RESEARCH:

DISCOVERY AT PRINCETON UNIVERSITY
Research universities like Princeton stand in the forefront of America’s research enterprise, channeling public and private dollars into critical fields of inquiry. The kind of fundamental research that universities undertake has no analogue in American society—research universities are the research engine of our nation—and the new knowledge that is generated in this process is placed at the service of national goals and applied and adapted by the marketplace, enhancing human health and well-being and creating new industries that diversify and strengthen our economy.

~ Shirley M. Tilghman, president

Princeton University
Princeton is a major research university that ranks among the best in the world. It is a place where scholars pose and answer profound questions that could not even have been asked a few years ago, generating scientific discoveries, technologies, and new ideas that will redefine society itself. Moreover, it is a place where high-quality research across all academic areas forms an essential part of Princeton’s distinctive commitment to undergraduate and graduate teaching, and to the training of the next generation.

Princeton thrives in a new research environment that increasingly transcends disciplinary boundaries. Interdepartmental relationships always have been close, making it natural to create institutes to address new initiatives, such as the Princeton Environmental Institute and the Princeton Institute for the Science and Technology of Materials, which link researchers in engineering and the sciences. Other prime examples include the new Princeton Neuroscience Institute and the Lewis-Sigler Institute for Integrative Genomics, which bring together biologists, chemists, physicists, neuroscientists, psychologists, engineers, and computer scientists to perform experiments and theoretical research. In the social sciences, the new Center for African American Studies joins leading thinkers in sociology, history, politics, religion, philosophy, and the arts in a groundbreaking collaboration. Princeton researchers also benefit from intellectual connections with the Princeton Plasma Physics Laboratory, the Geophysical Fluid Dynamics Laboratory at Forrestal, and the neighboring Institute for Advanced Study.

Nevertheless, the University must continue to meet the challenges innovation demands. Research is expensive and space-intensive, with requirements that include new laboratory buildings with sophisticated facilities, high startup costs for new faculty, and the ongoing need to renew all facets of existing infrastructure. Yet it is clear that to make progress one must go where no one has gone before. As Princeton physicist and Nobel Prize winner Val Fitch once said, “You can’t buy a ‘world’s-best’ department, but you have to pay for it!” We face huge challenges today—depleting energy sources, health crises, climate change, and issues of national and international security. To solve them, we need new ideas and discoveries that only basic research can provide.

The Office of the Dean for Research was created in 2006 to assist our faculty as they initiate new research and compete for funding in an increasingly competitive environment. To this end, several previously separate administrative functions have been brought together and report to the dean for research. These include the University Research Board, which oversees University research policy; the Office of Research and Project Administration, which oversees administration of government funding and sponsored research for individual faculty members; the Office of Corporate and Foundation Relations, which connects research projects and corporate and foundation support; and the Office of Technology Licensing.

In this report you’ll find a snapshot of research at Princeton—results and work in progress in the words of the researchers themselves, faculty honors, recent books, and a few statistics. My colleagues and I hope these pages convey the excitement and importance of research at Princeton today.
The “Stabilization Wedges” concept of carbon management, first published in Science in 2004 by Stephen Pacala (Ecology and Evolutionary Biology) and Robert Socolow (Mechanical and Aerospace Engineering), has since engaged the world press and public officials with its innovative approach to managing global climate change. A centerpiece for the climate change solutions touted by 2007 Nobel Peace Prize-winner Al Gore in An Inconvenient Truth, the wedges concept stresses that existing technologies can be used to solve the climate problem. The analysis showed that 15 strategies that could each cut carbon by 25 billion tons over 50 years, or one “wedge,” already exist in the areas of energy efficiency, lowering the carbon intensity of electricity production by means of fuel shifting, carbon capture and storage, nuclear energy, renewable energy, and biological storage of carbon in forests and agricultural soils. Just seven wedges need to be implemented to freeze carbon emissions at current levels and get the world off the path toward dangerous climate change.

Mapping the heavens with unprecedented detail, the Sloan Digital Sky Survey reveals that faraway quasars live in clumps of dark matter a trillion times more massive than the sun. Using a map of the 4,000 most distant known quasars—enormous black holes that are among the most luminous objects known—Yue Shen and Michael Strauss (Astrophysical Sciences) found them to be strongly clustered together. This finding, when interpreted in the context of modern cosmological models, implies that the quasars are surrounded by rare massive halos of dark matter. This discovery supports our understanding of dark matter and its tendency to form structures. The early universe had an almost perfectly smooth distribution of matter, but during the approximately 14 billion years since the cosmos formed, gravity has pulled matter into the highly structured universe in which we live today. By examining quasars that lie more than 11 billion light years from Earth, Shen and Strauss were able to look at an intermediate step in that evolution. Because the light from these distant beacons started traveling toward Earth long ago, images of them provide a snapshot of the cosmos as it appeared in its youth.

The proposal of a sustainable national security strategy for the United States resulted from The Princeton Project on National Security of the Woodrow Wilson School of Public and International Affairs. More than 400 leaders from government, academia, business, and the nonprofit sector met over a three-year period for conferences, roundtable discussions, and working groups on the topics of Grand Strategic Choices, State Security and Transnational Threats, Economics and National Security, Reconstruction and Development, Anti-Americanism, Relative Threat Assessment, and Foreign Policy Infrastructure and Global Institutions. The resulting strategy addressed a number of critical issues facing the United States: terrorism, nuclear proliferation, instability in the Middle East and East Asia, global pandemics, and energy. Recommendations ranged from a “global counterinsurgency” to address multiple threats to security and sweeping reforms for international institutions to the building of democracy through incentives and support for common problems, retaining the option of preventive uses of military force as a last resort under strict controls, and a gas tax.

African American political thought, black religious ideas and practice, and social and clinical psychology come together in the research of Melissa Harris-Lacewell (Politics and African American Studies). In a study conducted while she was at the University of Chicago, Harris-Lacewell and team found that media coverage of Hurricane Katrina contributed to radically different reactions between blacks and whites in the aftermath of the disaster. In “Racial Attitudes and the Katrina Disaster Study,” Harris-Lacewell used an original survey to show that in the aftermath of Katrina, blacks and whites held strikingly polarized views about everything from why victims did not evacuate to the appropriateness of the government response, and conducted a randomized experiment to explore the effect of media framing on this racial gap. The research findings were consistent with the theory of social identity, with implications for political psychology and the study of racial politics. The research team’s surveys found that subtle image manipulations made blacks more sympathetic toward their own racial group, while similar in-group bias was found for gender, with women showing more sympathy when they saw an image portraying a female victim with children. The findings also suggest that racialized differences in emotional response to this national disaster were rooted in America’s racial history and that Americans’ political and racial beliefs were significantly related to their emotional experiences in the weeks following Katrina.
Advanced geometry offers a tool for understanding musical structure, Dmitri Tymoczko (Music) has found. “The Geometry of Musical Chords” is the first music-theory paper published in Science in its 128-year history. Tymoczko used topology and non-Euclidean geometry to devise a new and comparatively simple way of understanding how music is constructed, describing geometrical spaces in which points represent chords and line segments represent mappings between their notes, or voice leadings. These spaces are called orbitfolds and contain “singular points” at which their geometry is not well behaved. The model can be used to represent both the intrinsic properties of chords (their “harmonic” quality such as their consonance or dissonance) as well as the chords’ distance from one another (their “contrapuntal” relations).

Using the geometrical model, Tymoczko shows that many superficially different musical styles in fact deploy fundamentally similar techniques. The research suggests a more general framework for thinking about music history, as well as for understanding the compositional possibilities open to living composers.

A new laser technique that allows for instant detection of bioterrorism agents has been developed by a team led by Marlan Scully (Mechanical and Aerospace Engineering, with joint appointment in Physics at Texas A&M). A report on the research appeared in Science. While anthrax tests typically require a time-consuming lab culture process, Scully’s team uses lasers to detect anthrax in less than a tenth of a second. The new technique is based on coherent anti-Stokes Raman scattering (CARS), a phenomenon that measures the scattering of light that occurs when a molecule is bombarded by light energy (photons). The CARS signature of anthrax can be obscured by background signals from other molecules present in the medium containing the anthrax spores, so the team developed new techniques for minimizing the background “noise” and maximizing the coherent molecular oscillations crucial to detecting anthrax endospores. They have accomplished this by using a succession of femtosecond pulses so that the first two laser pulses in the CARS process prepare a coherent molecular vibration, then time-delaying the third laser pulse, which scatters off the molecule and produces the unique fingerprint. This effectively cancels the noise from vibrations of non-anthrax molecules.

The largest research effort ever on unmarried partnerships with children has found that while two-thirds of the parents expected to marry at the time of their children’s birth, only 16 percent of the couples did marry, and almost half were no longer together by the time the child turned 3. “The Fragile Families and Child Wellbeing Study,” led by Sara McLanahan (Sociology), provides groundbreaking research of the impact of unmarried parents on society, following a cohort of nearly 5,000 children born in U.S. cities between 1998 and 2000 (roughly three-quarters with unmarried parents) to study the conditions and capabilities of unmarried parents, especially fathers; the nature of the relationships between unmarried parents; the impact on the children born into these families; and the impact of policies and environmental conditions on families and children. The study is based on interviews with mothers and fathers at birth and again when children are ages 1, 3, and 5, plus in-home assessments of children and their home environments at ages 3 and 5, as well as review of administrative records and surveys.

The nation’s electronic voting systems are vulnerable to hackers, according to research led by Ed Felten (Computer Science), whose team created demonstration vote-stealing software and tested it on a Diebold AccuVote-TS, a commonly used electronic voting machine. The team found that the software can fraudulently change vote counts without being detected. The researchers also demonstrated how the machines “are susceptible to computer viruses that can spread themselves automatically and invisibly from machine to machine during normal pre- and post-election activity.” These machines are extremely vulnerable to attacks, Felten noted, and people with physical access to a voting machine, or to a memory card that will later be inserted into a machine, can install malicious software in as little as one minute. Felten said that the purpose of his team’s research was to help “guide public officials so that they can make wise decisions about how to secure elections in the future.”

Research by Fields Medal winner Andrei Okounkov (Mathematics) reveals profound new connections between different areas of mathematics and provides new insights into physics, combining the use of notions of randomness and representation theory to attack problems from algebraic geometry and statistical mechanics. With collaborators, he has studied questions in enumerative algebraic geometry, an area that in recent years has been enriched by the exchange of ideas between mathematicians and physicists. A standard way of studying algebraic curves is to vary the coefficients in the polynomial equations that define the curves and then impose conditions—for example, that the curves pass through a specific collection of points. With too few conditions, the collection of curves remains infinite; with too many, the collection is empty. But with the right balance of conditions, one obtains a finite collection of curves. The problem of “counting curves” in this way—a longstanding problem in algebraic geometry that also arose in string theory—is the main concern of enumerative geometry. Okounkov and his collaborators have made substantial contributions to enumerative geometry, bringing in ideas from physics and deploying a wide range of tools from algebra, combinatorics, and geometry.

Playing art detective, scientists used wavelets to uncover fakes by connecting science, engineering, and art history at the Van Gogh Museum in Amsterdam. To study paintings at the museum, the team of Ingrid Daubechies (Mathematics and Applied and Computational Mathematics), Peter Ramadge (Electrical Engineering), and their jointly advised graduate students Shannon Hughes and Eugene Brevdo analyzed high-resolution grayscale digital scans of over 100 paintings presently or formerly attributed to van Gogh. They found features that capture elements of van Gogh’s style, distinguishing different scales at which characteristic details appear. Using even finer scales that analyze the fluency of the brushwork, they also could clearly distinguish forgeries or copies from originals; the celebrated Walker forgeries were easily picked out by this analysis. The public television program NOVA challenged the team to identify alongside five authentic Van Goghs the one copy by art conservator Charlotte Caspers; NOVA was scheduled to reveal whether they were successful in June 2008. Daubechies has been a pioneer in the development of wavelets, a mathematical tool used to compress data and then to unbundle it, usually via computer, so that the information sent is reproduced as accurately as possible.
Astronomers discovered the smallest planet outside our solar system using a technique called gravitational microlensing that researchers believe will uncover other planets that potentially harbor life. The rocky, icy planet is about five-and-a-half times the mass of Earth and is located more than 20,000 light years away in the constellation Sagittarius, close to the center of our Milky Way galaxy. The discovery, detailed in Nature, was made by a collaboration of astronomers worldwide, including the Optical Gravitational Lensing Experiment (OGLE) group co-founded by Bohdan Paczynski (Astrophysical Sciences), who died in 2007. Gravitational microlensing allows astronomers to detect changes in the brightness of a star when a massive object in space—such as a planet, another star, or even a black hole—crosses in front of it. The object’s strong gravitational pull bends the light rays from the distant star and magnifies them like a lens. By analyzing the patterns of the brightening of the distant star’s light rays, researchers can identify the object passing in front of it.

A new method of assembling organic molecules, discovered by a team led by David MacMillan (Chemistry), may sidestep many of the expensive and hazardous barriers that stand in the way of drug development. Many drug molecules produced by pharmaceutical companies can exist as two mirror images—known as enantiomers—that cannot be distinguished by most lab tests, yet can have dramatically different effects on the human body. The organic catalysts discovered by MacMillan’s team and highlighted in Science can be used to selectively produce only one mirror image of a variety of different molecules without employing toxic metal catalysts or generating alternate versions of drug molecules that can damage the body. MacMillan is a pioneer of the field of “organocatalysis,” a new area of chemistry that exclusively employs organic molecules to catalyze chemical reactions instead of metal-containing catalysts that often are toxic, environmentally hazardous, and expensive. The research found that MacMillan’s organic catalysts can activate molecules in a way that was not previously known to produce a variety of single-mirror-image building blocks that will allow the accelerated discovery or production of new single-mirror-image pharmaceuticals. Previous work by MacMillan had established that simple, inexpensive chiral amine catalysts will react with aldehydes (a fundamental chemical building block) to transiently generate enamines that will add selectively to a range of common electrophiles, allowing molecules to be pieced together in a manner that produces only one mirror image. MacMillan demonstrates that upon exposure to an oxidant, the same enamines will undergo electron loss to generate a chiral radical cation that will also couple with a variety of reaction partners that are now nucophile in nature, thereby dramatically expanding the scope of organocatalysis. The team’s work was made possible through the Princeton’s new Merck Center for Catalysis.

Physicists now have an unprecedented level of control over the atomic-level structure of a semiconductor, turning them into magnets through the precise placement of metal atoms within a material from which chips are made. Ali Yazdani (Physics) said that manipulating semiconductors could eventually revolutionize computers by exploiting not just the flow of electrons but also their quantum property, called “spin,” for computation. “Using the tip of a scanning tunneling microscope, we can take out a single atom from the base material and replace it with a single metal that gives the semiconductor its magnetic properties,” said Yazdani. By incorporating manganese atoms into the gallium arsenide semiconductor, the team has created an atomic-scale laboratory that can reveal what researchers have sought for decades: the precise interactions among atoms and electrons in chip material. The team used their new technique to find the optimal arrangements for manganese atoms that can enhance the magnetic properties of gallium arsenide. The results of Yazdani’s research were published as the cover article of Nature.

Using fMRI to break ground in neuroeconomics and other fields, Jonathan Cohen (Psychology and Neuroscience Institute) and his research team are studying the interaction between cognitive and emotional processing. Recent research has begun to explore interactions between cognitive and emotional processes in a variety of behavioral domains, including economic choice (e.g., gambling tasks), social interaction (e.g., ultimatum and bargaining games), and moral decision making. Initial findings, using both behavioral and neuroimaging methods, have provided clear evidence for the prevalent engagement of emotional systems in tasks traditionally considered to be predominantly cognitive. This work offers the hope of producing a more accurate portrayal of real-world behavior, and is also likely to have direct relevance to understanding psychiatric disorders, which invariably involve complex interactions between disturbances of thought and feeling.

An easier and more cost-effective new method to sequence genomes is providing key data in days rather than months. As described in Science by Leonid Kruglyak (Lewis-Sigler Institute and Ecology and Evolutionary Biology), the technique employs new microarrays and computational methods to compare sequences and identify subtle differences between genomes. The microarrays—small, computer-chip-like devices spotted with segments of DNA—enable scientists to quickly establish which genes are expressed at what level in a cell. Microarray experiments to detect small differences in sequence had only been feasible for small regions of genomes. A new product from a company called Affymetrix offered dense coverage of the entire genome of yeast—a commonly used model system for studying many cellular processes—on one microarray. Kruglyak and his team developed the necessary algorithms and software to extract information about small sequence alterations from these arrays.
Many disorders, such as diabetes, cancer, and neurodegenerative diseases, develop in an age-related manner, reducing the quality of life with age. The research being led by Coleen Murphy (Molecular Biology) is focused on identifying the molecular mechanisms underlying such age-related decline. Murphy’s team is using the worm C. elegans, a creature whose biology is well understood by researchers, and genetic, genomic, and biochemical approaches to identify molecular changes associated with age. During C. elegans’ two- to three-week lifespan, it exhibits many obvious phenotypes of aging, such as reduced reproduction, slowed motility, cognitive decline, and tissue deterioration, all of which parallel human aging’s effects. Murphy’s work first identified the genes that are controlled by a major lifespan regulator and then elucidated the cell biological and biochemical mechanisms used by these genes to affect lifespan. The genes that regulate lifespan are conserved from worms to mammals, making findings relevant for humans.

Researchers can now follow the process by which a fly embryo metamorphoses from a single cell into thousands of differentiated cells. While biologists have long known that the structure of adult animals follows a blueprint laid out in the early stages of embryonic development, classical biological experiments have provided only isolated “snapshots” of this process. Now, the team of William Bialek (Physics), David Tank (Molecular Biology and Physics), and Eric Wieschaus (Molecular Biology) has replaced these snapshots with a movie, allowing them to see the first steps of blueprint formation in the fly embryo literally live and in color. In two recent papers, based on the Ph.D. thesis of their student Thomas Gregor, the team followed the signal carried by the protein Bicoid, which is placed in the egg by the mother and provides the first clue for cells to determine their position in the developing embryo. They showed that this signal is extremely stable and reproducible, as if the mother had precise control over the number of molecules that she puts into the egg. They also observed the first cellular responses to Bicoid, and found that two neighboring cells can respond differently even though they experience Bicoid concentrations that differ by only 10 percent. This precision was a surprise, and suggests that these basic biological processes operate with an accuracy close to the physical limits set by the counting of individual molecules.

Contrary to popular belief, Mexican immigration is not a tidal wave—the rate of undocumented migration has not increased in over two decades, and Mexico is not a demographic time bomb, as found by the Mexican Migration Project, co-directed by Douglas Massey (Sociology). Funded by the National Institutes of Health and the Hewlett, Mellon, Russell Sage, and MacArthur foundations, the project has provided annual data on documented and undocumented Mexican migration since 1987 by randomly sampling households in communities located throughout Mexico. After gathering social, demographic, and economic information, interviewers collect basic information on each person’s first and last U.S. trip, compiling a history of U.S. migration and the last trip northward, focusing on employment, earnings, and use of U.S. social services. Following completion of the Mexican surveys, interviewers go to U.S. destination areas to administer identical questionnaires to migrants from the same communities sampled in Mexico. Massey’s work has earned a MERIT Award from the National Institutes of Health and election to the National Academy of Sciences. Massey, along with Jorge Durand and Nolan Malone, described their research on Mexican migration in Beyond Smoke and Mirrors: Mexican Immigration in an Era of Economic Integration.

Physics researchers have invented a higher resolution form of nuclear magnetic resonance (NMR), representing an improvement over standard NMR, which creates images of living tissue without dangerous radiation or intrusive surgery but is limited in obtaining detailed images of those regions. To overcome these limitations, Michael Romalis (Physics) and his team beamed laser light through a sample of liquid and then measured the rotation of the polarized light beam caused by the NMR’s magnetic field. The team observed the effect in water and liquid xenon, two transparent fluids that are commonly used in NMR. Romalis said that the technique was general enough to be used in any transparent liquid and some solids, and could therefore reveal new information about the chemical environment of the nuclei in the illuminated area. The new technique can return information about small volumes of fluid, limited only by the focal power of the laser. The team published their findings in Nature.
The first real-time observation of low-energy solar neutrinos—fundamental particles created by nuclear reactions that stream in vast numbers from the sun’s core—has been made by Frank Calaprice and Cristiano Galbiati (Physics) and Jay Benziger (Chemical Engineering), working as part of an international collaboration at the underground Gran Sasso National Laboratory near L’Aquila, Italy. The team made their observations with the lab’s giant, highly sensitive Borexino detector, located more than a kilometer below the Earth’s surface. The scientists’ precise measurements of the neutrinos’ energy provide long-sought proof of the theory regarding how these neutrinos are produced. Most solar energy is generated by a complex chain of nuclear reactions that converts hydrogen into helium. Steps along several of these reactions’ routes require the presence of the element beryllium, and physicists have theorized that these steps are responsible for creating about 10 percent of the sun’s neutrinos, but technological limitations made the theory difficult to test until now. Most particles that emerge from the sun take so long to escape the interior that they change drastically before scientists can study them, so it has been difficult to prove how the sun creates energy. Neutrinos provide a key because they escape before they have time to change.

Researchers have long had a candidate for the smallest hyperbolic space, a tiny snarl known as the Weeks manifold, but until now they lacked proof. David Gabai (Mathematics) and others have shown that the Weeks manifold is indeed the smallest possible hyperbolic space. Their research, covered in Science, is part of a larger effort to understand the structure of small-volume hyperbolic 3-manifolds. While the concept of least volume is meaningless in ordinary Euclidean geometry, the curvature of hyperbolic geometry brings with it intrinsic units of length, area, and volume. The Weeks manifold is based on the space around a pair of intertwined loops known as the Whitehead link. Links and knots are a fruitful source of hyperbolic manifolds. For many years, the best that was known was that the smallest volume had to be at least 0.001. Only in the past 10 years did Gabai and others begin to improve the bound, first to 0.166, then to 0.33, and, just a few years ago, to 0.67. In mid-2007, Gabai finally had proof of the smallest volume.

Deciphering the liquidity crunch of 2007 is one of the research challenges of Markus Brunnermeier (Economics and Bendheim Center for Finance). He notes that while the estimated losses in subprime mortgages of between $200 to 300 billion seem to be very large, they are relatively modest when put into perspective. For example, the losses roughly correspond to a not-so-uncommon drop between 1 percent and 2 percent of the U.S. stock market. In this light it seems surprising that the mortgage crisis has caused such turmoil in financial markets. To understand this, Brunnermeier studies various amplification mechanisms that explain how modest shocks can cause large dislocations. A crucial concept in his research is the emergence of liquidity spirals. At times of crisis when asset prices and market liquidity drops, funding requirements for financial institutions increase, since the collateral value of the underlying assets erodes and margins rise. Higher margins force financial institutions to cut back on leverage, exacerbating the initial price decline and so forth. Another amplification mechanism is the risk of financial gridlock. This can emerge when financial institutions are lenders and borrowers at the same time and each individual institution is not able to pay its obligation only because the others are not paying theirs. While coordination might resolve this, this may be difficult in today’s complex and interwoven financial system.

Synthetic biology may lead to sweeping medical breakthroughs, thanks to a team led by Ron Weiss (Electrical Engineering), who co-wrote a recent cover story for Scientific American on the emerging field of synthetic biology. The team is programming genetic circuits into stem cells by embedding synthetic biochemical logic circuits, sensors, actuators, and intercellular communication mechanisms into cells. For example, the team is working to design a self-regulating system that instructs mouse stem cells to become insulin-producing pancreatic beta cells, which are mistakenly destroyed by the body’s own immune response in Type I diabetes. The goal is to transplant these engineered stem cells into a human pancreas, restoring the patient’s natural insulin production. In another project, engineered stem cells would be instructed to differentiate into other cell types, potentially regenerating muscle, bone, or even neurons for repairing injured spinal cords. “We can now regard cells as ‘programmable matter,’” Weiss said. “Soon we will be able to program cell behaviors as easily as we program computers.”

Using modern survey, mapping, and digital modeling techniques to step back in time, researchers are deepening their understanding of the history of the late Roman, Byzantine, and Seljuk/Ottoman periods through the Princeton Avkat Survey. The international and multidisciplinary research initiative is led by John Haldon (History and Hellenic Studies) in partnership with colleagues from art and archaeology, Near Eastern studies, geosciences, and others. The project is based in and around the village of Beyözü in Turkey, formerly called Avkat, the site of an ancient and medieval city. With little known about the transition from Roman to Byzantine to Turkish settlement, visualization technologies can help shed light on how ancient people used their land, using multiple data formats for digital imagery for photographic and video footage, satellite imagery and 2- and 3-D remote sensing data as well as archaeological and architectural data records, historical sources, remotely sensed pre-modern communications networks, and paleo-channels. Researchers are reconstructing ancient and medieval landscapes, habitats, communications networks, and settlement patterns to develop a better appreciation of the past, the fragility of the environment, and to understand how to improve it for human use and conservation for the future.
Statistical tools of finance may help solve a range of health problems including pediatric cancer, heart disease, and spinal cord injury through the work of Jianqing Fan (Operations Research and Financial Engineering) and his collaborators. Using statistical tools to overcome the large amounts of noise and bias that exist in experimental microarray data, the researchers worked to identify genes that may play important roles in neuroblastoma tumor progression and metastasis, and represent possible targets for future therapies. In another area of focus, Fan looked at how the inflammatory response to spinal cord injury affects the function of neurons. As published recently in Bioinformatics, Fan and his team proposed several techniques to compare the effectiveness of different microarray normalization methods, which allow researchers to analyze multiple arrays at once. Their work may help guide researchers to choose the most appropriate normalization method for a given array and assess the extent to which “noise” caused by variations in experimental conditions has been removed.

A central concept of nanotechnology has been challenged by Salvatore Torquato (Chemistry), with important implications for the computer and telecommunications industries. Torquato and colleagues published a paper in Physical Review E outlining a mathematical approach that would enable them to produce desired configurations of nanoparticles by manipulating the manner in which the particles interact with one another. The team’s approach, which they call “inverse statistical mechanics,” differs from the traditional trial-and-error method of self-assembly used by nanotechnologists and found in nature, in that they begin with the blueprint of the nanostructure they want to build. They have demonstrated their concept theoretically with computer modeling, illustrating how their technique would apply to three-dimensional systems that normally self-assemble under pressure into a close-packed configuration. But by optimizing the interactions among particles, the team made them self-assemble into a “synthetic” diamond crystal, creating their pattern with “non-directional bonding,” which was not thought to be possible previously. Torquato and his colleagues hope that their efforts will be replicated in colloids in the laboratory.

Regulating levels of carbon dioxide in the Earth’s atmosphere could depend on circulation in Antarctic waters, Jorge Sarmiento (Geosciences) and former graduate student Irina Marinov reported in Nature. Their research found that the waters in the highest latitudes of the Southern Ocean play a far more significant role than was previously thought in regulating atmospheric carbon, and—in contrast to past theories—the waters in the northern part of this region do comparably little to regulate it. Cold water that wells up regularly from the depths of the Southern Ocean spreads out on the ocean’s surface along both sides of the dividing line between the regions, but that water performs two very different functions depending on which side of the line it flows toward, noted Marinov, the study’s lead author. While the water north of the line generally spreads nutrients throughout the world’s oceans, the second, southward-flowing stream soaks up carbon dioxide from the air. Such a sharply defined difference in function could mean that a change to one side of the cycle might not affect the other as much as once suspected.

Researchers at Mid-Infrared Technologies for Health and Environment (MIRTHE) are developing a new generation of low-cost, lightweight, highly sensitive sensors made possible by advances in mid-infrared quantum cascade lasers, with the potential to revolutionize medical diagnostics, detect pollution, and improve homeland security. Led by Claire Gmachl (Electrical Engineering), researchers are using lasers to identify what had been invisible substances in greenhouse gases and compounds that indicate disease. As noted in Nature Materials, MIRTHE researchers recently constructed the first three-dimensional metamaterial made from semiconductors. While materials found in nature have positive refractive indices, the new material invented has a negative index of refraction, which gives it the ability to bend light in the opposite direction from all naturally occurring materials. This material may enable the development of superior lenses and contribute to advances in health, the environment, and security.

To better tackle disease, tiny, biodegradable particles have been developed by a team led by Robert Prud’homme (Chemical Engineering) to deliver medicine deep into the lungs or infiltrate cancer cells while leaving normal ones alone. Only 100 to 300 nanometers wide, the particles can be loaded with medicines or imaging agents, like gold and magnetite, that enhance the detection capabilities of CT scans and MRIs. The particles are made using a new technique called flash nanoprecipitation, which allows researchers to mix drugs and materials that encapsulate them. The success of nanoprecipitation depends in large part on the fact that some molecules are hydrophobic, or water-fearing, while others are hydrophilic, or water-loving. In nanoprecipitation, two streams of liquid are directed toward one another in a confined area, one of which is an organic solvent that contains the medicines and imaging agents, as well as polymers, and the second of which contains pure water. When the streams collide, the hydrophobic medicines, metal-imaging agents and polymers precipitate out of solution in an attempt to avoid the water molecules. The polymers immediately self-assemble onto the drug and imaging agent cluster to form a coating with the hydrophobic portion attached to the nanoparticle core and the hydrophilic portion stretching out into the water. While similar methods had been used to create bulkier pharmaceutical products, the team, which includes colleagues Yannis Kevrekidis and Athanassios Panagiotopoulos, is the first to apply the technology to the creation of nanoparticles.

A new way to trap light better controls transmission and may eventually improve communication technologies. Fiber-optic cables currently used in computers, televisions, and other devices can transport light rapidly and efficiently, but cannot bend at sharp angles. Information in the light pulses has to be converted back into cumbersome electrical signals before they can be sorted and redirected to their proper destinations. As detailed in Nature, Paul Steinhardt (Center for Theoretical Physics) and team constructed a three-dimensional model of a quasicrystal—made of two building blocks, or groups of atoms, that repeat regularly throughout the structure with two different spacings—to test their use for controlling the path of light. Unlike ordinary crystals, which are made from a single building block that repeats with equal spacings, quasicrystals can have more spherical symmetries to better trap and redirect light. The team observed how microwaves were blocked at certain angles to gauge how well the structure would control light passing through it and found building the physical model more valuable than using complex mathematical calculations.
From its inception, the Princeton Plasma Physics Laboratory (PPPL) has been a world leader in the development of magnetic fusion energy as a safe and inexhaustible means of generating electricity. The laboratory has achieved numerous major scientific and technological successes, deepening the theoretical understanding of the very hot gases—called plasmas—the fuel used to produce fusion energy. PPPL has set a number of world records in attaining the plasma conditions required for fusion and in the production of fusion power.

Global warming has brought a heightened sense of urgency to PPPL’s critical mission. Fusion has many advantages, including worldwide long-term availability of low-cost fuel, no contribution to acid rain or global warming, no possibility of a runaway reaction, and materials and by-products unsuitable for weapons production.

**30 Years of PPPL Discovery:**

**1978** First Achievement of Fusion-relevant Plasma Temperatures. The Princeton Large Torus achieved, for the first time, ion temperatures in excess of 58 million degrees Celsius, the minimum required for a self-sustaining fusion reaction.

**1984** Development of the Soft X-ray Laser. PPPL’s Soft X-ray Laser demonstrated X-ray lasing at 18.2 nanometers.

**1986** Discovery of the Self-sustaining Bootstrap Current. The TFTR team positively identified the presence of a powerful self-sustaining current in toroidal fusion plasmas at high temperatures and densities. New Enhanced-confinement Regime Discovered during experiments on the TFTR. Peaked plasma density profiles were obtained with neutral-beam plasma heating, leading to a reduction in energy leakage by a factor of two to three.

**1986** Discovery of the Self-sustaining Bootstrap Current. The TFTR team positively identified the presence of a powerful self-sustaining current in toroidal fusion plasmas at high temperatures and densities. 

**1994** Record Levels of Fusion Power Produced. The TFTR produced a record 10.7 million watts of controlled fusion power in the world’s first series of magnetic fusion experiments using a fuel mixture of 50/50 deuterium/tritium.

**1995** Highest Temperature Ever Produced in a Laboratory. A plasma was heated to 510 million degrees Celsius in PPPL’s Tokamak Fusion Test Reactor (TFTR)—five times that required for production of practical amounts of fusion power.

Start-up of the Magnetic Reconnection Experiment (MRX). MRX is studying the physics of magnetic reconnection—the topological breaking and reconnection of magnetic field lines in plasmas, with a goal of understanding the governing principles of this important plasma physics process and gaining a basic understanding of how it affects plasma confinement and heating. The results of these experiments have relevance to solar physics, astrophysics, magnetospheric physics, and fusion energy research.
Magnetic fusion research at Princeton began in 1951 (code name Project Matterhorn) through the leadership of Lyman Spitzer Jr., professor of astronomy, who for many years had studied very hot, rarefied gases in interstellar space. Inspired by the fascinating but exaggerated claims of fusion researchers in Argentina, Spitzer conceived of a plasma being confined in a figure-eight-shaped tube by an externally generated magnetic field. His concept, deemed “the stellarator,” was reviewed by the Atomic Energy Commission as well as designated scientists throughout the U.S., resulting in funding and the birth of Princeton University’s controlled fusion effort. In 1958, magnetic fusion research was declassified, allowing all nations to share their results openly.

Three years later, Project Matterhorn became PPPL, which today is managed by Princeton University under contract with the United States Department of Energy.

Enhanced Reversed-shear Mode Discovered. During experiments on TFTR, scientists increased the central density of the plasma up to three-fold and reduced particle leakage by a factor of 50 using the enhanced reversed-shear mode of plasma confinement. This could eventually lead to smaller, more economical fusion power plants.


1999 Start-up of National Spherical Torus Experiment. The National Spherical Torus Experiment produced its first plasma two months ahead of schedule and operated with its full design plasma current (1 million amperes) nine months ahead of schedule. It has since surpassed its design value and attained a 1.4 million ampere plasma current. The concept could play an important role in the development of a smaller and more economical fusion reactor.

2000 Progress in Fusion Outpaces Computer Speed

2004 Record Values of Toroidal Beta for National Spherical Torus Experiment. Neutral-beam injection heating coupled with good confinement has resulted in a toroidal beta approaching 40 percent. Beta is a figure of merit that relates to the economics of fusion power production.

PPPL Partners with Oak Ridge National Laboratory. The partnership leads U.S. participation in an international fusion energy project known as the International Thermonuclear Experimental Reactor (ITER), which is an unprecedented international collaboration of scientists and engineers for designing and building a burning plasma experiment. This has been identified as the next major step in the world fusion program. The fusion power produced by ITER (which in Latin means “the way”) will be at least 10 times greater than the external power delivered to heat the plasma.

2005 Dramatic Advances in Magnetic Confinement Physics and Computation Capabilities. These advances have yielded a promising new configuration—the compact stellarator. A new experimental facility, the National Compact Stellarator Experiment (NCSX), is launched as the centerpiece of the U.S. effort to develop the physics and to determine the attractiveness of the compact stellarator as the basis for a fusion power reactor.
As the senior University officer responsible for advancing research at Princeton, the **Dean for Research** oversees the solicitation of research funding, implements Princeton's research policies, and helps to shape the research priorities of the University. The dean also supervises certain research units. In 2006 Princeton University appointed longtime faculty member A. J. Stewart Smith as its first dean for research.

**The University Research Board**, which consists of six faculty members, provides oversight of organized research activities throughout the University, dealing with questions of policy in the acceptance and administration of research grants and contracts, and supervising the application of established policy in this area.

**The Office of Corporate and Foundation Relations** builds strategic partnerships with corporations and foundations in support of research and programs across all academic areas.

**The Office of Research and Project Administration** administers government grants and sponsored research and is responsible for compliance and regulatory matters.

**The Office of Technology Licensing** promotes technology transfer through the patenting and licensing of discoveries made in Princeton laboratories.

“History is the story of people mobilizing intellectual and practical talents to meet demanding challenges…. If our children and grandchildren are to enjoy the prosperity that our forebears earned for us, our nation must quickly invigorate the knowledge institutions that have served it so well in the past and create new ones to serve in the future.”

~ Norman R. Augustine ’57 *59 (Master in Engineering)

Former chair and chief executive officer of Lockheed Martin
The Office of Corporate and Foundation Relations (CFR) builds strategic partnerships in support of the University’s research enterprise by matching the interests of corporations and philanthropic foundations with research being conducted at Princeton. In doing so, CFR promotes intellectual exchange and fosters relationships that deliver breakthrough discoveries to the world. CFR also secures external support for education programs, conferences, scholarly publications, and other University initiatives. Working with corporations and foundations in innovative ways, Princeton researchers are today addressing such fundamental challenges as climate change, sustainable energy, national and international security, child well-being, and global health. Corporate and foundation contributions take many forms—from term funding for specific projects, to in-kind gifts, to endowed fellowships that bring visiting scientists and scholars to campus. Total commitments from corporations and foundations in FY07 were $24 million, with roughly half directly tied to specific research activity.

Princeton offers its partners the opportunity to preview emerging fields and technologies, to collaborate with leading researchers in areas of common interest, and to recruit outstanding young talent. CFR builds support for Princeton programs and projects in all academic areas, from the humanities and social sciences, to the natural sciences, engineering, and policy.

Selected Partnerships

As a National Science Foundation Engineering Research Center, Mid-Infrared Technologies for Health and Environment (MIRTHE) is expected to conduct more than $40 million in research and educational activities over 10 years. Industrial affiliates include Argus; Consensus Business Group; Daylight Solutions; Corning; Klab; Ekips; ExxonMobil; GHO Ventures; Hamamatsu; IRFlex Corporation; LaserMax; Maxion Technologies, Inc.; New Jersey Small Business Development Center; New Jersey Commission on Science and Technology; Pacific Northwest National Laboratory/Battelle; Physical Sciences, Inc.; PTAC; Sandia National Laboratories; Siemens; United States Army Edgewood Chemical Biological Center; and the United States Naval Research Laboratory.

BP and Ford Motor Company have partnered with Princeton to establish the Carbon Mitigation Initiative at the Princeton Environmental Institute, with the goal of developing new approaches to the management of carbon emissions. In 2000 the companies pledged $20 million to support the effort for 10 years.

The Merck Company Foundation has expanded on a 27-year-old Princeton partnership to create the Adel Mahmoud Global Health Scholars Program and Lecture Series in Global Health. The scholars program and lecture series, based at the Center for Health and Wellbeing at the Woodrow Wilson School, is named in honor of global health pioneer Adel Mahmoud M.D., Ph.D. The foundation also recently established the Merck Center for Catalysis and has supported a variety of professorships including most recently one in organic chemistry.

One of world's fastest supercomputers now aids Princeton researchers thanks to a unique partnership with IBM. The “Blue Gene” high-performance computer, nicknamed “Orangena,” already claimed a spot in the “Top500 Supercomputer Sites” 2007 list.

A grant from Johnson & Johnson enabled Princeton to host its first forum on health information, genomics, and ethics in 2007. The forum addressed the impact of the global economy and demographics on the healthcare landscape, medical privacy and patients' rights, and personal genome information profiles. In addition, J&J has supported numerous research projects in chemistry, molecular biology, and synthetic biology.

A new partnership between the Princeton University Library and Google will make approximately 1 million books in Princeton’s collection available online in a searchable format.

Through the joint support of the Ford Foundation, the William and Flora Hewlett Foundation, and a generous gift from David Rubenstein, co-founder and managing director of the Carlyle Group, the Woodrow Wilson School Princeton Project on National Security has proposed a sustainable and effective national security strategy for the United States.

Responding to the urgent need for more investment in science education, the Howard Hughes Medical Institute has provided a four-year commitment to Princeton’s Undergraduate Science Education Program to improve education in the biological sciences.

The Andrew W. Mellon Foundation has awarded three grants under the Emeritus Faculty Fellowship program to support research projects by outstanding scholars who have recently retired, provided support of the Center for Arts and Cultural Policy Studies, and funded a New Directions Fellowship.
The Office of Research and Project Administration (ORPA) manages the entire lifecycle of sponsored research—from proposal submission through award close-out—with the goal of providing principal investigators, grants managers, and central and lab administration officials with the resources to manage sponsored funds effectively.

Specifically, ORPA assists faculty members and students in their search for funding by reviewing proposals, negotiating awards, and managing post-award administration, including monitoring sponsored projects for compliance with sponsor terms and conditions, University policies, and federal regulations. Working closely with departmental and financial officers, ORPA prepares and implements financial, administrative, and compliance policies and procedures of interest to the research community.

Princeton research sponsored by external funding totaled $219 million in 2007, which includes $74 million in external funding to the Princeton Plasma Physics Laboratory (PPPL). The total funding accounts for 22 percent of Princeton’s operating budget. External sources funded 1,235 separate research projects in 2006–07 (not including the PPPL). There were 531 sponsored projects in the natural sciences, 448 in engineering and applied sciences, 170 in the humanities and social sciences, and 86 in centers, institutes, and non-departmental programs. Funding for these projects totaled $145 million—86.6 percent from government, 8.2 percent from foundations, 3.4 percent from industry, and 1.8 percent from other sources.
Bringing discoveries made by Princeton faculty to bear on real-world problems is a vital enterprise for the University. The ability to unleash the power of intellectual property through technology transfer supports the mission of the University, and helps to recruit and retain outstanding faculty.

Working on the frontiers of knowledge can lead to discoveries that offer commercial success, but this is not the main goal at a research university. The goal at Princeton is to support the best people as they work at the highest level in their disciplines. On occasion, this research coincides with efforts in industry and leads to extraordinary outcomes.

For example, Princeton is the home of such discoveries as the cancer drug Alimta™ invented by Edward C. Taylor, the A. Barton Hepburn Professor of Organic Chemistry Emeritus and senior chemist, in collaboration with Eli Lilly. The story of Alimta highlights how basic, curiosity-driven research can yield completely unpredictable discoveries many years later. As a student in 1946, Taylor was intrigued by a newly identified organic molecule with a unique architecture—two fused loops of carbon and nitrogen atoms seen before only in the wing pigments of butterflies. That molecule, later known as folic acid, became a target for inhibiting cancers. Taylor established himself as the leading expert on folic acid chemistry and biochemistry, and in the 1970s his research focused on the synthesis of antitumor agents. Realizing that his discoveries had biomedical potential, Taylor partnered with Eli Lilly in 1985 to create scores of new molecules aimed at interfering with folic acid and cancer growth. One of these molecules eventually became Alimta—a perfect example of how curiosity can lead to scientific discovery that can change the world. Taylor’s drug reduces or eliminates a variety of solid tumors while easing suffering and extending life. Initially, it was targeted to slow the progress of malignant pleural mesothelioma, a lethal and painful cancer of the chest wall often caused by asbestos. For his work, Taylor received the Heroes in Chemistry award from the American Chemical Society.

Princeton maintains an ongoing active program to identify and protect its discoveries. In fiscal year 2007 alone, Princeton filed over 100 patent applications in the United States. However, the protection of intellectual property is only the beginning of the technology transfer process. In order for the public to benefit from these ideas, a company must further develop the intellectual property and bring it to the marketplace. Princeton therefore has a vigorous program to identify and license industrial collaborators, resulting in the execution of 23 new agreements to commercialize 25 new technologies. Additionally, Princeton received almost $35 million in revenues relating to the licensing of its intellectual property.

In FY 2007, Princeton received $37.6 million in program income related to the licensing of its intellectual property.

Princeton University Patents and Licensing Activity
FY 2003–07

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* Shows the number of Princeton technologies that are licensed and/or optioned yearly.
“From John Witherspoon in the 18th century, to the great physicist Joseph
Henry in the 19th, to the celebrated literary critic Carlos Baker *40 in the 20th,
Princeton’s faculty are the magnets that draw each year to campus the most
talented students in the world. The scientific and scholarly distinction of our
faculty is evident in their books published by the best university presses, their
publications in prestigious journals, the major research grants that they suc-
cessfully compete for, and, last but not least, in their selection for national and
international awards. Spanning every discipline, these honors are both a form of
public recognition and a source of practical support.”

~ Shirley M. Tilghman, president

Claire Gmachl, professor of electrical engineering, received a MacArthur Fellowship in 2005 from the
John D. and Catherine T. MacArthur Foundation and is the fourth member of Princeton’s faculty to receive
this “genius grant” in the last six years. Gmachl’s research involves the development of quantum cascade lasers, a high-per-
formance and exceptionally versatile semiconductor light source with a wide range of applications—from detecting explosives to enhancing wireless communication. Winning a MacArthur in 2001 was David Spergel, the Charles A.
Young Professor of Astronomy on the Class of 1897 Foundation, professor of astrophysical sciences, and chair of that department. Bonnie Bassler, the Squibb Professor in Molecular Biology, won in 2002, and Naomi Leonard, professor of mechanical and aerospace engineering, won in 2004.

Alan Krueger, the Bendheim Professor in Economics and Public Policy, was awarded the 2006
IZA Prize in Labor Economics by Germany’s Institute for the Study of Labor. Along with former professor of economics David Card *83, Krueger was honored for a multifaceted body of work that has “crucially shaped the research agenda in labor economics and has certainly raised the standards for empirical research in applied economics.”

Andrei Okounkov, professor of mathematics, received the Fields Medal, his discipline’s highest
honor, in 2006 for producing work that “has revealed profound new connections between different areas of math-
ematics and has brought new insights into problems arising in physics.”

Peter Schäfer, the Ronald O. Perelman Professor of Jewish Studies, professor of religion, and director of
the Program in Judaic Studies, received an Andrew W. Mellon Foundation Distinguished Achievement
Award in 2006 in recognition of his far-reaching contributions to the field of Judaic studies and an array of related disciplines. Schäfer joins Henry Putnam University Professor of History
Anthony Grafton, Philip and Beulah Rollins Professor of History
Peter Brown, Edmund N. Carpenter II Class of 1943 Professor in the Humanities and Professor of Philosophy and Comparative Literature Alexander Nehamas *71, and Class of 1943 University Professor of Near Eastern Studies Michael Cook as the fifth
member of Princeton’s faculty to win this award.

Marta Tienda, the Maurice P. During ’22 Professor in Demographic Studies and professor of sociology
and public affairs, received the 2006 Outstanding Latina Faculty in Higher Education Award in Research and Teaching from the American Association of Hispanics in Higher Education.

Yueh-Lin (Lynn) Loo, associate professor of chemical engineering, received the Allan P. Colburn
Award from the American Institute of Chemical Engineers in 2006.
C. K. Williams, lecturer with the rank of professor in creative writing and the Peter B. Lewis Center for the Arts, received the 2005 Ruth Lilly Poetry Prize, conferred on American poets “whose lifetime accomplishments warrant extraordinary recognition.” Williams, whose previous honors include a Pulitzer Prize and National Book Award, was cited by Poetry Foundation president John Barr for crafting poems that represent “a joint venture between place . . . and the state of mind observing the place,” a collaboration that “brings us to a more nuanced understanding of what it is to be human.”

Princeton faculty and Geophysical Fluid Dynamics Laboratory scientists were among the ranks of distinguished scientists who played lead roles in the U.N. Intergovernmental Panel on Climate Change, which was awarded the 2007 Nobel Peace Prize with former U.S. Vice President Al Gore. Past faculty members David Gross and Frank Wilczek (*’73), along with David Politzer, received the 2004 Nobel Prize in Physics for their 1973 discovery of asymptotic freedom. This phenomenon, and its connection with the theory of strong interactions, was discovered by Gross and Wilczek at Princeton and independently by Politzer at Harvard. Asymptotic freedom is one of the cornerstones of modern particle physics.

Five Princeton faculty members have been elected to the 2007 National Academy of Sciences. They are among 72 new members and 18 foreign associates chosen in recognition of their distinguished and continuing accomplishments in original research. The inductees are: Bruce Draine, professor of astrophysical sciences; Peter Grant, the Class of 1877 Professor of Zoology and professor of ecology and evolutionary biology; Philip Johnson-Laird, the Stuart Professor of Psychology; Stephen Pacala, the Frederick D. Petrie Professor in Ecology and Evolutionary Biology and director of the Princeton Environmental Institute; and David Spergel, the Charles A. Young Professor of Astronomy on the Class of 1897 Foundation, professor of astrophysical sciences, and chair of that department.

Simon Levin, the George M. Moffett Professor of Biology and professor of ecology and evolutionary biology, won the 2005 Kyoto Prize for his use of mathematical models to understand the complex patterns of the biosphere. He also received the 2007 American Institute of Biological Sciences Distinguished Scientist Award.

Named to the National Academy of Engineering: 2007—

Stephen Chou, the Joseph C. Elgin Professor of Engineering and professor of electrical engineering; was recognized for his invention of the nonimprinting technique, and also won a Nano 50 award from Nanotech Briefs magazine; 2006—

Harvey Lam, the Edwin S. Wiley Professor of Mechanical and Aerospace Engineering Emeritus, was named for his “contributions to aerospace engineering in the areas of plasma flows, combustion, turbulence, and adaptive controls”; 2005—

Robert Calderbank, professor of electrical engineering, mathematics, and applied and computational mathematics and director of the Program in Applied and Computational Mathematics, was acknowledged for “leadership in communications research, from advances in algebraic coding theory to signal processing for wire-line and wireless modems;” and J. Stuart Hunter, professor of civil engineering emeritus, for “the development and application of statistical methods for efficiently designed experiments and data interpretation.”

The Center for Architecture, Urbanism, and Infrastructure won the 2007 Latrobe Prize to fund a project transforming the Upper Bay of the New York Harbor into a Central Park of the 21st century, led by Guy Nordenson, professor of architecture, and James Smith, professor of civil and environmental engineering, director of the Program in Geological Engineering, and director of the Program in Environmental Engineering and Water Resources.

President Shirley M. Tilghman was awarded the 2007 Genetics Society of America Medal for her pioneering work in epigenetics and imprinting, which has expanded knowledge of embryo development in mammals.

The 2007 Pioneer Prize was awarded by the International Council for Industrial and Applied Mathematics to Ingrid Daubechies, the William R. Kenan Jr. Professor of Mathematics and Applied and Computational Mathematics, for her mathematical contributions to time-frequency analysis, recognizing her contributions to applied mathematics and computing that have transformed science and industry, specifically in the area of wavelets, which have important applications in data compression.

Manuel Linós, assistant professor of molecular biology and the Lewis-Sigler Institute for Integrative Genomics, received a 2007 Burroughs Wellcome Investigators in Pathogenesis of Infectious Disease Award for Research to investigate the metabolic aspect of host-pathogen interactions in the malaria-causing parasite Plasmodium falciparum as a means to identify novel drug targets.

The Society for Industrial and Applied Mathematics presented the 2007 Ralph E. Kleinman Prize to Salvatore Torquato, professor of chemistry and the Princeton Institute for the Science and Technology of Materials and a senior faculty fellow in the Princeton Center for Theoretical Physics. Torquato was recognized for his contributions to the modeling, analysis, and computational study of heterogeneous materials. His multifaceted approach has led to highly original advances in the characterization of microstructure, the prediction of macroscopic properties of heterogeneous materials, percolation theory, the understanding of liquid and glass states, and the optimal design of composite microstructures.

Joyce Carol Oates, the Roger S. Berlind ’52 Professor in the Humanities, was named the 2007 Humanist of the Year by the American Humanist Association. Oates, also a professor of creative writing and the Peter B. Lewis Center for the Arts, has earned the National Book Award, the PEN/Malamud Award, and the O. Henry Prize, among other honors.

James McPherson, the George Henry Davis 1886 Professor of American History, Emeritus, in 2007 received the first Pritzker Military Library Literature Award for lifetime achievement in military writing and the Ford’s Theatre Lincoln Medal.
The National Academy of Sciences selected Robert Cava, the Russell Wellman Moore Professor of Chemistry, to receive the 2005 John Carty Award for the Advancement of Science. The academy cited Cava “for his outstanding contributions in the synthesis and characterization of many new materials that display interesting and important superconducting, dielectric, magnetic, or thermal properties.” Cava, who is also chair of the Department of Chemistry, is a member of the Princeton Institute for the Science and Technology of Materials.

Giacinto Scoles, the Donner Professor of Science and professor of chemistry, received the 2006 Benjamin Franklin Medal in Physics for development of new techniques for studying molecules, including unstable species that could not be examined otherwise, by embedding them in extremely small and ultra-cold droplets of helium.

The European Geosciences Union chose Eric Wood, professor of civil and environmental engineering, to receive the 2007 John Dalton Medal, “for distinguished research in hydrology reviewed as an earth science.” Wood heads the department’s land-surface hydrology research group.

David MacMillan, the A. Barton Hepburn Professor of Organic Chemistry, received the American Chemical Society’s 2007 Arthur C. Cope Scholar Award and the Mukaiyama Award, presented by the Society of Synthetic Organic Chemistry in Japan.

Rosemary Grant and Jeremiah Ostriker were elected to the Royal Society, the United Kingdom’s national academy of science in 2007. Grant, a senior research biologist in the Department of Ecology and Evolutionary Biology and a native of Scotland, received the Darwin Medal from the Royal Society in 2002. Ostriker, a professor of astrophysical sciences and director of the Princeton Institute for Computational Science and Engineering, was elected one of the society’s foreign members, and received the U.S. National Medal of Science in 2000 and the Royal Astronomical Society Gold Medal in 2004.

Cornel West, the Class of 1943 University Professor in the Center for African American Studies, received the 2005 Lannan Prize for Cultural Freedom at Shiloh Baptist Church in Sacramento, his childhood house of worship. The award recognizes work celebrating the human right to freedom of imagination, inquiry, and expression. His latest book is Democracy Matters: Winning the Fight Against Imperialism.

In 2006 the National Science Foundation granted CAREER awards, its most prestigious grants for scientists early in their careers, to Craig Arnold, Benjamin Sudakov, and Olga Troyanskaya. Arnold, an assistant professor of mechanical and aero space engineering, will develop new ways of processing materials that could result in improved batteries and other devices. Sudakov, an assistant professor of mathematics, is studying problems related to Ramsey theory, graph colorings, extremal combinatorics, and random and pseudo-random graphs. Troyanskaya, an assistant professor of computer science and the Lewis-Sigler Institute for Integrative Genomics, will combine computational and experimental techniques for analyzing networks of biological processes within organisms.

David Bellos, professor of French and Italian, professor of comparative literature, and director of the Program in Translation and Intercultural Communication, received the Translator’s Prize attached to the first Man Booker International Award for Fiction, won in 2005 by the Albanian novelist Ismail Kadare. Bellos has translated six of Kadare’s novels into English.

Professor of French and Italian Pietro Frassica received the Italian Val Comino Prize in Rome for his 2004 book, Variants and Invariants in Evoked Themes, which analyzes the works of several 20th-century Italian authors.

John Carty Award

Ana Caraiani, Class of 2007, was the 2007 recipient of the Alice T. Schafer Prize for Excellence in Mathematics by an Undergraduate Woman from the Association for Women in Mathematics.

The American Mathematical Society awarded its 2005 Stefan Bergman Prize to the Albert Baldwin Dod Professor of Mathematics, Elias Stein.

Paul Seymour, professor of mathematics and applied computational mathematics, received one of three Fulkerson Prizes for 2006, sponsored jointly by the Mathematical Programming Society and the American Mathematical Society.

Zoltan Szabo, professor of mathematics, was awarded the 2007 Oswald Veblen Prize in Geometry by the American Mathematical Society for contributions made to three- and four-dimensional topology.

Assistant Professor of Molecular Biology and the Lewis-Sigler Institute for Integrative Genomics Coleen Murphy was named a 2006 PEW Scholar by the Pew Charitable Trusts and the University of California–San Francisco. In addition, she received an Ellison Medical Foundation New Scholars in Aging award to support basic biomedical research on understanding aging processes and age-related diseases and disabilities.

Joshua Rabinowitz, assistant professor in chemistry and the Lewis-Sigler Institute for Integrative Genomics, was awarded an Arnold and Mabel Beckman Foundation Young Investigators grant in 2005 and received the NSF Early Career Award.

Assistant Professor of Electrical Engineering Li-Shiuan Peh was named the winner of the 2007 Anita Borg Early Career Award by the Computer Research Association’s Committee on the Status of Women in Computing Research.


Two papers co-authored by Professor of Electrical Engineering Niraj Jha have been selected as being among 2007 “The Most Influential Papers of 10 Years” and were part of the Design Automation and Test in Europe Conference, which is among the top three most prestigious conferences in the field.
Robert Fagles, the Arthur W. Marks ’19 Professor of Comparative Literature, Emeritus, and Bernard Lewis, the Cleveland Dodge Professor of Near Eastern Studies, Emeritus, were awarded the 2006 National Humanities Medal by President George W. Bush.

Thomas DaCosta Kaufmann, the Marquand Professor of Art and Archaeology, received the F. Polacky Honorary Medal for Merit in Social Sciences by the Czech Academy of Sciences in 2006; in 2005 he was named a Halecki Lecturer, and he was appointed to the National Committee for the History of Art.

João Biehl, associate professor of anthropology, won the 2007 Margaret Mead Award for his book Vita: Life in a Zone of Social Abandonment, which was its sixth major award.

The 2005 Crafoord Prize, known as the “Nobel Prize” of astronomy, was awarded to James Gunn, the Eugene Higgins Professor of Astronomy, and James Peebles, the Albert Einstein Professor of Science, Emeritus, and professor of physics, emeritus. Gunn also received the 2006 Gruber Prize and the 2005 Russell Prize. Astrophysicist Bohdan Paczynski, who died in 2007, received the 2006 Russell Prize.

The National Ground Water Association chose Michael Celia, professor of civil and environmental engineering and chair of that department, as the 2008 Henry Darcy Distinguished Lecturer, citing him “as one of the most outstanding ground water hydrologists in North America.”

Valerie Smith, the Woodrow Wilson Professor of Literature, professor of English and the Center for African American Studies, was named an Alphonse Fletcher Sr. Fellow in 2006 to pursue a research project that contributes to improving race relations in American society.

Rubén Gallo, associate professor of Spanish and Portuguese languages and cultures, received the 2006 Katherine Singer Kovacs Prize recognizing an outstanding book published in English in the field of Latin American and Spanish literatures and cultures. Gallo’s book Mexican Modernity: The Avant-Garde and the Technological Revolution was chosen by the Committee on Honors and Awards of the Modern Language Association.

David Tank, the Henry L. Hillman Professor in Molecular Biology, professor of molecular biology and physics, and co-director of the Princeton Neuroscience Institute, received the Alden Spencer Award from the Center for Neurobiology and Behavior at Columbia University in 2006.

Jason Lyall, assistant professor of politics and international affairs at the Woodrow Wilson School, received the 2007 American Political Science Association’s Helen Dwight Reid Award.

In 2006 Mung Chiang, assistant professor of electrical engineering, was named one of the world’s top 35 innovators under the age of 35 by Technology Review magazine.

Five Princeton faculty members were selected as Alfred Sloan Research Fellows in 2007: Simone Warzel and Jacob Rasmussen, assistant professors of mathematics; Anatoly Spitkovsky, assistant professor of astrophysical sciences; Boaz Barak, assistant professor of computer science; and Esteban Rossi-Hansberg, professor of economics and international affairs in the Woodrow Wilson School. 2006 winners included Marco Battaglini, assistant professor of economics, Niklas Beisert, assistant professor of physics, Simon Brendle, assistant professor of mathematics, Coleen Murphy, assistant professor of molecular biology, Li-Shuan Peh, assistant professor of electrical engineering, and Alice Shapley, assistant professor of astrophysical sciences. Barak and Shapley have also received prestigious fellowships from the David and Lucile Packard Foundation.

Guggenheim Fellowships: 2007—Daniel Rodgers, the Henry Charles Lea Professor of History, for research on “Transformation in Social Thought in 1980s America”; José Scheinkman, the Theodore A. Wells ’29 Professor of Economics, for research on “The Economics of the Informal Sector”; Nigel Smith, professor of English and chair of the Committee for Renaissance Studies, for research on “Literary Production in Early Modern Europe, 1500–1700”; Dmitri Tymoczko, assistant professor of music, for music composition; Michael Wachtel, professor of Slavic languages and literatures, for research on “Pushkin’s Lyric Poetry”; Tommy White, lecturer in visual arts and the Peter B. Lewis Center for the Arts, for painting.

2006—Diana Fuss, the Louis W. Fairchild ’24 Professor of English, for “Poetry and the Art of Resuscitation”; Daniel Trueman, assistant professor of music, for music composition.

2005—Leonard Barkan, the Arthur W. Marks ’19 Professor of Comparative Literature and director of the Society of Fellows in the Liberal Arts, for research on “The Analogy of Poetry and Painting”; Yannis Kevrekidis, the PomEROY and Betty Perry Smith Professor in Engineering and professor of chemical engineering, for research on “Equation-free Studies of Complex Systems”; Philip Nord, the Rosengarten Professor of Modern and Contemporary History, for research on “Institutional and Cultural Reform in the Modern French State, 1930–1950”; John Pinto, the Howard Crosby Butler Memorial Professor of the History of Architecture and professor of art and archaeology, for research on “Architecture and Urbanism in Rome, 1680–1780”; Valerie Smith, the Woodrow Wilson Professor of Literature, professor of English and Center for African American Studies, and director of the Center for African American Studies, for research on “The Civil Rights Movement in Cultural Memory”; Vance Smith, associate professor of English, director of the Program in Medieval Studies, and chair of the Committee on Index of Christian Art, for research on “The Relation between Language and Death in Middle English Literature.”
Selected Research Centers and Initiatives

Arts and Culture
Center for Arts and Cultural Policy Studies
Index of Christian Art
Lewis Center for the Arts
Tang Center for East Asian Art
University Art Museum

Economics and Finance
Bendheim Center for Finance
Center for Economic Policy Studies
Chow Econometric Research Section
Industrial Relations Section
International Economics Section

Engineering
Center for Information Technology Policy
Mid-Infrared Technologies for Health and the Environment
Operations Research and Financial Engineering
Princeton Institute for the Science and Technology of Materials
Program in Integrative Information, Computer, and Application Sciences

Environmental and Earth Science
Carbon Mitigation Initiative
Center for Biocomplexity
Center for Environmental Bioinorganic Chemistry
Cooperative Institute for Climate Science
Princeton Environmental Institute
Program in Atmospheric and Oceanic Sciences

Ethics, Religion, and Society
Center for African American Studies
Center for the Study of Religion
University Center for Human Values

Health and Wellbeing
Bendheim-Thoman Center for Research on Child Wellbeing
Center for Health and Wellbeing
Center for Health Care Strategies

Historical Studies
Center for the Study of Books and Media
Davis Center for Historical Studies

International Affairs
Center for Migration and Development
Institute for the Transregional Study of the Contemporary Middle East, North Africa, and Central Asia
Liechtenstein Institute on Self-Determination
Princeton Institute for International and Regional Studies
Research Program in Developmental Studies

Liberal Arts
Council of the Humanities
Program in Translation and Intercultural Communication
Society of Fellows in the Liberal Arts

Life Science and Psychology
Center for the Study of Brain, Mind, and Behavior
Lewis-Sigler Institute for Integrative Genomics
Princeton Neuroscience Institute

Mathematics and Computational Science
Princeton Institute for Computational Science and Engineering
Program in Applied and Computational Mathematics
Program in Integrative Information, Computer, and Application Sciences

National Laboratories
Geophysical Fluid Dynamics Laboratory
Princeton Plasma Physics Laboratory

Physical and Chemical Sciences
Center for Theoretical Physics
Imaging and Analysis Center
Princeton Center for Complex Materials

Politics and Public Affairs
Bobst Center for Peace and Justice
Center for Arts and Cultural Policy Studies
Center for the Study of Democratic Politics
James Madison Program in American Ideals and Institutions
Policy Research Institute for the Region
Princeton Laboratory for Experimental Social Science
Program in Low and Public Affairs
Program in Science, Technology, and Environmental Policy
Program on Science and Global Security

Population and Statistical Research
Office of Population Research
Center for Migration and Development
Survey Research Center

Architect’s rendering at left:
As part of a new science neighborhood, the new chemistry building, designed by Hopkins Architects of London in collaboration with Payette Associates of Boston, will be closer to the facilities for physics, molecular biology, genomics, and other science departments. Construction is expected to be completed by 2013.
Many leading colleges and universities make a choice between research and teaching. Great liberal arts colleges tend to put teaching first and research second. Great research universities often put research first and undergraduate teaching second. Princeton insists on both.

~ Christopher L. Eisgruber, provost

Princeton University

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