the Academy and its partners are creating a Global STEM Alliance that seeks to extend STEM excitement and engagement to the next generation.

The outcomes of such outreach—from New York to points all over the globe, and back again—strengthen both New York’s science community and those abroad. As Rubinstein says, “The major global challenges facing our world today will require a global response. We will not solve the problems of malnutrition or energy sustainability or chronic disease in isolation—we will solve them together, with science and technology as our common language.”

Rubinstein and a team from the Academy will continue to advise QF on creating partnerships and implementing programs to address the Challenges.

Doha high school while the medical school facility was constructed, has grown to 265 students from 30 countries today. And while the curriculum is identical to that of the Weill Cornell Medical College in New York—even down to the exams—the faculty and students in Doha are engaged in a suite of projects all their own, including original research on genetic disorders and stem cells, and a high school engagement program to build enthusiasm for a new generation of native physicians.

In 2011, the government of Qatar made a commitment to advancing sustainability and establishing the State as a center for research and development. There was only one problem—they had neither the local expertise nor the capacity to identify the actions needed to achieve these goals. Enter the New York Academy of Sciences. With members spanning the globe, the Academy has considerable reach, along with a history of assisting international leaders in identifying science and technology priorities.

In cooperation with the Qatar Foundation for Education, Science and Community Development (QF), the Academy facilitated communication between stakeholders across multiple sectors in Qatar, ultimately arriving at six Grand Challenges spanning secure and sustainable natural resources, healthcare, information and computing technology, human capacity development, and urbanization. “When Qatar turns to New York for guidance, it signals something interesting,” says Academy President and CEO Ellis Rubinstein. “We don’t have all the answers, but this is the best international city to pull the right people together to address big challenges.”

Rubinstein and a team from the Academy will continue to advise QF on creating partnerships and implementing programs to address the Challenges.

Hallie Kapner is a freelance writer in New York City.
is proud to partner with the New York Academy of Sciences and participate in the 10th Annual Gala. The Institute values its collaboration with the Academy on the Ross Prize and looks forward to next year’s Ross Prize ceremony, which will be held in the summer at the Academy.
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Tailoring Treatment with Big Data

Last year, the Icahn School of Medicine at Mount Sinai introduced the world to Minerva, a supercomputer which is among the most powerful at academic medical centers in the country. Named for the Roman goddess of wisdom, Minerva is designed to bring order to the ever-expanding “digital universe,” and to make use of one of the most striking technological developments of recent years—big data.

Minerva’s data of choice are genome samples, massively complex data sets which can be as large as 1 terabyte for a single patient. Minerva has access to such samples through Mount Sinai’s BioMe Biobank Program, a clinical care cohort of 27,000 Mount Sinai patients who volunteered to share their genomic sequences and electronic health records for groundbreaking research.

Eric Schadt, chair of genetics and genomic sciences and the Jean C. and James W. Crystal Professor of Genomics at the Icahn School of Medicine hopes that Minerva will be able to see patterns in those genomes that lesser computers cannot—patterns like which patients are likely to develop cancer, heart disease, or Alzheimer’s. Identify the patterns, and it becomes possible to stop a disease before it starts—an idea so revolutionary it would not be a stretch to call it the holy grail of 21st century medicine.

“We analyze big data from multiple levels—or scales—to build predictive models that offer novel insights on disease, and we apply these models in a clinical setting to improve diagnosis and treatment for our patients,” says Schadt, also the director of the Icahn Institute of Genomics and Multiscale Biology at Mount Sinai. “In the same way that sophisticated predictive mathematical models drive decision making in the global financial markets [what stocks to buy, how long to hold, when to sell], medicine has begun to rely on such models to derive meaning from vast amounts of patient data, with the goal of better understanding and treating human disease.”

Using big data to achieve small-scale results, specific to each patient, is at the heart of precision medicine. Carlos Cordon-Cardo, Irene Heinz Given and John LaPorte Given Professor and chair of the Department of Pathology, says the aim of this movement is “to switch from group-management approaches—ones that stratify patients into disease categories and apply therapies based on pre-determined protocols—to an approach that uses patient-specific clinical and biological characteristics to predict treatment efficacy and drug sensitivity.”

To this end, Mount Sinai has launched a new initiative, called PRECISE Medical Diagnostics™, or PRECISE MD™, designed to advance the field of systems pathology. The goal, says Cordon-Cardo, who is also professor, Department of Genetics and Genomic Sciences, at the Icahn School of Medicine, is “to translate data into knowledge, and use such knowledge to render more effective and efficient patient care and health management.”

But medicine cannot become fully precise until the sort of genomic sequencing that Minerva relies on becomes widespread. After all, a physician can’t use a patient’s genome to make predictions about his future health if his genome has never been sequenced. Whole genome sequencing is currently too expensive to be routine—costing between $5,000 and $10,000, and rarely covered by insurance—but the technology, Schadt says, “is becoming more comprehensive and less expensive.”

This is partly due to the work of non-profit organizations like the New York Genome Center, of which Mount Sinai is a founding partner. An independent research facility dedicated to making genome sequencing more affordable and more common, it is a joint partnership between a number of New York medical institutions—including the Albert Einstein College of Medicine, Columbia University, and The Rockefeller University. It is these kinds of organizations that led Dennis S. Charney, Anne and Joel Ehrenkranz Dean,
Icahn School of Medicine at Mount Sinai, and president for academic affairs at the Mount Sinai Health System, to predict that New York will become “the Silicon Valley of the east coast, certainly in terms of innovation in biomedical research and health information technology.”

Mount Sinai alone has invested more than $100 million in multi-scale biology, confident that the eventual savings from precision medicine will more than make up for the cost.

“In light of the current healthcare crisis, and with federal research funding facing dramatic cuts, academic medical centers need to invest in big data and its infrastructure,” says Charney. “While costly up front, investing in big data will provide significant long-term return because it will help us better prevent, diagnose, and tailor treatment for disease, which will reduce the cost burden on health systems and the nation as a whole.”

Schadt is dreaming of a day when, as he puts it, “the practice of medicine will be so personalized that physicians will be able to pinpoint what disrupted the network that caused a person’s disease, predict the course of the disease, and determine how best to treat or even prevent it.”

In some cases, it may be possible to deliver a cure before a disease even strikes—a feat truly worthy of a Roman goddess.

“In the same way that sophisticated predictive mathematical models drive decision making in the global financial markets, medicine has begun to rely on such models to derive meaning from vast amounts of patient data.”
Each day, content on Facebook wins 2.7 billion comments and likes. By 2016, it's projected that worldwide e-commerce transactions will top $326 billion. Those staggering numbers represent just a fraction of the recent explosion of digital information. It is an incredible jump, and it has challenged businesses, governments, and universities to innovate as never before.

To meet this challenge, New York University (NYU) has launched a series of initiatives dedicated to providing students, faculty, and researchers with the tools necessary to dominate this rapidly expanding field. The university seeks to ensure that New York remains a center of data innovation not just for the next few years, but for decades to come.

In February 2013, NYU announced the formation of the Center For Data Science, a new program that will offer a two-year master’s program designed to teach graduates to use automated methods to grapple with massive data sets—and to profit from what that data teaches them. Although data science has an incredible array of everyday applications—from building smarter parking meters to making fire departments more efficient—the Center’s director, Yann LeCun, believes the field holds the key to accelerating scientific discovery and innovation.

“By making better use of the enormous amount of readily available data,” he says, “we will be better equipped to address a range of vital questions: How does the brain work? How can we build intelligent machines? What is the structure of the universe? How do we find cures for diseases? How can we predict human behavior?”

Although the Center for Data Science, which is also planning to offer a doctorate in the field, will include faculty from the Courant Institute of Mathematical Sciences, the Center is a pan-university enterprise involving numerous schools, including the Polytechnic Institute of NYU (NYU-Poly). Nearly every one of the school’s colleges, including the Stern School of Business and the Steinhardt School of Culture, Education, and Human Development, have faculty working in the field of data science.

It’s clear that data science is having a moment. In 2012, the Obama administration organized a cross-government big data initiative, which aims to make government more efficient in areas as varied as national security, engineering, healthcare, and education. And data science is invaluable to tech companies across the country, from IBM to Etsy. “Enter the data scientist,” wrote the tech news website BetaBeat in February 2013, “which suddenly every startup simply must have.”

Despite the field’s importance, a 2011 study estimated that the United States is facing a shortfall of as many as 190,000 qualified data science experts, and 1.5 million managers and analysts who are familiar with the field. Where there is an employment shortfall, there is an opportunity for graduates, for a university, and for a city like New York, which hopes to become what LeCun called “a data science mecca.”

The Center for Urban Science and Progress (CUSP) was created in 2012 as a historic partnership of NYU, NYU-Poly, New York City, and additional academic and industrial partners to make cities around the world more efficient, livable, equitable, and resilient. CUSP aims to be the leading authority in the emerging field of urban informatics—the collection, integration, management, and analysis of data to improve urban systems and quality of life. The eventual home for CUSP will be in downtown Brooklyn, where NYU will take abandoned Metropolitan Transportation Authority headquarters and transform it into a hub for research, experimentation, prototyping, and incubation of ideas and companies. Until its new home is ready in 2017, CUSP is occupying 26,000 square feet of office space, including two massive “visualization labs” where researchers are testing theories and developing models to help cities overcome crowding, energy efficiency, and crumbling infrastructure.
“Data science is becoming a necessary tool to answer some of the big scientific questions and technological challenges of our times,” says Gerard Ben Arous, director of the Courant Institute.

The one-year program aims to shape its students into the next generation of scientists who will understand urban data sources and how to manipulate and integrate large, diverse datasets. “Data science is becoming a necessary tool to answer some of the big scientific questions and technological challenges of our times,” says Gerard Ben Arous, director of the Courant Institute.

Whether at CUSP or the Center for Data Science, the goal is to build multi-disciplinary platforms for scholars working across numerous fields, from engineering and computer science to education and business. Over 500 tech startups are located in and around downtown Brooklyn, the home of CUSP, and hundreds more occupy the neighborhoods around NYU’s Manhattan campus, where the Center for Data Science is located. Partnerships with companies like these will provide valuable expertise for the faculty at the Center for Data Science, whose graduates will prove invaluable to the startups of the future. For LeCun, it’s easy to see why New York is becoming an appealing alternative to Silicon Valley.

“It’s partly because of the initiatives from Mayor Bloomberg and partly because of an extremely vibrant local industry of large and small startup companies that are all highly involved in data analysis,” LeCun told the New York Times in April 2013, adding that “It’s much more fun to be in New York, in terms of life besides work.”
In the fall of 2012, as the storm that would become Hurricane Sandy was gaining strength in the Caribbean, one question was on the minds of residents up and down the eastern seaboard: Where would the storm hit? On both sides of the Atlantic, weather analysts combed through massive amounts of data on the so-called superstorm, trying to predict its path. While American analysts expected the storm to graze the coast before turning out towards sea, the “European model” predicted that Sandy would take a sharp left turn and head straight for New York and New Jersey.

Thankfully, officials in those two states heeded this warning, and prepared accordingly. That the devastation wreaked by the storm was not far worse is a testament to data analysis and high performance computing. In an era when the amount of data at our fingertips is growing exponentially, it has never been more vital to know how to understand it. As the aftermath of Hurricane Sandy shows, reading data can sometimes be a matter of life and death.

“The U.S. and European models eventually converged,” said Rensselaer Polytechnic Institute President Shirley Ann Jackson in a recent speech. “But, the Europeans got it right first, giving more time for those in Sandy’s path to prepare... no doubt saving lives. The difference in the early predictions lay with the strength of the analytical models and the computational power.”

Rensselaer Polytechnic Institute (RPI), located in upstate New York, understands the importance of “big data,” high performance computing, and webscience, as well as any center of higher learning in the country. Since its founding in 1824, nearly two centuries ago, the nation’s oldest technological research university has been at the forefront of discovery and innovation. In the university’s first decades, its researchers worked to come to grips with the many changes being wrought by the industrial revolution. This new frontier of data analysis is no less daunting—and just as important.

To meet this challenge, Rensselaer announced in the summer of 2013 the formation of the Institute for Data Exploration and Applications (IDEA), a university-wide initiative to find new ways to understand and benefit from the ever-rising tide of information. It is an opportunity, Jackson says, for the university’s researchers to take the reins of a “data-driven, supercomputer-powered, web-enabled, globally interconnected world.”

“Working across disciplines and sectors,” she says, “they will apply powerful new tools and technologies to access, aggregate, and analyze data from multiple sources and in multiple formats, in order to address challenges and opportunities across the spectrum, including in basic research, environment and energy, water resources, healthcare and biomedicine, business and finance, public policy, and national security.”

To meet these grand goals, IDEA will be anchored in six of the university’s strongest areas: high-performance computing, web science, data science, network science, cognitive computing, and immersive technologies. At a university already well known for its advances in supercomputers—including its Computational Center for Nanotechnology Innovations supercomputing center and the IBM Watson computer, which became famous for dominating human opponents on Jeopardy!—IDEA is a natural fit. Vice President for Research Jonathan Dordick called Rensselaer, “a leader in the fundamentals and applications of computation science.”

“With the formation of the Rensselaer IDEA,” he continued, “we will innovate new data-driven solutions to important and complex challenges facing every family, every community, and every nation.”

First projects for IDEA include collaborating with Mount Sinai to develop better healthcare analytics, in order to help realize the dream of personalized...
medicine—when every level of treatment, from diagnosis to lifestyle advisement, is personally tailored to the patient through DNA analysis. Working with the Center for Architecture Science & Ecology, IDEA will be analyzing data necessary to design urban footprints with zero net energy, and a self-regulating “building biome.” And because any mention of big data raises concerns about online privacy, IDEA will tackle the question of cybersecurity, looking for ways that information can be used without being abused.

“From improving healthcare, to environmental stewardship, to creating new educational technologies, researchers at Rensselaer are known internationally for using data science to attack some of the world’s most pressing problems,” says James Hendler, head of the Rensselaer Department of Computer Science. “The Rensselaer IDEA will create a collaborative space where our faculty and students can explore the intersections of different leading-edge data research, and then use what they find to jump-start new programs, products, and companies. A key focus of the IDEA is data-driven innovation, which builds on the Rensselaer legacy of pushing forward the frontiers of basic science and changing the world with outstanding inventions and applications.”

Mayor Bloomberg’s support for the sciences, says Jackson, has made possible the sort of innovation that IDEA hopes to build on.

“Attention goes to that which we value,” she says. “Mayor Bloomberg clearly understands the extraordinary value and transformational capacity of scientific discovery and technological innovation. His focused attention has helped spark, enable, and expedite a more robust innovation ecosystem; one that fosters collaborations among the business, academic, and government sectors, and is an attractor of talent and bold ideas.”
A convergence of industry research and development is transforming science and technology in the New York metro area—and beyond.

BY STEVEN BARBOZA

In its quest for creating new products as one of the world’s leading food and beverage companies, there’s hard science at work behind PepsiCo’s research and development initiatives. For instance, in the area of flavors, PepsiCo scientists have enlisted a high-tech company robot, encased in a clear glass box and hardwired to the genetic sequences of human taste buds. The robot might taste 100,000 assays ranging from roots, plants, and fruits per day; and the payoff could be huge. PepsiCo, based in Purchase, NY, sees the use of this technology as one of the many ways to continue building upon its success of offering a highly diversified portfolio that ranges from treats to healthy eats. Today, that success includes 22 $1 billion brands.

“The robot is a tool to help us look into nature more efficiently, faster, and actually with greater sensitivity,” says Mehmood Khan, PepsiCo’s executive vice president and chief scientific officer of Global Research and Development, adding that the taste quest then shifts into higher gear: “How do we take a leaf and find the ingredient inside it? That’s the bridge between modern science, robotics, and the culinary arts.”

PepsiCo’s advanced technological taster is not only a unique capability; it symbolizes the innovation inherent in corporate research and development (R&D) in the New York metro area. Corporate research ranks among the most important sources of discovery, whether seeking solutions to problems—from everyday ills to major global challenges; improving quality of life; or even extending life itself. And the New York tristate area is a veritable hotbed of corporate activity.

“How do we take a leaf and find the ingredient inside it? That’s the bridge between modern science, robotics, and the culinary arts.”

Hundreds of company labs provide the area with considerable scientific clout stemming from a significant investment in everything from basic scientific research to applied technology development, and grease the wheels of the megaregion’s $2 trillion-plus economy. From the food we eat, to the medicines we rely on, to the electronics we use, and the energy sources that power them—corporate research is constantly pushing the envelope of “new and improved.” Here, we take a look at just a few of the corporate research initiatives driving scientific and technological innovation in the New York-metro area, and the resulting products and services that are changing our world, both near and far.
Targeting the Big C
Scores of world-class biopharmaceutical companies are creating the therapies of the future, right now, in the New York region. Called the “nation’s medicine chest,” the New York tri-state area is home to the biggest concentration of life sciences companies in the world. It has long been home to major industry players like Bayer, which invented aspirin in 1897, and is now conducting research in oncogenomics—a field of research that identifies and characterizes genes associated with cancer—to develop therapeutic agents that selectively target cancer genome alterations.

Further moving the needle in oncology research, Johnson & Johnson’s Janssen Pharmaceutical Companies is advancing a cancer interception initiative aimed at developing a new paradigm in cancer diagnosis and treatment. Johnson & Johnson is the world’s largest healthcare company, and Janssen is one of the largest pharmaceutical companies and the sixth largest biotech in the world. Janssen, based in New Jersey, is striving to achieve a more robust understanding of the mechanisms underlying the initiation of normal cells to a pre-malignant state. Its goal is to develop products capable of interrupting the carcinogenic process—eventually allowing clinicians to diagnose and intercept cancer at its earliest stages, when pre-malignancies are less complex and less resistant to therapy.

Driving Breakthrough Therapeutics
Among Janssen’s recent successes is SIRTURO™, a medicine for multi-drug resistant tuberculosis (TB). SIRTURO was granted accelerated approval by the U.S. Food and Drug Administration in 2012. It is the first medicine for pulmonary multi-drug resistant TB with a novel mechanism of action in more than 40 years. TB, second only to HIV/AIDS as one of the greatest killers worldwide, infected 8.6 million people last year, and more than 1.3 million died.

Eli Lilly & Company is also tackling a notoriously tough foe: Alzheimer’s disease. This year marks the company’s 25-year commitment to investing in Alzheimer’s disease R&D. “Our R&D approaches and expertise in Alzheimer’s disease have resulted in a strong pipeline encompassing both potential diagnostics and therapeutics for amyloid and tau pathways,” says Jan Lundberg, president of Lilly Research Laboratories, which has a significant presence in New York.

However, because for every 10,000 compounds researched in laboratories, only 100 are tested, and perhaps only one will become an actual medicine, Lilly developed a five-part Timely Valued Medicines strategy to improve the odds of success. Part of this strategy involves better disease understanding and validated disease targets or mechanisms; for example: Lilly developed Amyvid, an imaging agent that allows researchers to image the brains of patients for detection of amyloid plaques, a key characteristic of Alzheimer’s disease.

Pfizer—the world’s largest research-based pharmaceutical company, with an annual R&D budget approaching $7 billion—also has a robust commitment to innovation, with the end-goal of significantly improving patients’ lives.

“We believe that over time precision medicine—delivering the right drug, to the right patient, at the right time—will result in superior clinical outcomes for patients and enable more efficient clinical development,” says Mikael Dolsten, president of worldwide R&D at Pfizer, which is based in New York.

One example of this is Pfizer’s Xalkori (crizotinib), which is designed for a specific group of lung cancer patients with a defect in the ALK gene. In 2011, Pfizer received U.S. FDA approval for this first-in-class therapy. Pfizer researchers continue to apply precision medicine R&D to advance future therapies for patients with difficult-to-treat cancers.
Similarly committed to patient outcomes, Acorda Therapeutics is invested in restoring function to and improving the lives of people with multiple sclerosis (MS), spinal cord injury, and neurological conditions. It was founded in 1995 by a physician who operated the company out of a bedroom with the motto, “Therapies or bust!” Today the company, based in Ardsley, NY, manufactures and markets Ampyra, the first and only MS therapy that has been specifically approved to improve walking in people with MS.

Acorda’s neurology pipeline encompasses five separate products at the clinical or pre-New Drug Application stage. The company is now exploring the use of extended release dalfampridine in new disease areas: post-stroke deficits and cerebral palsy. Initial data show improved walking in people with post-stroke deficits—a potentially huge boon to the more than 7 million stroke survivors in the U.S.

With names like Bausch & Lomb, Bristol-Myers Squibb, Kadmon, Merck, Novartis, and Regeneron, dotting the local map, the New York tri-state region is an incredible source for groundbreaking diagnostics, treatments, and cures.

**Advancing the Digital Realm**

Perhaps no other company has a research legacy quite like Armonk, NY-based IBM. With 12 laboratories in 10 countries, the company has generated more patents than any other company for 20 consecutive years. IBM Research aided Apollo moon landings, was crucial to the discovery of fractals, and invented the technology behind laser eye surgery. IBM Research is also responsible for a series of technologies and products that have transformed day-to-day living: the automated teller machine, the hard disk drive, the magnetic stripe card, the Universal Product Code, and the Sabre central reservation system, which revolutionized the travel industry and served as precursor for the entire universe of e-commerce.

Now, IBM Research is embarking on a new frontier: cognitive computing, which the company expects to dramatically change our relationships with computers.

“The most exciting dynamic in technology and business today is the confluence of four massive trends—big data, the cloud, social media, and the instrumented, connected world we call the Smarter Planet,” says John E. Kelly III, director of Research at IBM.

“This environment drives completely new thinking and is driving the emergence of a third ‘cognitive’ era of computing. We believe cognitive systems that learn, reason, and interact naturally with people will become the biggest opportunity in our industry over the next few decades.”

The first cognitive computer was IBM’s Watson, which debuted in 2011 in a televised Jeopardy! challenge and beat the show’s two greatest champions. Today, Watson is working with doctors, insurers, and customer service professionals to transform the outcomes that can be achieved. But that vision will require computer scientists to reinvent virtually every aspect of computing, from how we think about applications and data, to the nature of computer hardware.

“We believe cognitive systems that learn, reason, and interact naturally with people will become the biggest opportunity in our industry over the next few decades.”

IBM scientists want to eventually create computing systems that emulate the brain’s capacity to adapt. As a result, cognitive computers will not be programmed; they will be trained using enormous volumes of data that no single human could ever process.

“Research is central to IBM because we are continuously shifting to higher value,” says Kelly. “It’s important to have the courage to disrupt yourself—based on deep insight and fueled by powerful ideas brought to life by very unique skills.”

**Powering Our World**

The cities and towns that make up the New York-metro area are home to a staggering number of businesses, and one thing they all have in common is a thirst for more and more energy. New York City’s commercial and industrial sectors consumed more than 42% of power usage in 2011, and their energy needs are growing.

Perhaps surprisingly, New York is among the nation’s most energy-efficient cities due to its reliance on public transportation (two of every three users of mass transit in the U.S. live in Greater New York) and its sheer density (1 million buildings crammed into 300 square miles). Even so, energy concerns abound as demand grows, and area companies are seeking novel ways to reduce carbon footprints while increasing the reliability and efficiency of energy delivery.

Con Edison, a utility whose electric and steam businesses date back to the days of Thomas Edison, has new plans to meet tomorrow’s energy needs. Among its consumer-focused programs is one that allows New Yorkers with room air conditioners to remotely control their thermostats using a device called a Modlet. In addition, the modern electrical outlet allows engineers to remotely control window units on the hottest days.
With 6 million room air conditioners in its service territory, Con Edison sees great potential in the device.

Con Edison Development and Con Edison Solutions—competitive energy businesses—are looking heavily to clean energy development, with a $500 million investment in solar projects, making it one of the top five solar producers in North America.

Meanwhile, Connecticut-headquartered General Electric is picking up the pace of its product development cycle by using a Rapid Prototyping Center. The center’s 3D printer, which creates products by printing them layer upon layer, reduces part development time by 80% on average.

Better Together
While the sheer range of companies involved in R&D in the New York region is astounding, there is increasing overlap, both within and outside of the corporate sector. PepsiCo, which is planning the future of food, cites a need for 40% more food productivity on the planet by 2050 due to population growth. While industry has to take up the cause, “because 90% of the world’s population buys its food from the private sector,” says Khan, “food companies, academia, governments, NGOs—all of us—must come together to work collaboratively. Ultimately, we need to deliver this food.”

The focus on the greater good—and major global challenges—is apparent in medicine too. Biomarker experts at Johnson & Johnson’s Janssen are collaborating with academic centers to develop and commercialize next-generation circulating tumor cell technology for capturing, counting, and characterizing tumor cells found in a patient’s blood. The cross-sector work is not usual for the company.

“In total, I think we do 100 collaborations per year in early science and technology,” says Paul Stoffels, chief scientific officer, Johnson & Johnson, and worldwide chairman, Janssen Pharmaceutical Companies of Johnson & Johnson. This includes work that comes out of the company’s new research hubs, one of which is based in New York, that foster R&D collaborations with entrepreneurs, emerging companies, and leading academic centers.

Pfizer’s Center for Therapeutic Innovation, which collocates industry scientists with academic researchers in major bio-innovation clusters, including New York City, aims to transform the biopharmaceutical R&D model—making it speedier and more creative. “We seek to be a nodal player at the center of a thriving ecosystem that includes academic scientists, patient foundations, government researchers, and other innovators. We recognize that science requires extensive and open collaboration,” says Dolsten.

“We recognize that science requires extensive and open collaboration.”

The idea—that working together leads to bigger gains—is one that in the past might have been dismissed as a barrier to the all-important competitive edge, but is today part and parcel of New York’s booming research industry mindset. The companies that call New York home see such close quarters in terms of benefits, not just concessions. And to be sure, New York derives immeasurable value from the industry tenants that help to shape its status as a region always looking to the future.

Steven Barboza is a writer in New Jersey.
Professor Robert L. McCrory calls it “bringing star power to Earth”—re-creating on our planet the nuclear reactions that power the Sun, and thereby securing an inexhaustible source of energy that emits no greenhouse gases, requires no environmentally-destructive mining or drilling, and relies on fuel as abundant as seawater. This is the vision of the University of Rochester’s Laboratory for Laser Energetics (LLE), which is committed to making the dream of producing electricity from nuclear fusion, which makes the Sun shine, a reality.

Hydrogen bombs also get their energy from the fusion of atomic nuclei, of course, but for nuclear fusion to generate energy that can be tapped for electricity, the reaction must scaled down more than a million times in energy. The LLE therefore investigates inertial confinement fusion, which explores the behavior of matter under conditions of extremely high energy density and temperature. In inertial confinement fusion, ultra-high power lasers emitting hundreds of terawatts of power (1 terawatt equals 1 trillion watts, and is comparable to the power produced by 1,000 electric power plants) irradiate a capsule containing the heavy hydrogen isotopes, deuterium and tritium. The laser energy compresses and heats the hydrogen to conditions near those at the center of the Sun, causing it to undergo fusion. The result is helium fuel and other energetic particles.

If the compressed mass is large enough, the high-pressure, high-temperature conditions last long enough to produce more energy than is used to power the laser, allowing inertial confinement fusion to be used to produce electric power. The field has made significant strides since it began in the early 1970s and is now within 10 years of demonstrating its scientific feasibility.

The LLE is the country’s only large-scale facility for inertial confinement fusion at a university rather than a weapons lab. Its showcase facility is the 60-beam OMEGA laser, which can deliver more than 30 billion times the instantaneous power of sunlight that falls on one square meter of the Earth’s surface, but concentrates it all on a target less than 1 millimeter across.

Inertial confinement fusion research has potential applications in other important areas of science and technology. The most immediate is in nuclear weapons security. By simulating the extreme temperatures and pressure of a thermonuclear burn, inertial confinement fusion can be used to, for instance, predict how nuclear warheads in the nation’s stockpile degrade as they age; as a result, much of the LLE’s research is funded by the Department of Energy’s National Nuclear Security Administration. Research on inertial confinement fusion at the LLE has also opened up new areas of basic research ranging from laboratory astrophysics (simulating the nuclear reactions inside stars) to the investigation of the behavior of matter under ultra-high dynamic stress.

Rochester and its surrounding area has long been a technologically sophisticated region with significant resources in optics, physics, materials science, chemistry, nuclear physics, plasma physics, photonics, and laser technology. When the late Professor Moshe Lubin began the work that would lead to the official founding of the LLE in 1970, he started with lasers abandoned by the Eastman Kodak Company, another Rochester-based institution. The University of Rochester, too, has long had strong programs in optics, photonics, and physics.

The importance of the LLE in advancing inertial confinement fusion for energy production as well as national security and basic research is reflected in the breadth of its support. The lab, directed by McCrory since 1983, receives funding from the National Nuclear Security Administration and the New York State Energy Research Development Authority.

The next decade promises a number of historic milestones. The LLE is on track to demonstrate inertial
confinement fusion ignition and burn, showing the way toward long-term applications of this approach to energy production. The OMEGA laser, by producing ultra-high-density states of matter, promises to solve many outstanding puzzles in materials science, fundamental atomic physics, fundamental nuclear science, and plasma physics.

And although they do not have the sex appeal of the lasers themselves, the ultra-high speed and high-precision instrumentation required to measure the conditions in the targets probed by the lasers promise to generate revolutionary technologies in their own right. The LLE is also expected to inspire the development of advanced numerical models that, running on tomorrow’s high-speed computers, will be able to aid in the design and modeling of future experiments—think of it as virtual nuclear fusion. In addition, the central role that the OMEGA laser plays in the LLE is expected to lead to the development of ever-more powerful high-efficiency descendants.

The LLE continues to be one of the leading energy research facilities in the world. Attracting as many as 300 scientists each year from laboratories, universities, and companies across the country and the world to carry out advanced research in high-energy/high-density physics and inertial confinement fusion, it is a significant source of innovation and talent (almost 1,000 individuals are currently involved in the program). As a result, the LLE has been a key economic driver for the Finger Lakes region, where LLE technology has served as the foundation for such area companies as QED Technologies, Inc., Sydor Instruments LLC, and Lucid, Inc.
In 2001, mapping the human genome was a $100 million project—and an astonishingly successful one. Today, an individual’s genome can be sequenced for as little as $3,500. The availability of rapid, inexpensive sequencing technology is already leading to unforeseen findings in basic biology and unprecedented breakthroughs in clinical research. In order to realize this technology’s full potential, The Rockefeller University is preparing to establish a new Center for Genomic Medicine.

The current genomics revolution was seeded at Rockefeller in 1944, when medical scientists Oswald Avery, Colin MacLeod, and Maclyn McCarty discovered that DNA is the chemical that transmits hereditary information. Just 70 years later, we are close to the day when information gleaned from a patient’s own DNA sequence will be integrated into the planning of his or her medical care. Clearly, the dawn of the era of personalized medicine has arrived.

The new Center for Genomic Medicine will accelerate the pace of discovery in biomedicine by making the techniques and approaches of today’s genetic research available to Rockefeller faculty members representing a broad range of disciplines in the life sciences. Investigators heading basic science laboratories are interested in expanding their current research programs by adding capabilities in human genetics. For these scientists and many others in the university’s 73 laboratories, the new Center will be the vehicle that helps them take their most significant discoveries into the realm of human biology and, eventually, enables them to see their findings applied in the clinic.

In establishing the Center, the University will build on its considerable strengths in human genetics. The current faculty includes: Jeffrey Friedman, recipient of an Albert Lasker Award, who is noted for his discovery of the weight-regulating hormone leptin; Jean-Laurent Casanova, who conducts paradigm-changing research on the role of heredity in infectious disease; and Agata Smogorzewska, who studies the genes involved in DNA repair and how failures in these mechanisms contribute to cancer. Rockefeller is now in the process of recruiting additional world-class human geneticists to join the Center.

For Friedman, who identified leptin in the mid-1990s through an arduous gene-mapping approach that he now describes as “mind-numbing,” today’s speedy and powerful sequencing technologies offer a world of exciting possibilities. He says that the new Center will provide “unprecedented opportunities to establish the clinical significance of DNA variants—genetic differences large and small that will be found within and across human populations. We’ll develop an understanding of the variants that cause disease and those that underlie the normal characteristics that make every human being unique.”

The ability to decipher all 3 billion units of a person’s DNA is just one element of a research program that strives to discover new genetic diseases and identify unknown, clinically relevant subtypes within categories of illness that are now understood only in the broadest sense. The Rockefeller University Hospital, which has pioneered advanced approaches to clinical investigation since its opening in 1910, can play a critical role in achieving these goals. The hospital has unique assets for phenotyping, the rigorous clinical characterization of individuals and families affected by disease. The quality and organization of collected patient information will play a key role in any analytic method designed to extract clinically relevant insights from DNA sequence data.

The Rockefeller University will also take full advantage of its close association with the New York Genome Center (NYGC), which was created two years ago by a dozen area institutions on a collaborative model that allows members to draw on resources and expertise for experimental design, sequencing, and genomic bioinformatics—the development
and application of computational tools to interpret sequence and clinical data.

Robert Darnell, a professor at Rockefeller and the founding president of the New York Genome Center, notes that genetic studies undertaken by Rockefeller scientists and other NYGC members will “tap into the ethnic diversity of New York.” This not only means better science; such a strategy also represents an “egalitarian approach that is crucial to the future of medicine.”

Rockefeller President Marc Tessier-Lavigne adds that genomics will also serve to “accelerate drug discovery by helping pharmaceutical developers identify the patients who stand to benefit most from new therapies.”

The Center for Genomic Medicine at Rockefeller will be a productive participant in a city-wide initiative that is bringing the best minds in academic bioscience to New York. The Center will also build and support partnerships between academia and the pharmaceutical/biotech sector, further assisting in efforts to enhance New York’s standing as a science capital. As DNA sequencing unlocks the secrets of both health and disease, The Rockefeller University—a leading light in New York for well over a century—will continue to make essential contributions in this golden age of biomedical research.

“The Center will provide unprecedented opportunities to establish the clinical significance of DNA variants.”
If non-scientists know anything about quantum mechanics, it is probably the thought experiment known as Schrödinger’s cat. Imagine that an unfortunate feline is locked in an airtight box, physicist Erwin Schrödinger proposed in 1935, along with a radioactive atom that has a 50-50 chance of decaying within the next hour and a vial of poison that the radioactive emission will shatter. After that hour, is the atom intact and the cat alive, or has it decayed, to the fatal detriment of kitty? Remember, the atom has a 50% probability of decaying in the hour.

The standard answer is that kitty is suspended in a state of both living and dead, what physicists call a “superposition” of equal-probability states. Superpositions are a key consequence of quantum mechanics, which describes the behavior of subatomic particles. The superposition resolves into one or the other of its constituents—a live cat or a dead one—only when an observer opens the box and looks. Not surprisingly, when laypeople think about superpositions of dead and living cats and the notion that reality is created by an observer, their reaction is probably not, aha, I know just how I can apply this to build a 21st-century computer.

But that, oversimplified, is what physicist Britton L.T. Plourde of Syracuse University thinks. Britton is involved with several projects unified by a belief almost as startling as Schrödinger’s cat: that the weirdness of quantum mechanics, which for decades had been regarded as more interesting to philosophers than useful to technologists, can be harnessed to produce computers that, when applied to problems like database searching and simulation of quantum systems, would make those existing today look like fancy abacuses.

Plourde and his team hope to explore “the strangeness of the quantum world at the scale of circuits on a chip,” he says, with the goal of developing the elements of a quantum computer. Such a device would execute computations not by manipulating the binary state (on or off) of minuscule spots of electric charge or magnetism, the basis for the 1s and 0s of binary code. Instead, it would carry out computations with superconducting quantum bits, or “qubits.”

Each qubit could be placed in an arbitrary superposition of states, not dead cats and living cats but more like, for instance, an ammonia molecule in which the nitrogen atom is above (state 1) or below (state 2) the plane of the three hydrogen atoms. In a quantum computer, “each qubit can be in any arbitrary superposition of states,” says Plourde. Partly because the number of possible states is vastly greater than the two used in today’s computers, a quantum computer “would be capable of solving many problems which are intractable on even the most powerful classical computer, such as the factorization of large numbers.” In a sense, he said, “these entire circuits are able to do two different things at once!” Once the researchers can fabricate a few such circuits on a chip and demonstrate their quantum properties, “it should, in principle, be possible to scale up to many such qubits on a chip using standard microfab techniques,” Plourde says.

Another source of a quantum computer’s power would come from a property of quantum interactions called entanglement, which seemed so bizarre to Albert Einstein that he used it as part of his decades-long argument that quantum mechanics cannot possibly be correct if it leads to such ridiculous consequences. In a nutshell, entanglement refers to a property of two or more particles that essentially joins them forever. If two particles were created so that they had opposite spins, then before any measurements each particle has a 50-50 chance of being measured in either state. After measuring the state of one particle, however, the state of the other is completely determined; it is as if measuring the spin of one brings into existence the opposite spin of the other. Qubits, too, can be entangled, allowing for computational processes not possible with classical bits.
Since coming to Syracuse in 2005, Plourde has made the university one of the leading players in the development of quantum computing with superconductors. The research is highly collaborative, involving projects with labs from Germany to Wisconsin. A key partnership is with IBM Experimental Quantum Computing Group at the T.J. Watson Research Center in Yorktown Heights, NY, whose proximity allows for frequent exchanges of scientists between Syracuse and IBM. The superconducting circuit technology employed in the IBM/Syracuse effort is also representative of the strength of superconductor research and industry in New York, which boasts a world-leading superconductor device fabrication and digital electronics center at Hypres in Elmsford, superconducting MRI magnets from Philips Medical Systems in Latham and from General Electric Global Research in Schenectady, and superconducting cables from SuperPower in Schenectady. Finally, easy access to the state-of-the-art fabrication capabilities at the Cornell NanoScale Facility and Center for Materials Research has helped Plourde’s research.

This is not to say that there are not daunting obstacles to superconducting quantum computing, both scientific and practical. As more superconducting qubits are added to the chips, the circuits become harder to fabricate and control. Also, maintaining a stable supply of liquid helium, which has surged in price in recent years, has made it challenging to operate low-temperature experimental apparatus. Nevertheless, says Plourde, “I am confident that in the coming years, the work we and others are doing will lead to critical advances in the development of novel information processing systems as well as fundamental investigations of quantum mechanics.”

“A quantum computer would be capable of solving many problems which are intractable on even the most powerful classical computer.”

TOP: Custom-built dilution refrigerator for cooling superconducting quantum circuits to temperatures near absolute zero and performing experiments with microwave signals. CENTER: Low-temperature measurement of the oscillatory exchange of a microwave excitation back and forth between a superconducting qubit and a resonant circuit. BOTTOM: A view of the Syracuse University campus. Photo credit: SU Photo & Imaging Center
The nursery rhyme about London Bridge falling down gives a fair assessment of the fate of bridges. Patch them up with wood and clay, and the wood and clay will wash away. Iron and steel would fare better, but eventually these bridges will bend and bow. But what about plastic?

Structural plastic—the stuff of recycled milk cartons, detergent bottles, and car bumpers—is actually a bridge-builder’s dream. It can be molded into T-beams then bolted into I-beams that are eight times stronger than steel at one-eighth the density. It can be drilled, screwed, sawed, pinned, and even sprayed with a fire retardant coating.

Theoretically, a plastic George Washington Bridge is possible. “There’s no technical limit to how big a beam we can make out of plastic. All you need is bigger beams to make bigger bridges,” says Tom Nosker, professor of materials science and engineering, who developed structural plastic at Rutgers University’s Advanced Polymer Center in NJ.

The engineering lesson is elementary. Even sturdy wooden or cement-and-steel bridges are destined to erode given enough time, traffic, and exposure to wind and weather. Plastic beams will not buckle; they’re impervious to rot; and they’re eco-friendly, providing a novel use for mountains of discarded milk containers.

But there’s a broader lesson here: the entire New York tri-state region is a kind of science and technology Grand Central, where researchers bustle to push back the boundaries of possibility. Structural plastic is only one of the region’s thousands of innovations bound to affect our lives in extraordinary ways in the not-so-distant future. An incredible array of scientific progress and energy, changing the world far beyond its borders.

A bridge made of recycled plastic lumber is built in Scotland.
of area research universities are bristling with a spirit of invention that extends New York’s science ecosystem into a much larger footprint—creating an entire region of unparalleled scientific excitement.

**A New Frontier in Manufacturing**

Connecticut is brewing a latter-day industrial revolution of its own, as it paves the way for digital manufacturing. The University of Connecticut (UConn) has built a sort of factory of the future—one of the most advanced additive manufacturing centers in the nation. Additive manufacturing is a breakthrough method of making things—from flight-proven rocket engines to individually tailored hearing aids. Instead of using lathes, drills, molding machines, and stamping presses, it uses software and digital 3D printers that build items layer by layer. There’s no waste, molds, or assembly of intricate parts.

![A 3D printer in UConn’s Pratt & Whitney Additive Manufacturing Innovation Center.](image)

The new Pratt & Whitney Additive Manufacturing Innovation Center, a partnership of UConn and Pratt & Whitney, is the Northeast’s first such facility to work with metals. Techniques developed here might one day empower small and medium-sized firms and entrepreneurs to launch novel, incredibly complex products quickly, profitably, and more flexibly than ever, with minimal manual labor.

Imagine a new generation of intricate, lightweight, and durable custom products—printed in cost-efficient home factories.

At UConn’s center, which houses 3D manufacturing equipment and rapid prototyping technologies, two high-powered electron beam melting machines and lasers repeatedly melt layer upon layer of powdered material, such as titanium, into a single solid piece. The items are built to the exact specifications dictated by a 3D computer assisted design (CAD) model. Engineers are using the center to develop advanced fabrication techniques for production parts in aerospace, biomedical science, and other industries.

“The new center will allow us to push into new frontiers of manufacturing and materials science while training a new generation of engineers in some of the world’s most sophisticated manufacturing technology,” says UConn President Susan Herbst.

**Bringing Cybernetics to Life**

Scientists at Princeton University are also using 3D printing tools, not to crank out jet engines, but to print a fully functional organ—a bionic ear so sensitive it can tune into frequencies far beyond the limits of human hearing.

The bionic ear is a bold mixture of electronics and tissue. Researchers, led by Michael McAlpine, an assistant professor of mechanical and aerospace engineering, used an ordinary 3D printer purchased off the Internet to combine a matrix of hydrogel and bovine cells with silver nanoparticles. Using CAD software, the printer deposits layer upon layer of gel, silver, and cells, building the ear out of an array of thin slices. The nanoparticles form a working antenna, while the cells multiply and mature into cartilage.

“Using CAD software, the printer deposits layer upon layer of gel, silver, and cells, building the ear out of an array of thin slices.”

The finished product is soft and squishy and looks remarkably like the real thing, except there’s a coil antenna in the center. Two wires wind around its electrical “cochlea,” where sound is sensed. The wires can be connected to electrodes.

The ear is a step toward a device that someday could be used to restore a person’s hearing, or improve it by connecting electrical signals to a human’s nerve endings, as is customary with cochlear implants. But additional research and testing is being done. “The design and implementation of bionic organs and devices that enhance human capabilities, known as cybernetics, has been an area of increasing scientific interest,” the researchers wrote in an article. “This field has the potential to generate customized replacement parts for the human body, or even create organs containing capabilities beyond what human biology ordinarily provides.”

**Revolutionizing Computing Architecture**

As Princeton scientists chart a new course in the brave new world of cybernetics, Yale University scientists are inventing a new cyber age. Three Yale physicists are laying the foundation for the warp-speed...
computers of the future—machines that will harness the power of atoms and molecules to store, process, and transfer colossal amounts of data at almost unimaginable speeds, and do it in spaces so minuscule they cannot be seen by the naked eye.

Two applied physics professors—Robert Schoelkopf and Michel Devoret—are building a quantum computer, one “artificial atom” at a time. The scientists are putting “microwave quantum optics” on a chip by squeezing microwave photons, or tiny packets of light energy, into ultra small cavities on a chip. They’re also squeezing in electrical circuit elements, which act as artificial atoms that can be used as quantum bits, units that process and store quantum information.

These small “atoms” interact with the packets of light energy from the microwaves at extremely high speeds. The small cavity acts as a quantum bus of sorts, transmitting quantum information to and from the atoms. The result: a radical new architecture that may usher in the end of computing as we know it. Scientists hope to one day use this approach to create a huge integrated circuit of quantum bits, resulting in a quantum computer.

Old Fuel, New Production Method
Lehigh University researchers are looking to forge a new path in fuel production—creating a solution to the world’s unsustainable levels of energy consumption. They’re turning to the simple but powerful process most kids learn about in grade school, photosynthesis, to harness sunlight and synthesize liquid fuel from dissolved carbon dioxide.

While the process is new and extremely efficient, the fuel has been around for decades: it’s methanol, which is a safe fuel that burns cleaner than gas and can reduce hydrocarbon emissions by as much as 80%. In fact, methanol actually consumes CO2.

Methanol is mainly produced using natural gas or coal. Nobody knew it was possible to photosynthesize it into existence—until now. In the 1990s, methanol was marketed as an alternative fuel for vehicles. It was never fully adopted because there was no economic incentive for continuing methanol production as petroleum fuel prices fell in the ‘90s.

Why turn to methanol again? Because it has a higher octane level than gasoline, there are no technical hurdles for vehicle design and fuel distribution, and a methanol-based fuel economy would dramatically reduce energy dependence on dwindling fossil fuel sources.

By using a cross-disciplinary effort in catalysis, materials chemistry, and cellular engineering, Lehigh scientists have found a way to directly convert sunlight into methanol, bypassing the need to grow and process a plant.

“A low-cost, green fuel produced in large quantities from carbon dioxide, sunlight, and water could potentially meet our transportation needs.”

The team replaced slow, natural photosynthesis with rapid, efficient, and selective artificial photosynthesis, using semiconductor quantum dots (QDs) as photocatalysts. QDs are nanocrystals that once promised to revolutionize display technologies, solar power, and biological imaging. A key barrier has been price; they cost up to $10,000 per gram, thus their use has been limited to special applications.

The Lehigh team discovered a novel way to produce QDs: by using an engineered bacterial strain to initiate and control their growth—essentially a batch fermentation process. “We are thus able to achieve a cost of less than $38 per gram for quantum dots,” says Bryan Berger, professor of chemical engineering and co-principal investigator.

The Lehigh team has projected production costs for their methanol to be 65% cheaper than current costs for producing biodiesel fuel. If they can develop a production method that can be scaled-up and is commercially feasible, photocatalytic methanol production could have a significant long-term impact on society and the economy.

“ A low-cost, green fuel produced in large quantities from carbon dioxide, sunlight, and water could potentially meet our transportation needs. It would reduce oil imports without depleting our natural resources,” says Berger.
New Diagnostic Tools Target Tumors

The University of Pennsylvania (UPenn) technically sits outside the New York tri-state area and yet its extraordinary commitment to R&D (as exemplified by an annual budget of more than $800 million) and a legacy of discovery traced to Benjamin Franklin, the Founding Father with a knack for creating something out of nothing, makes it an important contributor to the region’s science ecosystem.

While UPenn created the first general-purpose electronic computer in the early 1940s, a 27-ton, 680-square-foot model that calculated ballistic trajectories during World War II, current UPenn scientists are leading explorers in the world of the infinitesimal. By developing nanotechnology as an effective diagnostic tool, researchers are hoping to revolutionize the prevention and treatment of disease.

While magnetic resonance imaging (MRI) can produce topographical maps of tissue, scan clarity isn’t always sufficient for diagnosis. To mitigate patients’ health risks and to improve imaging, UPenn researchers are coating an iron-based contrast agent so it interacts with the acidic microenvironments of tumors, making tumors stand out clearly from healthy tissue. The approach is both safer and less costly than other methods.

The coating of glycol chitosan—a sugar-based polymer that reacts to acids—allows nanoparticles to remain neutral when near healthy tissue but to become ionized in low pH. In the vicinity of acidic tumors, a change in charge causes the nanoparticles to be attracted to and retained by the tumors.

“Having a tool like ours would allow clinicians to better differentiate the benign and malignant tumors, especially since there has been shown to be a correlation between malignancy and pH,” says Andrew Tsourkas, associate professor of bioengineering. The coated nanoparticles are not limited to imaging, he added. “They can also be used to deliver drugs to tumor sites.”

Developing Infection-Resistant Medical Implants

Scientists at Stevens Institute of Technology are developing next-generation, bacteria-resistant biomaterials that could become an implant staple for millions of patients. And as the population ages, the market for orthopedic implants will experience exponential growth; by 2017, the global market will reach $46 billion. But 1% of hip implants, 4% of knee implants, and 15% of implants associated with orthopedic trauma fail—due to infection.

“Usually the only way to resolve a biomaterials-associated infection is to remove the device, treat the infected tissue, and later implant a second device,” says Matthew Libera, professor of materials science at Stevens. “Not only does this bring really significant cost to the healthcare system; it forces the patient to undergo a lengthy and challenging surgical and rehabilitation process. We would like to eliminate that risk.”

Stevens faculty from numerous disciplines, including materials science, chemical biology, and biomedical engineering, developed technology that actually repels bacteria and promotes the growth of healthy bone cells on uncemented implants. The surface of the implants is treated with hydrogel because most bacteria, particularly the staphylococci common to implant infection, do not adhere to most hydrogels. As a result, patients won’t have to take antibiotics orally; the medicine will go to work at the surface of the implant.

A Local Home for the World’s Biosamples

Many of the biospecimens used in research projects across the region, and around the world, are provided by Rutgers University, a national leader in genetics. RUCDR Infinite Biologics, founded in 1998 as the Rutgers University Cell and DNA Repository, is the world’s largest university-based biorepository. It provides DNA, RNA, and cell lines with clinical data to research laboratories worldwide, which use them to study a host of diseases and disorders.

RUCDR contains more than 12 million biosamples, logs 100 million database entries per year, operates one of the nation’s largest stem cell programs, and facilitates a slew of research initiatives.

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has partnered with the U.S. Army Corps of Engineers to build plastic lumber bridges that can tolerate punishing loads: 70-ton tanks and 120-ton locomotives.

“Usually the only way to resolve a biomaterials-associated infection is to remove the device, treat the infected tissue, and later implant a second device... We would like to eliminate that risk.”

In 2013, RUCDR received $44.5 million from the Cooperative Agreement award from the National Institute of Mental Health (NIMH), which will allow RUCDR to support the NIMH Center for Collaborative Genomics Research on Mental Disorders by collecting, processing, and analyzing blood and tissue samples from NIMH-funded scientists nationwide.

“With the new funding, RUCDR Infinite Biologics will implement new meta-analytic approaches for combined analysis of clinical and genetic data in the NIMH Human Genetics Initiative,” says Tischfield.

Transforming Lives through Research
Research projects such as those detailed above represent just a fraction of the novel endeavors under way in labs across the tri-state region—probing mysteries that puzzle us, creating technologies that amaze us, and making discoveries that alter how we live and think. And in the process, Tri-State scientists are bringing robust new revenue streams to the local economy—creating both short- and long-term benefits.

While we may never see a plastic twin of the George Washington Bridge, plastic bridges are on the horizon, literally. Rutgers

“For the first time, researchers will have robust epidemiological and biological information from large numbers of individuals so that they may correlate genetics to alcohol abuse behavior,” Tischfield says. “The results will be used to formulate national policy and improve healthcare services.”

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Chances are, structural plastic has already touched your life. If you’ve ever traveled by train, you have probably glided along rails held in place by plastic railroad ties. With 212,000 miles of track in the U.S., ties are big business; 20 million are replaced each year for maintenance, and composite ties are rapidly gaining notice for their corrosion-resistance.

Leave it to scientists in the tri-state region to come up with an ingenious idea for what to do with the world’s rubbish: create everlasting building blocks.

Steven Barbosa is a writer in New Jersey.
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