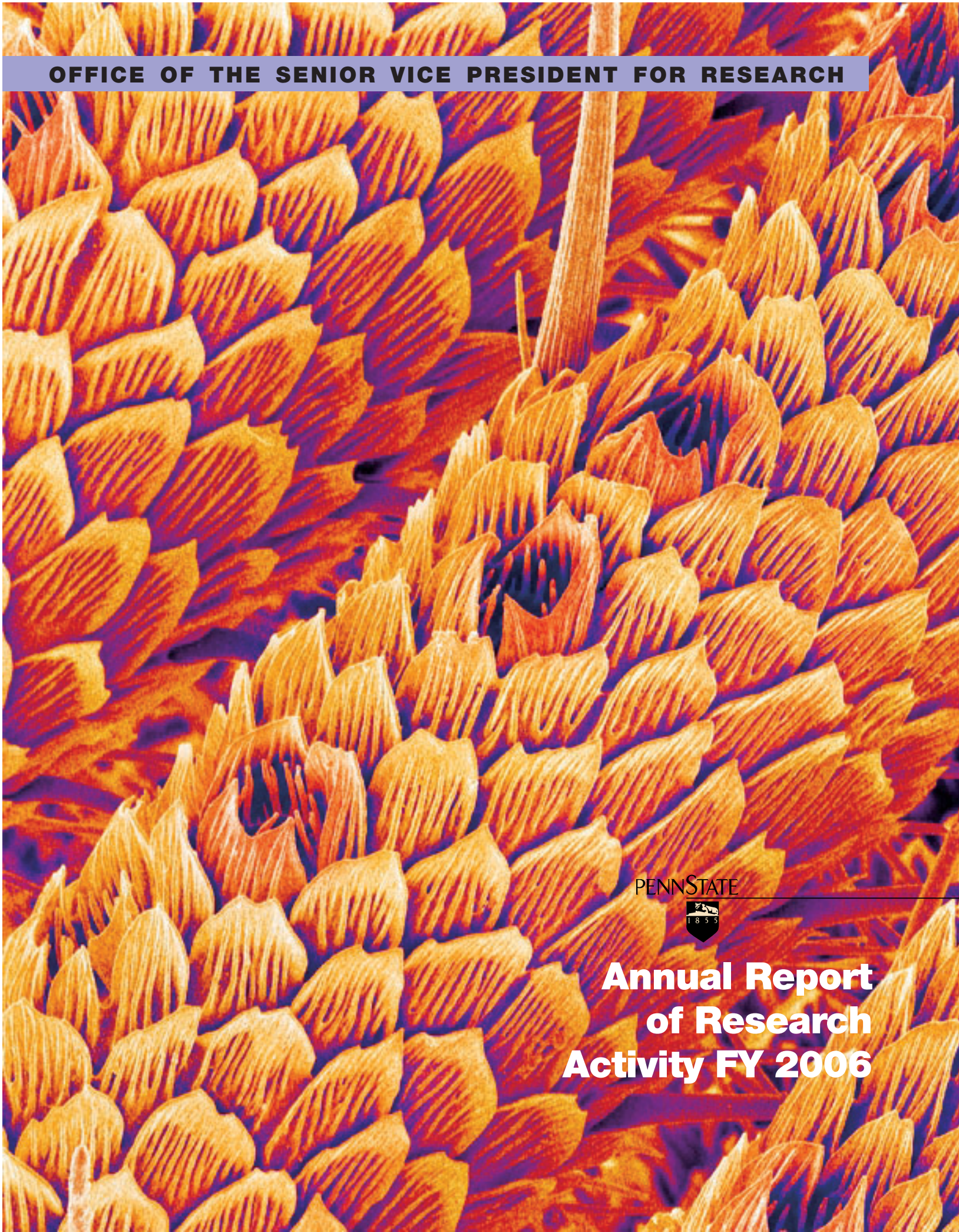

OFFICE OF THE SENIOR VICE PRESIDENT FOR RESEARCH
PENNSTATE
1855
Annual Report of Research Activity FY 2006

WELCOME

Cover: A scanning electron micrograph (SEM) image shows smell receptors (dark pits) on a moth's antenna. Penn State researchers are incorporating antennae arrays into a highly sensitive biosensor that can detect, discriminate, and locate unexploded land mines and other ordnance, drugs, and toxins.
See page 10.
Credit: Susumu Nishinaga / Photo Researchers, Inc.

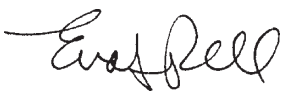
As one of the nation's leading research universities, Penn State impacts the region, the Commonwealth, and the nation in many different ways.

From its land-grant charter, Penn State has always emphasized "translational" research: the work that turns basic discoveries into real-world applications. In the twenty-first century, one important focus of this translation is economic development, as universities help to strengthen and revitalize their surrounding economies with the power of innovation. Penn State's number-two national ranking in industry-sponsored research expenditures is one measure of our commitment to this role.

In broader view, Penn State researchers are facing and solving the complex problems of the future—from developing sources of renewable energy to improving homeland security. Increasingly, doing so requires thinking and acting across disparate disciplines and seeing beyond traditional boundaries.

At Penn State, this interdisciplinarity is strong and growing stronger. Two projects highlighted in this report make particularly good examples. In one, materials scientists and entomologists are working together on an environmental sensor inspired by the exquisite sensitivity of a moth's antennae. In another, a biochemist and a geoscientist, jointly investigating an obscure undersea microbe, have uncovered both a new theory to explain life's origins and a potential source of energy.

A sampling of other research accomplishments are included in these pages, along with a breakdown and summary of Penn State's research activity during FY 2006. Whether the impact is local or global, the goal of these efforts remains the same: To create new knowledge that improves people's lives.



Eva J. Pell, Senior Vice President for Research and Dean of The Graduate School

Total research expenditures at Penn State increased by three percent in FY2006, moving from $638 million to $657 million. Included in this total was $372 million in funding from federal agencies, up from $365 million a year ago. Funding from the Department of Defense increased 2.5 percent to $149 million. Funding from the Department of Energy increased 48 percent to $20 million. Research expenditures supported by the Commonwealth of Pennsylvania were up 15 percent to $46 million.

An important component in Penn State's success is the wide-ranging quality of the University's research program. According to National Science Foundation data for 2004, the latest year available, Penn State ranked 9th overall among all U.S. universities in R&D expenditures, up from 11th in 2003, and tied with Johns Hopkins with more top-ten rankings for individual fields of study (14) than any other school in the top 20. As another measure of this breadth, Penn State ranked first in both materials and sociology.

At a time when industry sponsorship of research has declined nationally, Penn State's industry-sponsored research increased seven percent to $93 million, placing Penn State second in the nation in this important category. Last year the University engaged in 799 research projects with 371 companies in Pennsylvania totaling $31.6 million, and over 3,104 projects with over 1,151 companies nationwide. In addition, Penn State actively supports economic development in the state and beyond through its offices of technology transfer, whose activities are detailed on pages 12 and 13 below.

The University's relationships with industry reflect Penn State's core philosophy as the nation's second-largest land-grant institution, and benefit from its historic strengths in science and engineering. These relationships take many forms, from master agreements with large multi-national corporations to small-scale problem-solving for individual inventors.

Penn State currently has master agreements with some 35 companies inside and outside Pennsylvania, including Lockheed Martin, Bayer Materials Science, Air Products, Kennemetal, Eastman Kodak, and Pratt & Whitney. The latter is a key partner in a new Center for Advanced Power Generation Research to be located at the Philadelphia Navy Yard, one of a number of initiatives Penn State is pursuing as part of the Navy Yard's redevelopment as a key economic engine for the city of Philadelphia (see page 11).

Closer to University Park, the I-99 Innovation Corridor (see page 6) provides plentiful opportunities for small- and medium-sized companies seeking access to Penn State facilities and expertise.

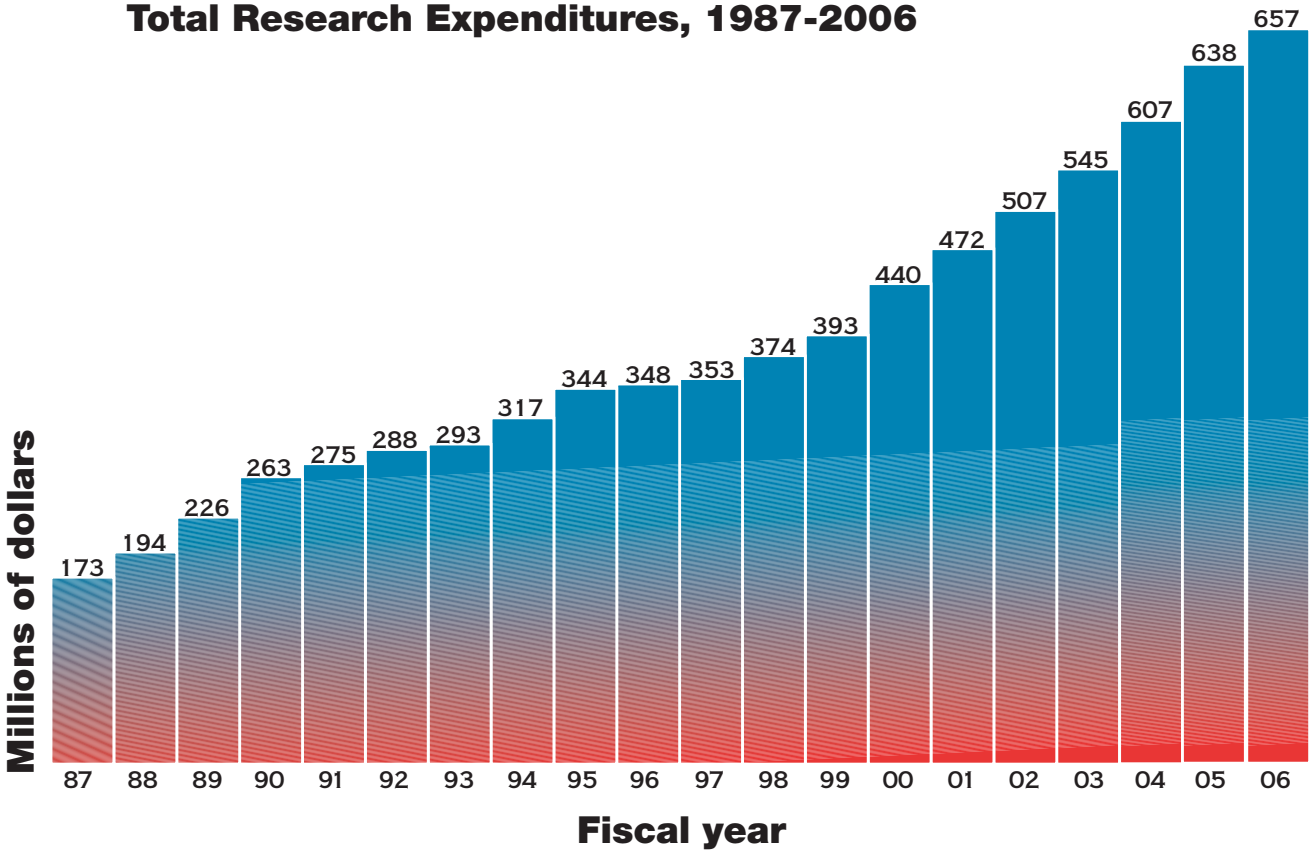
Another increasingly important way the University fosters economic development is through commercialization of its intellectual property in start-up companies. Over the past five years, an average of five new companies has been created annually. In 2005, a new program called Discovery@Penn State was initiated to identify additional start-up opportunities.

All of these economic-development activities, local, regional, and national, are natural outgrowths of the University's land-grant mission, stresses Eva J. Pell, senior vice president for research. "We're national leaders in industry-sponsored research," Pell says, "because we know how to do it so well."

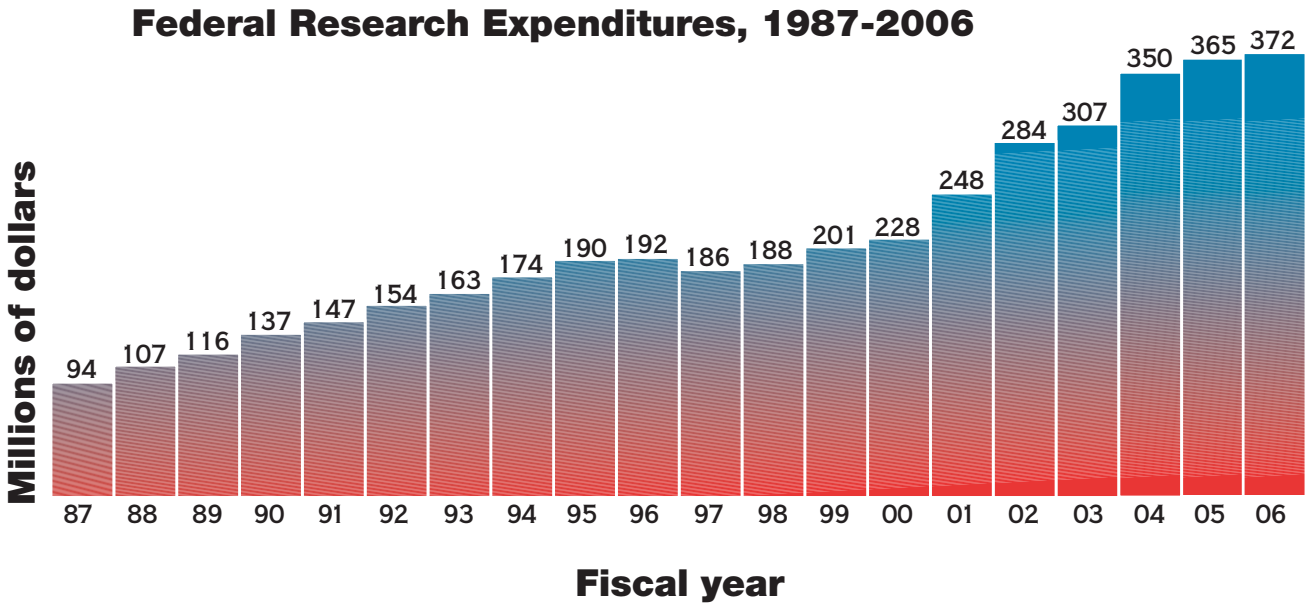
Courtesy Philadelphia Industrial Development Corporation

Aerial view of the Philadelphia Navy Yard, with the Delaware River in the foreground and Center City Philadelphia in the background. Penn State is pursuing several new research-based economic development initiatives as part of the Navy Yard's redevelopment.

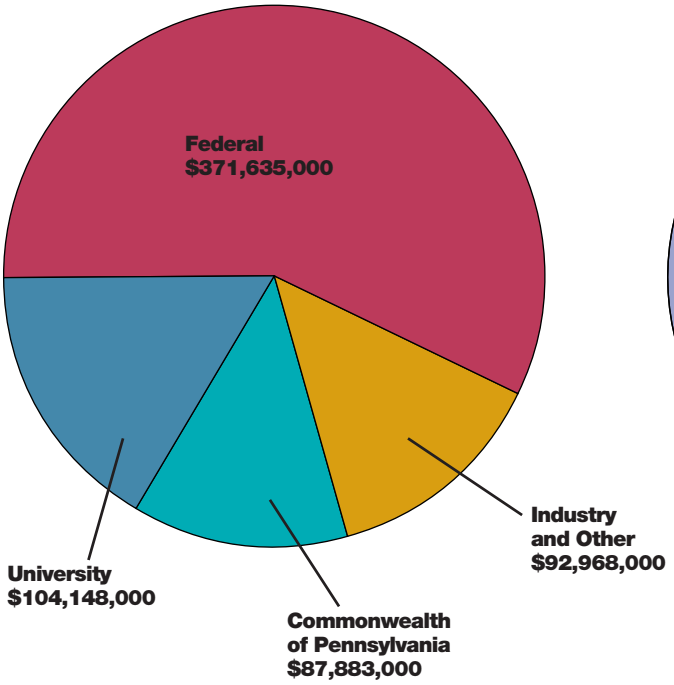
Total Research Expenditures, 1987-2006



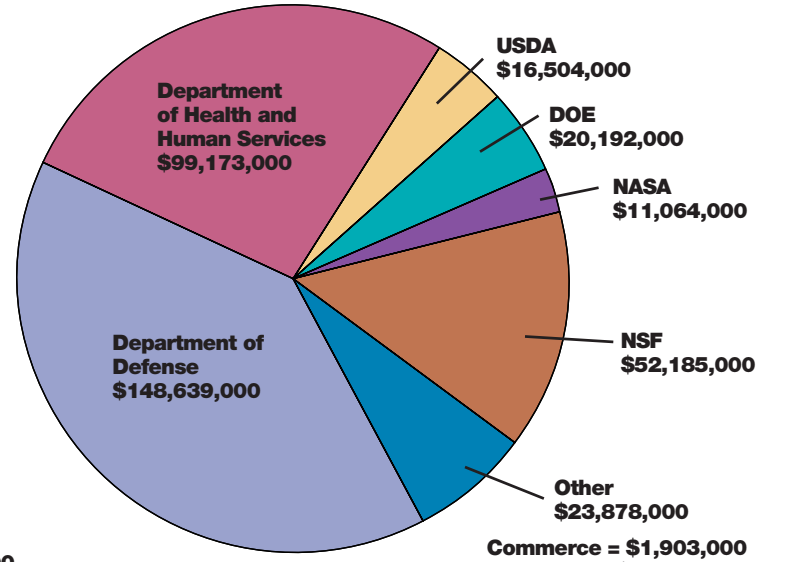
Federal Research Expenditures, 1987-2006



Sources of Research Funding
FY2006 Total - $656,634,000

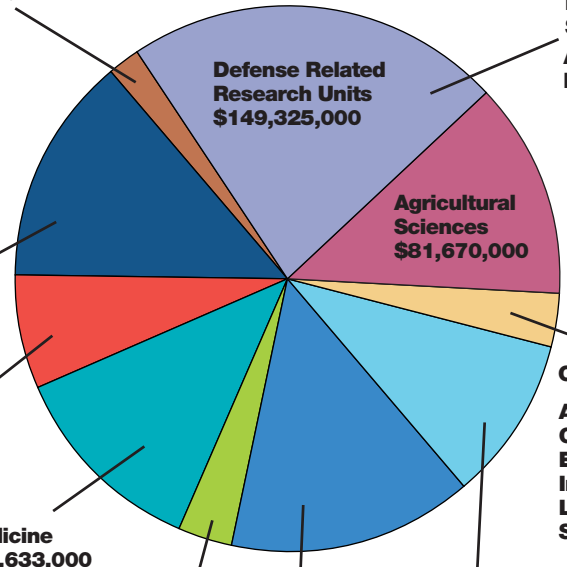


Expenditures from Federal Agencies
FY2006 Total - $371,635,000



Commerce = $1,903,000
Education = $2,499,000
EPA = $2,559,000
Interior = $1,162,000
Transportation = $4,473,000
Other Federal = $11,282,000

Expenditures By College
FY2006 Total - $656,634,000



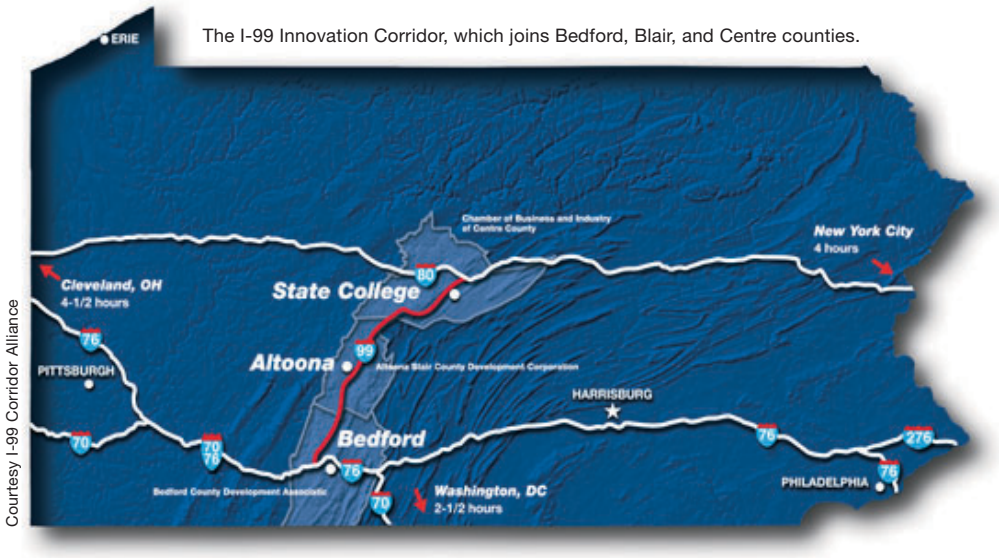
Other
Altoona College = $843,000
Behrend College = $4,287,000
Berks-Lehigh Valley College = $196,000
Capital College = $3,297,000
Great Valley = $310,000
Penn College = $1,126,000
Other Commonwealth
Campuses = $1,237,000

Applied Research Lab = $118,507,000
Electro-Optics Center = $30,818,000

Other Colleges = $20,914,000

Arts & Architecture = $1,240,000
Communications = $106,000
Education = $7,569,000
Information Sci & Tech = $6,388,000
Law = $149,000
Smeal College of Business = $5,462,000

I-99 MEANS INNOVATION



The I-99 Innovation Corridor, which joins Bedford, Blair, and Centre counties.

Courtesy I-99 Corridor Alliance

Like many states that flourished during the industrial era, Pennsylvania has struggled to adapt to a post-industrial global economy. An aging population, outmigration of young workers, and a lack of high-wage job opportunities are a few of the challenges the Commonwealth is facing.

One powerful asset for addressing these issues is the cutting-edge knowledge produced at the state's institutions of higher learning. In 2004, Gov. Edward Rendell established the Keystone Innovation Zone (KIZ) program, which joins these institutions with companies and communities to promote economic development on a local and regional scale.

One such partnership is the I-99 Innovation Corridor, which joins Penn State's University Park campus with the economic development organizations of the three counties that border the new north-south interstate: Bedford, Blair, and Centre.

The region offers numerous advantages to both new and established companies, according to Stephen McKnight, director of corporate services and governmental affairs for the Altoona-Blair County Development Corporation. With a cost of living far lower than that of nearby metropolitan areas, "This is a pretty cost-efficient place to do business," McKnight explains. "When you add to that the relationship with the University, with its workforce training potential, faculty engagement, and industrial research experience, there are very few places in the country where you can get that combination."

As a lead partner in the I-99 Innovation Corridor, Penn State strives to boost regional economic growth both by helping existing companies compete and by launching new technology companies through Discovery@ Penn State, a program established in 2005 to identify Penn State technologies with commercial potential and accelerate commercialization through start-up opportunities.

A central focus is Penn State's unique strength in materials science and engineering. At Innovation Park, adjacent to the University Park campus, companies have access to the Penn State Nanofabrication Facility, a $32 million user facility dedicated to the rapid advancement of nanoscale science and technology.

"The University's strength in materials has enabled us to reach out to a breadth of industrial sectors," notes McKnight. "And the College of Information Science and Technology is an important value-add to cutting-edge industry—as are Penn State's experts in supply-chain management and logistics.

"It's really the integration of all these things," he says, "that is so attractive."

To learn more, see: **www.i99corridor.org**

MAKING THE INVISIBLE VISIBLE

To protect the nation from terrorist attacks and natural disasters, the Department of Homeland Security (DHS) faces the daunting challenge of analyzing patterns in vast amounts of complex heterogeneous data, including text, photographs, emails, and satellite images. The DHS's ability to create predictive models based on these data is critical to the country's preparedness—and fortunately, they don't have to face this task alone.

With the 2004 creation of the National Visualization and Analytics Center (NVAC) five universities, including Penn State, have been tasked with developing a new generation of visualization and analysis tools for crisis response.

Alan MacEachren, E. Willard and Ruby S. Miller professor of geography, is the lead researcher of the North-East Visualization and Analytics Center (NEVAC) at Penn State.

"We're the only one of the five regional centers with a primary focus on geographic information," MacEachren says. Penn State's NEVAC team has two other crucial assets, he adds. "Our approach is very interdisciplinary and our GeoVISTA Center—in existence since 1998—has a history of working closely with colleagues in Information Sciences and Technology, cognitive science, and other disciplines.

Making critical information more accessible to emergency responders is a key part of NVAC's mission. "Look at the Hurricane Katrina situation," says MacEachren. "There was a pretty good national response plan but it didn't really get followed, partly because—for the average, on-the-ground emergency manager—it's not a very accessible document. I'm working with Prasenjit Mitra in IST to develop automatically generated 'concept maps' to visually represent and provide real-time access to these kinds of documents. The goal is to take complex texts and make it easy to visualize the people, places, and organizations described and how they're connected—and to leverage this information in response to the evolving situation."

Although all five of the university-based centers (the others are at Stanford, Purdue, a collaboration between UNC-Charlotte and Georgia Tech, and the University of Washington) are doing basic research, "we have a goal to make our projects relevant perhaps more quickly than with most basic science," notes MacEachren. Due to the highly critical nature of the issues faced by the DHS, "there's the expectation that some of the research will get turned into useful products in a one- to two-year time frame."

To learn more, see: **www.geovista.psu.edu/NEVAC**

BATTLING CHILDHOOD OBESITY

Despite detailed nutrition labels, diet pills, and fitness clubs on every corner, our nation is getting heavier—and children are not exempt from this trend. "Over the past three decades, obesity has skyrocketed among American youth, says Leann Birch. "In fact, the number of obese children has doubled for preschoolers and adolescents and has tripled for children between the ages of 6 and 11."

Birch, distinguished professor of human development and family studies, has led a strong, interdisciplinary response to this epidemic. Last year, within the College of Health and Human Development, and with additional support from the Penn State's Children, Youth and Families Consortium (CYFC), Birch established the Center for Childhood Obesity Research (CCOR), which brings together many of the leading Penn State researchers with an interest in this critical issue.

To date, there are thirty primary collaborators from numerous departments and colleges at Penn State involved in CCOR. Together they've begun to conduct research that will create an evidence base—"something that hasn't really existed before"—for developing successful interventions to prevent childhood obesity. The Center's mission also includes the development of collaborations with public health professionals and Pennsylvania communities in the design and implementation of childhood obesity prevention programs around the Commonwealth.

Birch is the Center's first director and, under her leadership, researchers have centralized their efforts to obtain funding from foundations, industry, and federal government. So far, they have obtained several grants totaling more than $6 million to fund studies examining such areas as the development of eating behaviors in girls 5-15 years old; infant feeding and sleeping patterns; and the effects of energy density and portion size on pre-school children. Many of these studies are being conducted in Pennsylvania.

The CYFC strongly supports the CCOR's efforts as well and has contributed approximately $150,000 towards the Center's activities, including funding for a post-doctoral fellow.

Says Birch, "These efforts of the Children, Youth and Families Consortium and the Center for Childhood Obesity demonstrate the leading role a land-grant university can play in furthering our understanding of critical social issues and serving the needs of the community."

To learn more, see: **www.hhdev.psu.edu/ccor**

A NEW THEORY OF LIFE

Beneath the kelp beds off the coast of southern California, in an oxygen-free and carbon-monoxide rich environment, an obscure undersea microbe called *Methanosarcina acetivorans* is thriving, due to its unique metabolism.

While other microbes make methane from carbon monoxide, researchers have shown that this species also produces acetate—commonly known as vinegar—in a unique metabolic process that may shed new light on the evolution of life and lay the foundation for a new source of clean fuel.

"The bug," as microbiologist J. Greg Ferry calls the microbe, "is very ancient indeed. It is quite possible that it represents the first metabolic cycle on the planet."

Ferry, Penn State's Stanley Person professor of biochemistry and molecular biology, discovered and named *M. acetivorans* 20 years ago and has been immersed in the field of anaerobic microbes since then. In the June 2006 issue of *Molecular Biology and Evolution*, he and assistant professor of geosciences Christopher House published results of a study that not only unlocks the biochemistry of how *M. acetivorans* produces acetate but also inspired them to construct a fundamental new theory of the origin of life on Earth.

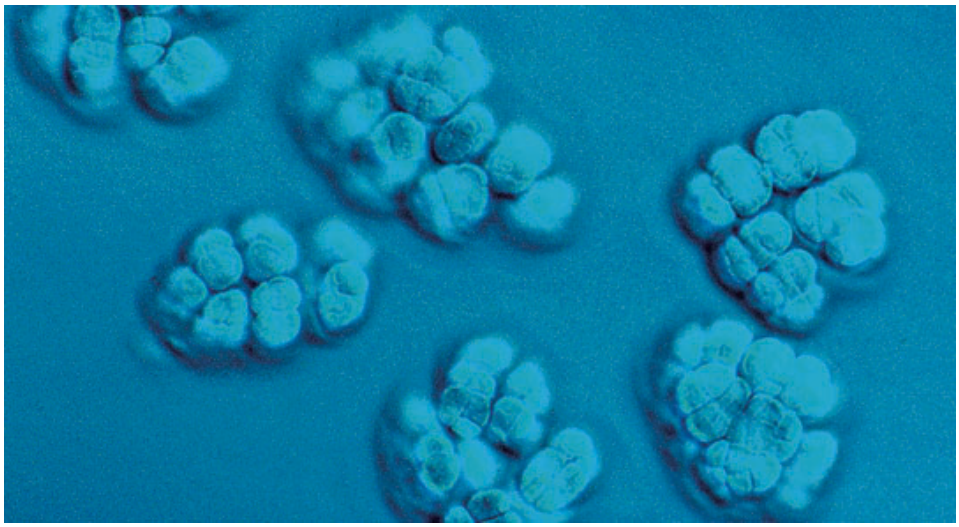
This new, "thermodynamic" theory of evolution proposes a central role for energy conservation during early evolution, based on a simple three-step biochemical mechanism. "It reshapes the two previous theories of life's origin, it shows how they overlap, and it extends both of them significantly," Ferry says.

The road to this discovery was paved in 2001 when Ferry and others urged colleagues at MIT's Whitehead Institute to sequence the microbe's genetic code. Less than a year later, they handed him the results of the sequencing. "For the first time we were seeing the details of how the bug works," said Ferry. "It was almost overwhelming, actually."

Anaerobes comprise nearly one-fourth of all living protoplasm on earth and the methane by-product of their metabolism may represent a renewable, clean-burning energy source. The Department of Energy and the NASA Astrobiology Institute both have sponsored Ferry's research.

"*Methanosarcina* and other anaerobes are our ancestors," reminds Ferry. "They laid down the metabolism for life as we know it today."

To learn more, see: **www.science.psu.edu/alert/Ferry5-2006.htm**



Courtesy Everly Conway de Macario and Alberto J. L. Macario

A live culture of *Methanosarcina acetivorans*, the ancient microbe that has inspired a "thermodynamic" theory of evolution.

THE DIABETIC EYE

Diabetic retinopathy—a condition that causes the eye's light-sensitive retina to swell and hemorrhage—is the leading cause of blindness among 25-74 year-olds in the industrialized world. Anyone with type 1 or type 2 diabetes is at risk for this eye disease and 45 percent of persons with diabetes already have some form of it.

With the incidence of diabetes predicted to double over the next 30 years, researchers are more committed than ever to finding new approaches to prevention and treatment of diabetic eye disease. At the Penn State Milton S. Hershey Medical Center and the College of Medicine, that commitment has generated a promising new therapy. Thomas Gardner, professor of ophthalmology and cellular and molecular physiology and vice chair for ophthalmology research at the College of Medicine, is enthusiastic about the new approach.

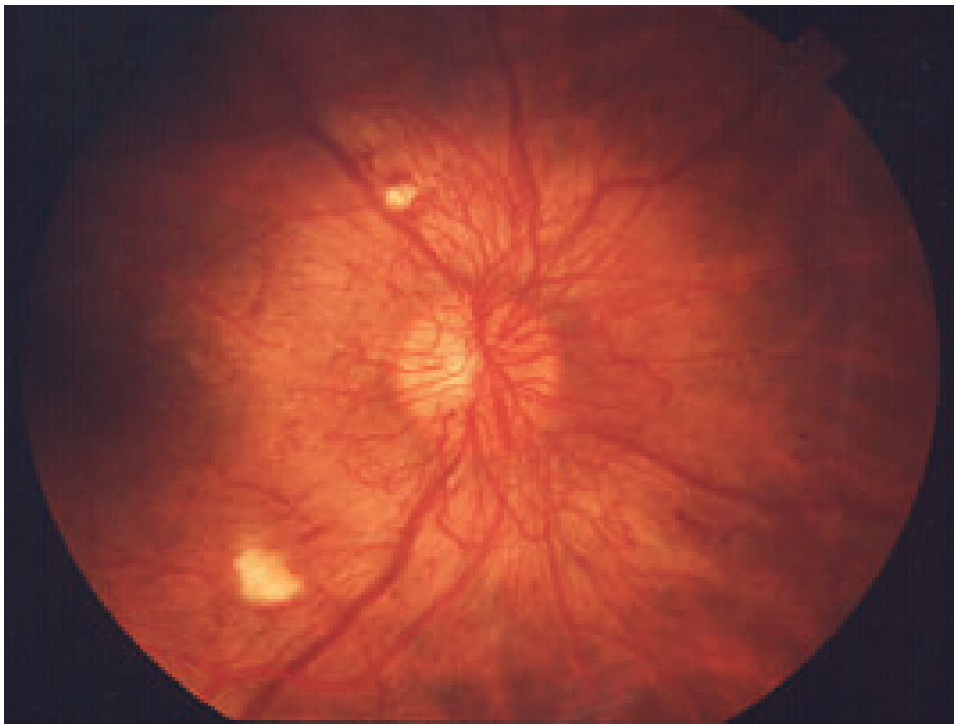
"Diabetic retinopathy is often not treated until the late stages of the disease and there is a limit to what laser surgery can achieve at that point," says Gardner. "We know that insulin helps retinal neurons survive," he continues, "but giving intensive insulin therapy to the patient systemically creates a high risk of hypoglycemia."

To reduce the risk of hypoglycemia yet still deliver the benefits of intensive therapy, Gardner explains, required a long-lasting, localized drug-delivery system. "We knew we needed something that was easy to administer and offered sustained-release therapy, because things like injections and daily eye drops discourage patient compliance."

Gardner and colleagues turned to Tao Lu Lowe, assistant professor of surgery, bio-engineering, and materials science and engineering at the College of Medicine, for help. Lowe's focus is the development of innovative drug-delivery systems. She responded to the needs of the retinopathy researchers by creating a non-toxic polymer hydrogel—"a little gel capsule" says Gardner—that could be implanted under the surface of the eye with a simple in-office procedure, and offer continuous low-dose insulin directly to the retina for six to twelve months.

"We've been doing rat studies on this approach for over a year to validate our concept," Gardner says. "I'd be happy to see human trials within the next five years."

To learn more, see: **http://retina.cbio.psu.edu**



National Eye Institute, National Institutes of Health

Proliferative retinopathy, an advanced form of diabetic retinopathy, occurs when abnormal new blood vessels and scar tissue form on the surface of the retina.

ENERGY FROM BIOMASS

It hardly needs saying: Energy is one of our most pressing issues for the coming century. Among the possible alternatives to dwindling fossil fuels, the use of crops such as corn, switchgrass, trees and manure for so-called biofuels represents a promising new avenue.

To explore their potential Penn State recently created the Biomass Energy Center.

Biomass is both carbon neutral and renewable, and it can be produced domestically, notes Tom Richard, associate professor of agricultural and biological engineering and the Center's director. Its conversion to energy can be accomplished in many ways. "While biomass cannot solve all our energy needs, it can provide a third of our transportation fuel needs and a significant amount of our other energy needs," Richard estimates.

That won't happen overnight, of course. As Richard allows, huge societal changes will be needed to break the country's dependence on imported oil. "Tens of thousands of landowners must change the way they are farming and managing their forests to provide not only our food, fiber, and recreation, but also biomass that will produce energy," he explains. The transition to a 21st-century bio-based economy will take decades.

"In terms of production, we need to develop cropping systems that provide food and fiber at levels at least equivalent to today, but also come up with energy-producing crop rotations such as cover crops to grow between food crops," Richard says. "We need to use land more intensively but use the land in an environmentally sound way. And we must develop the technology to make fuels from huge amounts of bio-mass such as switchgrass and small-diameter trees."

Penn State is well-positioned to contribute to this vast effort, he says. "The University has strong research programs on using thermal, chemical, and biological mechanisms to convert biomass to electricity, transportation fuels, chemicals, stationary power, and heat," he notes. "More than 50 faculty members at Penn State currently are involved in research related to biomass energy."

The Biomass Energy Center will seek to coordinate their efforts. An interdisciplinary initiative involving the College of Agricultural Sciences, the Eberly College of Science, the College of Engineering, and the College of Earth and Mineral Sciences, the Center will be housed in the College of Agricultural Sciences' Environment and Natural Resources Institute.

To learn more, see: **www.bioenergy.psu.edu**

AFFORDABLE SOLAR CELLS

Solar power is the ultimate energy solution: clean, renewable, and evenly distributed around the globe. The hold-up has always been cost.

"Solar cell technology is still predominantly silicon solar cells," explains Craig Grimes, professor of electrical engineering and materials science and engineering. Cylindrical boules of silicon are slowly grown then sliced into wafers, an energy-intensive—and therefore costly—process.

More recently, researchers have experimented with relatively inexpensive and easily fabricated solar cells based on thin films and light-absorbing dyes instead of bulk silicon. Grimes and his group have taken a different approach: making cells of titanium dioxide nanotube arrays.

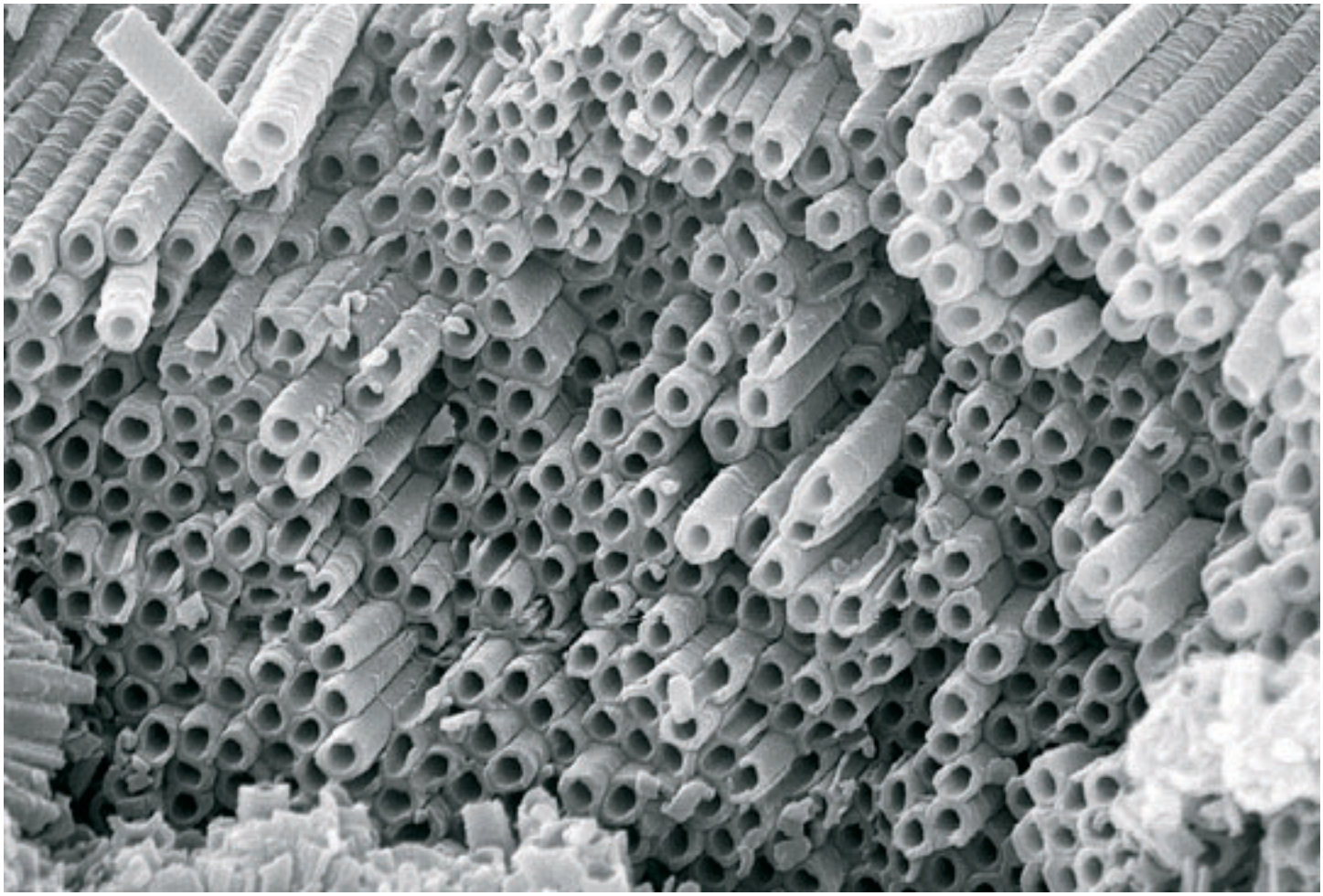
First, they coat a piece of glass with tin oxide and then sputter on a layer of titanium. They then anodize the layer by placing it in an acid bath with a mild electric current, and by this means grow vertically oriented, highly ordered arrays of titanium dioxide nanotubes. The tubes are then heated in oxygen until they crystallize and become transparent. Coated with a commercially available dye, the nanotube array becomes the cell's negative electrode. A positive electrode seals the cell which contains an iodized electrolyte.

When sun shines through the glass, the energy falls on the dye molecules and an electron is freed. If this electron and others make their way to the negative electrode, a current flows. The tube structure of the titanium dioxide allows an order of magnitude more electrons to make it to the electrode than with particulate coatings, Grimes notes.

Their initial attempt, funded by the Department of Energy, produced about three percent conversion of solar energy to electricity, they reported in a paper in *Nano Letters*. More recently, Grimes and his team reported a photoconversion efficiency of 7.2 percent in a paper in *Solar Energy Materials & Solar Cells*, and Grimes says they are poised for an even greater jump. A key is to grow longer titania nanotubes with which they get better conversion rates—"conceivably about 18 percent is within our reach," says Grimes. "And that's with a relatively easy fabrication system that is commercially viable."

Funding from the Pennsylvania Energy Development Authority will provide the equipment needed to make thicker titanium coatings, the first step to making longer nanotubes. Notes Grimes: "There is still a great deal of optimization of the design that needs to be done."

To learn more, see: **www.ee.psu.edu/grimes**



Courtesy Craig Grimes

Scanning electron micrograph (SEM) image of a titanium oxide nanotube array produced in Craig Grimes's lab.

Joint Strike Fighter program

Boeing X-32 Joint Strike Fighter during flight testing. Penn State ARL's materials technology program develops advanced composites and coatings for military aircraft, ships, and tanks, as well as sensor and electro-optics technologies for numerous defense applications.

MATERIALS FOR DEFENSE

Penn State has long been known for its excellence in both materials and defense-related research. Now, in the interest of homeland security, researchers in both areas are exploring the territory where their expertises overlap.

Penn State's Applied Research Laboratory has been serving the nation's defense-related research needs since World War II, and currently brings in over $118 million annually in Defense Department funding. In 1999, the Electro-Optics Center (EOC) was created as an outgrowth of ARL activities. Both ARL and the EOC do extensive research in advanced materials, says Tom Donnellan, ARL associate director, and their areas of expertise are complementary.

"ARL's materials technology program is focused on structures and systems, Donnellan explains, including composites that might soon be used to improve protective armor for both military vehicles and personnel. Sensor system technology is a second area of intense activity. A third is the development of coating technologies that can withstand the tough environmental conditions faced by military aircraft, ships, and tanks.

The EOC, true to its name, has focused on electro-optics technologies—which, in addition to being important in consumer products from remote control clickers to computer screens, are the basis for imaging, weapons, and communications technologies that impact our national defense.

Increasingly, as they push the high-tech envelope, ARL and EOC researchers collaborate with Penn State's broader materials-research community, Donnellan says. That's how fundamental studies of carbon nanotubes being conducted at the University's Materials Research Institute can be adapted by ARL scientists for possible use in lightweight body armor.

In the area of sensors, the challenge of detecting biological and chemical agents has brought together ARL sensor system expert Dave Swanson with materials scientists David Allara and John Badding and entomologists Tom Baker and Jim Tumlinson in a multi-disciplinary effort to design sensors inspired by the exquisite sensitivity of moth antennae.

Ultimately, this breadth and depth of available expertise, both applied and fundamental, gives Penn State what Donnellan calls a continuum of capability. "It allows us to develop and transition materials solutions for defense applications very effectively," he says. "We can go quickly from fundamental research to demonstrated materials capabilities to prototype components or devices. This kind of vertical integration is unique among universities."

To learn more, see: **www.arl.psu.edu/capabilities/mm.html**

EXPLORING PLACE

For twenty Pennsylvania teachers, the summer of 2006 will be remembered for a five-day seminar they attended as part of an outreach program of the Penn State Institute for the Arts and Humanities (IAH) with support from the National Endowment for the Humanities (NEH).

The interdisciplinary class, "Exploring Place through Writing and Photography," got participants out of their seats for hiking, canoeing, and photography expeditions—in addition to reading and writing assignments—to show educators how to "build visual and written literacy in the high-school classroom."

Team-taught by Robert Burkholder, associate professor of English, and Susanne Hackett, master's candidate in art education, the seminar's emphasis on the natural environment stems largely from Burkholder's expertise as a specialist in the American Romantics.

Says Burkholder, "Ralph Waldo Emerson tells his audience that 'few adult persons can see nature' and he encourages his readers to 'Turn the eyes upside down, by looking at the landscape through your legs.' We wanted to teach the seminar participants to change their angle of vision, in an Emersonian sense, and see the world in a new way."

Seminar students read theoretical texts from a wide range of writers, from John Dewey to Leslie Marmon Silko, viewed films such as *Rives and Tides: Working with Time* about environmental sculptor Andy Goldsworthy, and then put pedagogy into practice on outings such as a mountain hike and daylong canoe trip on Bald Eagle Creek. Hackett and Burkholder hope these experiences will inspire participants to take their own students on outings related to local ecology and history.

"As both teachers and learners," explains Hackett, "exploring our place in the natural world is essential in understanding our own identities and helps us share that depth of understanding with our students."

For their students, the combination of scholarship and field trips was "an invigorating experience that challenged the concept of the traditional classroom," according to Jeff King, a tenth-grade English teacher.

Marica Tacconi, executive director of IAH, agrees, adding, "We are committed to offering similar summer programs in the years ahead."

To learn more, see: **www.outreach.psu.edu/pst/ExploringPlace**

A NEW NAVY YARD

The 1995 closing of the Philadelphia Navy Yard marked the end of a long, proud era. Fewer than ten years later, a promising new era has begun.

In 2000, 1,000 acres of the 1,200-acre waterfront site were acquired by the nonprofit Philadelphia Industrial Development Corporation (PIDC). Redevelopment of this prime location as a haven for high-tech industry has become a central focus of the city's economic development plan.

Penn State has been involved with the Navy Yard since the mid-1990s, most recently serving on the reuse task force. In March 2005, when the Yard was designated a Keystone Innovation Zone (KIZ), the University was named a partner along with PIDC, the Naval Sea Systems Command (NAVSEA) Philadelphia, Ben Franklin Technology Partners of Southeastern Pennsylvania, and the Philadelphia Department of Commerce. Penn State's research strengths in physical sciences and engineering will anchor plans for technology transfer to companies both on site and throughout the region.

"In terms of materials science, Penn State is one of the strongest research institutions in the world," notes John Conley, PIDC vice president, "and their work in fuel cells and advanced power generation technologies dovetails very nicely with what the Navy is doing."

In addition to pursuing the creation of a Clean Fuel Systems Laboratory and a Center for Advanced Power Generation Research at the Navy Yard site, Penn State is involved in a number of other initiatives there. Since the fall of 2005, Penn State Great Valley has offered master's degree programs in systems engineering at the Navy Yard, with 27 students currently enrolled.

In collaboration with Mack-Volvo, Penn State is also proposing construction of a Heavy-Duty Engine and Hybrid Powertrain Research Center that would complement existing NAVSEA facilities.

These projects represent only a first phase, says Paul Hallacher, director of research program development at Penn State. "This is part of our land-grant mission, to translate our expertise through innovation into economic benefit for the Commonwealth."

To learn more, see: **www.navyyard.org**

A main gate at the Philadelphia Navy Yard.

Courtesy Philadelphia Industrial Development Corporation

TECHNOLOGY TRANSFER

Translating new knowledge into products and processes that benefit society is one of the central missions of a land-grant university. At Penn State, this technology transfer is handled through the integrated efforts of seven units, five under the purview of the Office of the Senior Vice President for Research and two in the University's Outreach division. Together these units cover every aspect of the commercialization process, from linking industrial research sponsors with faculty; to patenting and licensing intellectual property; to assisting start-ups with incubation and advice; to providing financing, counseling, technical assistance, and convenient physical facilities for companies large and small.

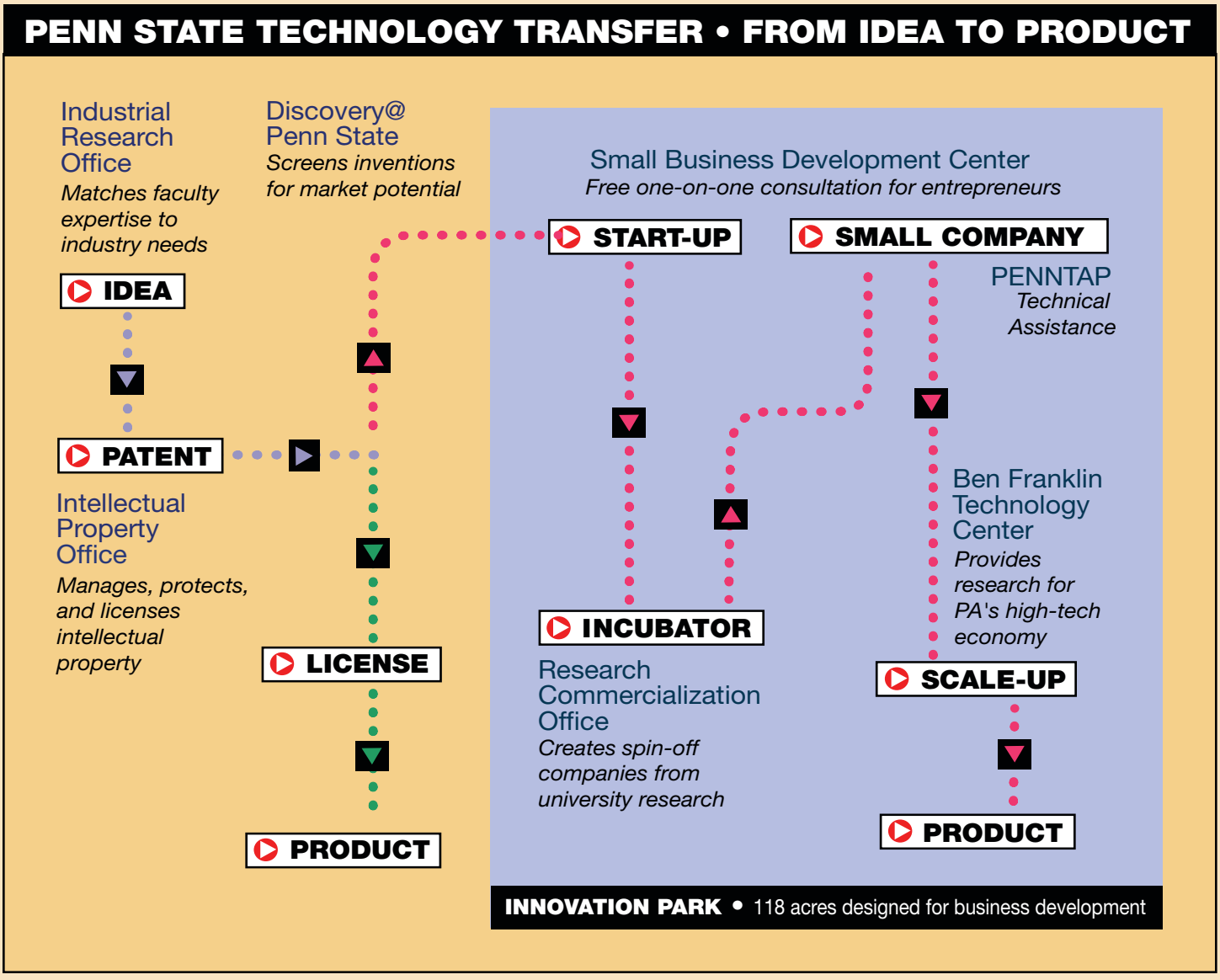
Like those of most universities, Penn State's early efforts in technology transfer focused mainly on pursuing patents and licensing its intellectual property to existing companies. In recent years, the University has devoted increasing attention to a complementary approach, looking to create start-up companies to produce and market its inventions. Since 1999, Penn State has helped spin off 45 start-ups, either through licensing or equity exchange. With a goal of doubling the number of start-ups formed each year, in 2005 Penn State launched Discovery@Penn State to proactively screen emerging technologies, identifying the most suitable candidates.

At the same time, Penn State has acted to further strengthen its economic development efforts across the state by adopting a Pennsylvania First strategy that gives priority in technology transfer to enhancing the competitiveness of existing Pensylvania firms, growing new companies which create new jobs, and helping to attract industries to the Commonwealth.

Last but not least, the opportunity to do relevant and commercially useful research forms an important component of the educational experience for many Penn State students, both graduate and undergraduate. These students are then well–prepared to play their parts in building a high-tech economy for the future—one more way that at Penn State research, education, and service combine to benefit the people of Pennsylvania.

To learn more, see: **www.techtransfer.psu.edu**

PENN STATE TECHNOLOGY TRANSFER • FROM IDEA TO PRODUCT



Intellectual Property Office

The Intellectual Property Office is responsible for managing, protecting, and licensing the intellectual property of faculty, graduate students, and staff at all Penn State locations. This includes assessing the commercial potential of approximately 200 University inventions per year, formulating and implementing patent and marketing strategies, and negotiating license agreements.

In calendar year 2006, director Ron Huss and his technology licensing officers filed 116 U.S. patent applications, and 37 patents were awarded, including one for a method that uses surfactants to prevent lung complications from cancer chemotherapy, another for a method for treating diabetes using trans-fatty acids, and a third for an environmentally-friendly thermoacoustic refrigerator that uses sound waves to cool.

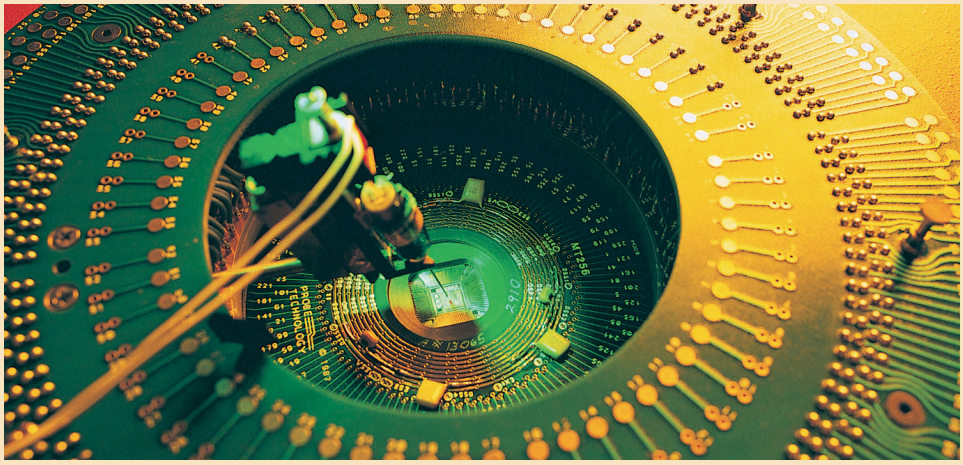
Not including the equity Penn State holds in 29 start-up and established companies, Penn State intellectual property generated revenues of $3.3 million. "We're not all about making money," Huss says, "although the financial aspect is inseparable from what we do. We're here to help professors whose work may have some public benefit."

Industrial Research Office

The Industrial Research Office is a catalyst for partnerships. By reaching out to a diverse community of corporate clients, IRO identifies new opportunities and aligns them with the appropriate intellectual resources at Penn State. Whether the result is a solution to a specific problem or an ongoing master agreement, "Our goal is to develop linkages that lead to mutually beneficial long-term relationships," says director Tanna Pugh.

During FY 2006, IRO staff facilitated 174 projects generated by 56 companies, totaling $12.5 million in industry-sponsored research. Nineteen of these companies and 57 of the projects were Pennsylvania-based.

To cite only a few examples, NPC, a high-volume printing company located in Claysburg and one of the top suppliers for the U.S. Government Printing Office, is working with Penn State engineers on information-management strategies. ChromBA, a small State College-based chromatography supplier, turned to Penn State scientists for help with sample-preparation techniques. And one factor in outdoor outfitter REI's decision to relocate a major distribution facility in Bedford County was Penn State's expertise in logistics and supply-chain management.



Research Commercialization Office

The mission of the Research Commercialization Office is to assist Penn State faculty and staff as they create new companies based on University research and technologies.

Working in partnership with Penn State's Intellectual Property Office and the recently established Discovery@Penn State intitiative, the RCO screens inventions for patentability and market potential, and helps identify sources of early stage capital such as seed funding programs, angel investors, and venture capital funds. In addition, RCO aids in identifying mentors and potential management-team members and in finding space for start-up companies in the Innovation Park at Penn State or at the Penn State Zetachron Center.

Examples of recent start-ups reflect the broad range of Penn State's expertise. They include DIApedia, which makes therapeutic shoe insoles for diabetics with foot complications; Anacor Pharmaceuticals, which develops drugs to treat dermatological disorders; and VideoMining, which creates software that analyzes in-store video and reveals customers' behavioral patterns. (For more on Penn State start-ups, see "Start Me Up," a Fall 2006 article in *The Penn Stater* magazine, available on the Web at **www.coolblue.psu.edu.**)

Ben Franklin Technology Partners of Central and Northern Pennsylvania

Ben Franklin Technology Partners of Central and Northern Pennsylvania (BFTP/CNP) is one of four regional centers of the Commonwealth's Ben Franklin Technology Development Authority, a statewide network that promotes economic growth and job opportunities through investments in high-tech innovation. The program provides operational assistance, entrepreneurial support, and investment capital to emerging technology-based companies and small manufacturing businesses.

In 2005/2006, the Center's board of directors approved investments totaling more than $6 million in a variety of industry sectors, including digital processing equipment, IT/software development, anti-terrorism/security devices, manufacturing, and nanotechnology, as well as in the infrastructure that supports innovation, including business incubators, workforce development projects, and university-based centers of excellence.

"Our relationship with Penn State has allowed both the Center and the companies in its portfolio to benefit from the vast array of expertise housed in a university noted for its world-renowned capabilities," says Steve Brawley, BFTP/CNP president.

Penn State's Technology Transfer units also include the Pennsylvania Technical Assistance Program (PENNTAP) and the Small Business Development Center (SBDC), both housed in the University's Outreach division. PENNTAP provides technical assistance for small companies, and SBDC provides one-on-one consultation for entrepreneurs in Centre and Mifflin counties. For more information on these units, see: **www.penntap.psu.edu** and **www.sbdc.psu.edu**

INNOVATION PARK

In its twelfth year of operation, Penn State's Innovation Park continues to grow in its mission to facilitate collaborations between business and University research that will result in new technologies and boost the region's economy.

With 118 acres of land designated for business development adjacent to the University Park campus at the interchange of I-99 and U.S. Route 322, Innovation Park is the central locus of the I-99 Innovation Corridor, which joins Penn State's University Park campus with the economic development organizations of the three counties—Bedford, Blair, and Centre—that border the new north-south interstate (see page 6).

Buildings completed and currently under construction total 750,000 square feet, and at its capacity the Park can accommodate about 1.4 million square feet of development. New construction completed in 2006 included the second multi-tenant building of the park's third phase at 330 Innovation Boulevard, developed by Innovation Capital Partners, a private partnership.

Eva J. Pell, senior vice president for research and dean of the graduate school, comments, "The goals of the Park are technology transfer, economic development, retention and recruitment of entrepreneurial faculty, and the formation of partnerships with business that will result in sponsored research opportunities and workforce development."

"Ultimately," adds Pell, "these activities will contribute to job creation and strengthening of the economic base of the region."

They are already doing so. A total of 50 tenants now make their headquarters in Innovation Park, with 1,320 employees supporting their activities. The park's close proximity and involvement with the University confers benefits on both the corporate tenants and the student body. In the past year, Innovation Park-based companies gave 103 Penn State students internships and hired 25 Penn State graduates for permanent positions.

In 2006, Innovation Park director Dan Leri started the "Cool Blue" campaign to draw attention to the park's advantages and attract potential investors, particularly Penn State alumni who, now successful in their careers, might want to return to the area. An article and corresponding full-page advertisement in the alumni magazine *The Penn Stater*, detailed this effort, and described some recent success stories of businesses created around Penn State research. (Both article and ad are on the Web at the URL below.)

As part of the campaign, the Park has adopted "The Cool Blue Lab Journal," a how-to manual for inventors written by "entrepreneurial professor" and technology industry executive Wendy Kennedy, as a "step-by-step toolkit for faculty, students, and local entrepreneurs to assess and articulate the business value of their leading-edge ideas," Leri says. The book "solves a specific problem for those of us in the commercialization field," says Leri. "That problem is the gap between good ideas and great commercial opportunities."

As it grows into the 21st century, Innovation Park continues to fulfill its promise, serving as a remarkable catalyst for successful collaborations between the University and the private sector.

To learn more, see: **www.coolblue.psu.edu.**

Courtesy Innovation Park at Penn State

Aerial view of Innovation Park at Penn State

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TECHNOLOGY TRANSFER

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