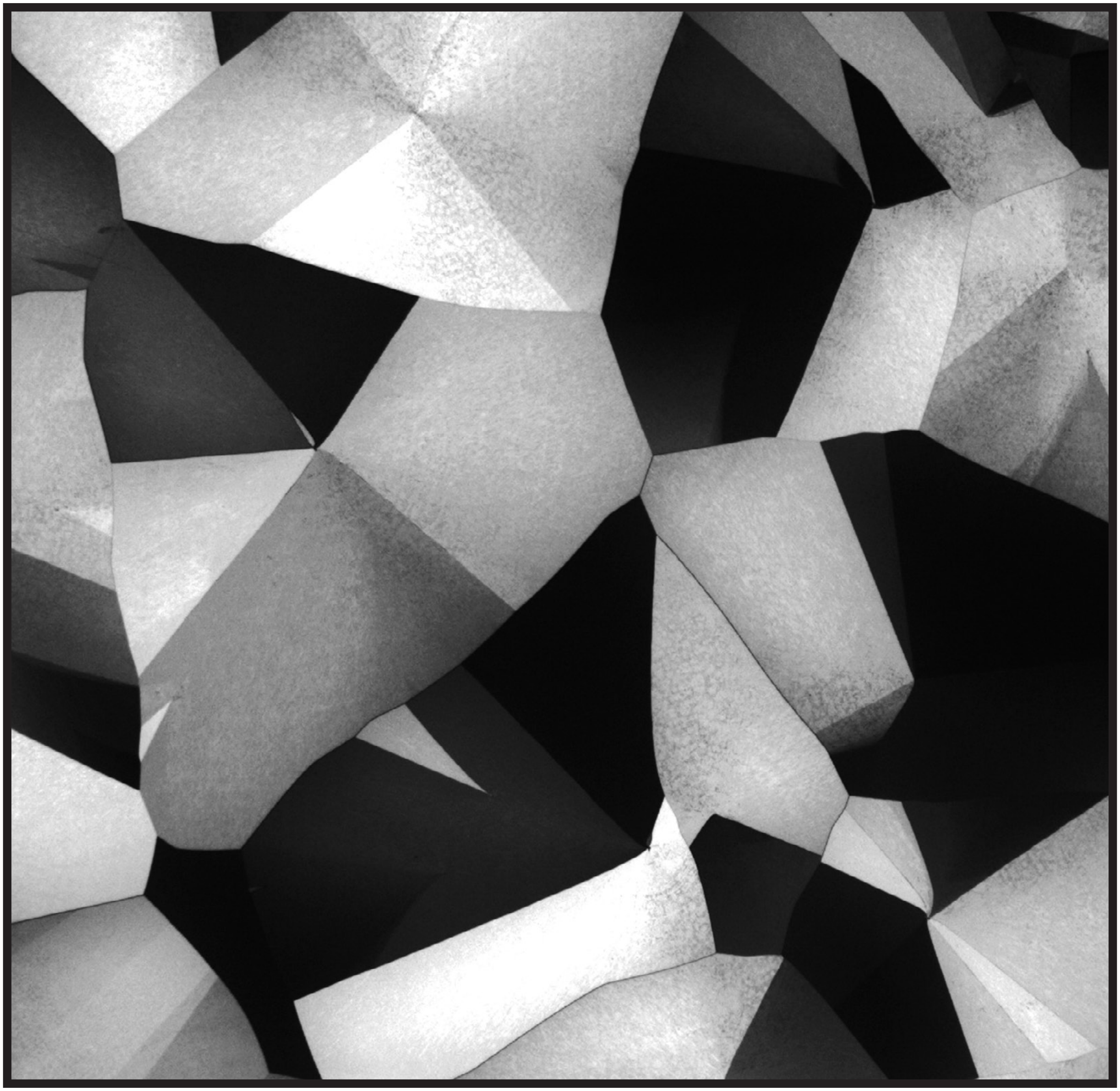
CELEBRATE PRINCETON INVENTION

2017



Research at Princeton

Research
at Princeton

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Celebrating the journey from research to impact

Princeton University is a place where deep thinkers and visionaries have the latitude to push basic discoveries into new realms. At this year's Celebrate Princeton Invention, we honor both those researchers who start with a problem and look for a solution, and those who make fundamental discoveries that they then apply in new areas.

An example of this latter type of inventor is Herschel Rabitz, the Charles Phelps Smyth '16 *17 Professor of Chemistry. His work on optimization theory has led to new ways to develop and formulate new medicines. Another example is Jeroen Tromp, the Blair Professor of Geology and a professor of geosciences and applied and computational mathematics. Tromp has adopted methods he created for studying the Earth's interior to the problem of improving medical imaging.

These pioneering projects complement the many avenues of invention featured this year, ones that are making buildings more energy efficient, ramping up the production of biofuels, bringing molecular diagnosis to remote locations with a new "lab on a chip," and helping to find the genes that contribute to autism.

All of these types of invention find support at Princeton, where we recognize that widespread impact may occur in just a few years, or may take generations. The pursuit of knowledge pays off in unexpected ways. I hope you'll join me in celebrating Princeton's tradition of supporting innovative fundamental and applied research at this year's Celebrate Princeton Invention.

Pablo Debenedetti
Dean for Research
Class of 1950 Professor in Engineering and Applied Science
Professor of Chemical and Biological Engineering

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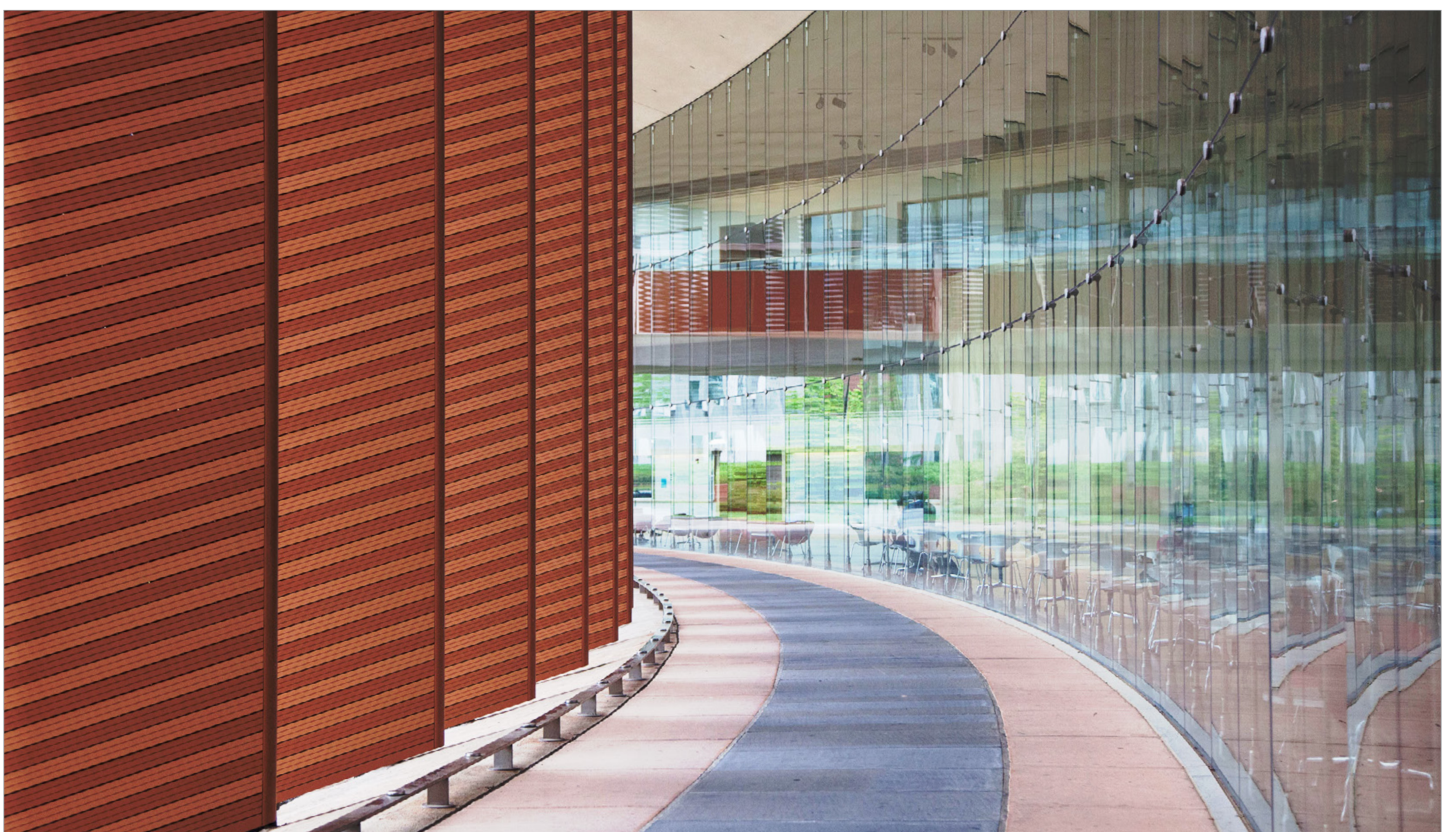


The Carl Icahn Laboratory is home to the Lewis-Sigler Institute for Integrative Genomics.

University research for societal benefit

Our mission in Princeton's Technology Licensing office is to facilitate the transformation of scientific and technological discoveries into products and services that can benefit society. We work closely with Princeton researchers to ensure that their discoveries can lead to real-world solutions in areas such as health care, communications, cybersecurity, environmental stewardship and beyond.

Over the past several years we've expanded our capacity to support this mission by facilitating the formation of startup companies, which are often initiated by faculty, graduate students and postdoctoral researchers who want to see their discoveries benefit humanity. Our Executive-in-Residence program provides mentorship for these budding research entrepreneurs. We realize that not all University discoveries are ready for the real world, so our IP Accelerator Fund offers support for additional research aimed at demonstrating the potential of early-stage innovations.

All of these efforts are aimed at one objective: to translate Princeton discoveries into products and services that will help people around the world, making lives healthier and safer, our environment cleaner, our electronic transactions more protected, and the world a better place. Join us in celebrating Princeton's inventors.

John Ritter
Director, Technology Licensing

"Princeton's scientists and engineers share a passionate commitment to research that deepens our understanding of the world and improves the quality of life within it. Across the University community, we continue to strengthen our entrepreneurial ecosystem to help stimulate discovery and catalyze innovations that will benefit society. Dynamic collaborations with a variety of partners are essential to this environment and play a critical role in expanding the boundaries of knowledge."

Christopher L. Eisgruber
President, Princeton University

"One of the most important and valuable roles that Princeton faculty members play is as research mentor to postdoctoral scholars and graduate students as well as undergraduates both in the lab and the classroom. These mentoring relationships are deeply engaging and personal for faculty members and students alike. They are also critical for developing the young talent that will lead to groundbreaking discoveries five, 10 or 25 years from now. Princeton's emphasis on faculty mentorship creates an environment that fosters innovation, discovery and an investment in the future."

Deborah A. Prentice
Provost, Princeton University

Invention
Using light to control biofuel production

José Avalos, assistant professor of chemical and biological engineering and the Andlinger Center for Energy and the Environment

José Avalos and his team use light to enhance the production of biofuels, drugs and commercial chemicals in bioreactors, which contain microorganisms such as yeast that have been metabolically engineered to make biological products. The team uses a technology called optogenetics—involving light to control cellular processes—to turn yeast genes on and off at specific times to optimize the production of the desired chemical or product.

José Avalos

The precise genetic control available through optogenetics addresses a longstanding goal in metabolic engineering: to create microorganisms that produce large quantities of a product that may be toxic to the organisms themselves. With the system developed by Avalos and his team, simply turning on the light can switch off the synthesis of the engineered product, while turning off the light can restart production. Different amounts of light give different rates and levels of production that allow the researchers to fine-tune and optimize the engineered pathway.

Avalos and his team have developed "gene circuits" that use light to control the activity of several genes simultaneously. These light-sensitive gene circuits can simplify the optimization of metabolic pathways, and reduce the cost of production. "This is a whole new way to operate bioreactors," Avalos said.

Team members

Evan Zhao, graduate student in chemical and biological engineering

Collaborators

Yannis Kevrekidis, the Pomeroy and Betty Perry Smith Professor in Engineering, Emeritus, professor of chemical and biological engineering and applied and computational mathematics, emeritus, senior scholar; Jared Toettcher, assistant professor of molecular biology

Development status

Patent protection is pending. Princeton is seeking outside interest for further development of this technology.

Funding sources

National Science Foundation, Alfred P. Sloan Foundation, Princeton University's Eric and Wendy Schmidt Transformative Technology Fund

Invention
Radiant-temperature sensor for improved human comfort

Forrest Meggers, assistant professor of architecture and the Andlinger Center for Energy and the Environment

Most people reach for the thermostat when the room feels hot or cold, but in fact air temperature makes up only about half of a person's thermal comfort level. The temperatures of surrounding surfaces—cold or hot windows, walls and floors—make a significant impact on one's comfort. "If surfaces around you are colder, then more heat radiates away from your body," Forrest Meggers said.

The Spherical Motion Average Radiant Temperature (SMART) sensor designed by Meggers and his team is a simple, cost-effective device that can quickly and accurately measure the surface temperature at multiple locations in a room, creating a three-dimensional picture of the radiant heat and cooling sources. The information can be used to design buildings that are more energy-efficient and that don't sacrifice personal comfort.

Forrest Meggers

Until now, designers have been hampered by the lack of a low-cost, versatile sensor. The most common radiant-temperature sensor, the black-globe thermometer, measures the interior temperature of a black ball that must be moved around to different locations. Other technologies use expensive optical filters.

The SMART sensor devised by Meggers and his team consists of a rotating platform containing an infrared temperature sensor, a device for scanning the room's surface geometry, and a microprocessor. The device can output a three-dimensional map of the hot and cold surfaces. The sensor can serve as a critical diagnostic tool for describing where additional insulation or other remedies should be placed. It can also be integrated into

Herschel Rabitz (far left), with his laboratory team

buildings to feed this information to a central management system in real time to save on energy costs and improve occupant comfort.

Team members
Jake Read, former research specialist at Princeton and now a researcher at the Waterloo School of Architecture, Ontario; Eric Teitelbaum, graduate student in architecture at Princeton

Development status
Patent protection is pending. Princeton is seeking outside interest for further development of this technology.

Funding source
Princeton University

Invention
Optimization tools for drug formulation and discovery

Herschel Rabitz, the Charles Phelps Smyth '16 *17 Professor of Chemistry

Finding the ideal formulation for a new drug can involve sifting through many possible ingredients and conducting a large number of experiments. A mathematical optimization program developed by Herschel Rabitz and his team provides the ability to model a mixture to predict the performance of all possible combinations of components. The approach can be used not just for drug formulation, but also in drug discovery and fundamental research.

The technology builds on nearly two decades of work in the Rabitz lab on how to understand and cope with systems that have large numbers of input variables. For example, when creating a new pharmaceutical compound, researchers must choose from many possible chemical groups to add to the structure. Similarly, when creating a peptide drug, researchers must decide which of the 20 common amino acids to include. In each case, the possible combinations are so numerous that it is impossible to test each combination.

The approach developed by Rabitz and his team can help handle the number of input variables that need to be considered. "Our mathematical tools help reduce the number of required experiments that are necessary when searching through multiple variables," Rabitz said.

The team has already verified the usefulness of their optimization protocol in experimental settings for the formulation of monoclonal antibody drugs. They have also built a computational platform for peptide drug discovery, and they are applying their methods to enhance a technology known as optogenetics, which involves the use of light to control cellular processes.

Team members
Alexei Goun, associate research scholar; Genyuan Li, research chemist; Zachary Quine, graduate student; Xi Xing, associate research scholar; all in the Department of Chemistry

Collaborators
William Welsch, professor of bioinformatics at Rutgers Robert Wood Johnson Medical School; Xiao-Jiang Feng, consultant

Development status
Princeton is seeking outside interest for further development of this technology.

Funding sources
National Science Foundation, U.S. Army Research Office, John Templeton Foundation

Invention

Low-cost silicon-based biosensor chip for medical diagnostics

Kaushik Sengupta, assistant professor of electrical engineering

This millimeter-sized, low-cost medical diagnostic chip relies on new technology developed by Kaushik Sengupta and his team to detect pathogens and disease biomarkers. The invention integrates optical structures and electronic systems into sophisticated, fluorescence-based sensors and scanners. Manufactured using the same process for making the chips that power today's smartphones and other electronics, this technology can drastically reduce the cost of medical diagnostics, a rapidly growing area in health care.

Molecular diagnostic devices detect and measure nucleic acids and proteins, which can be biomarkers for specific health conditions across a range of bacterial, viral and parasitic infections. However, today's diagnostic methods involve collecting blood or other biological samples and shipping them to a laboratory for analysis by skilled technicians using fluorescence-based optical scanners, which are bulky, expensive and nonportable. The device invented by Sengupta and his team enables the analysis of multiple molecular signatures simultaneously, making portable and low-cost diagnostic technology available at the point of care for use by personnel who have had relatively little training. Such a device could facilitate rapid testing for emerging diseases and outbreaks, thus shortening the response time of medical and public health officials.

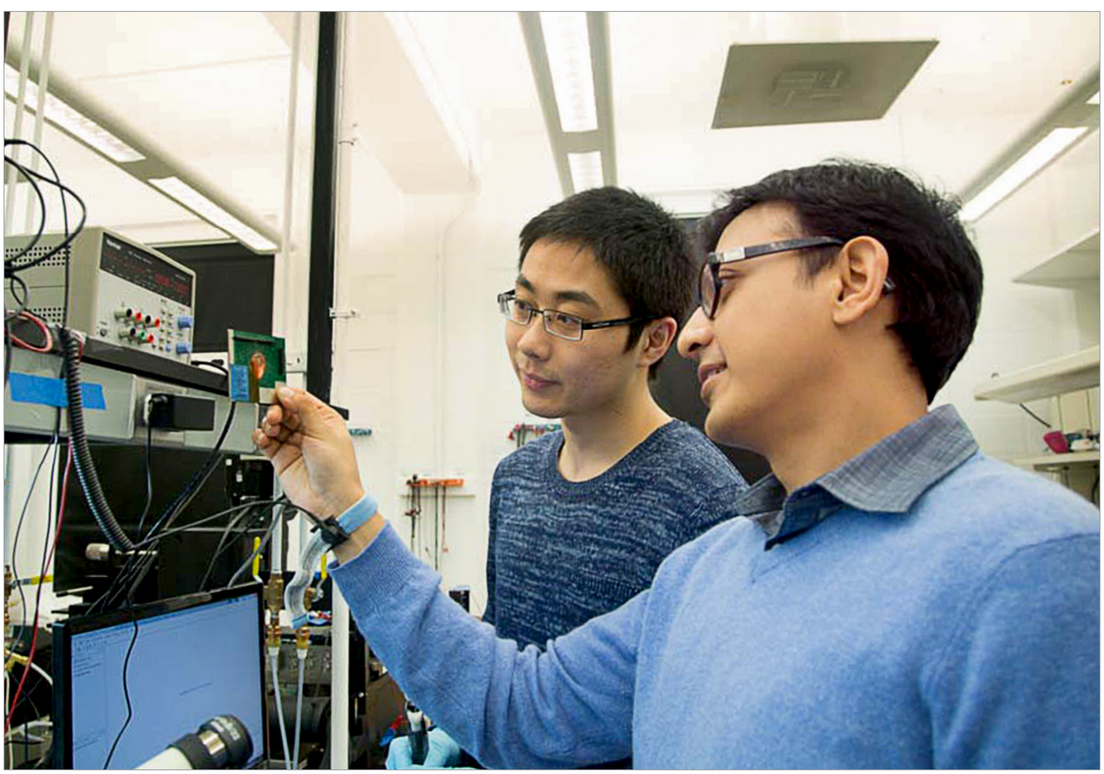
The diagnostic system is made possible by work in the Sengupta lab that incorporates novel optical nanostructures in silicon-based integrated circuit technology to manipulate, control, filter, detect and process signals of light in the visible range. This system eliminates bulky external optical components, and miniaturizes the entire multiplexed fluorescence scanner, including the optics and electronics, in a single chip. When the biomolecules are tagged with optical labels, the computer chip can detect and quantify them with high precision, thus identifying pathogens and other disease-causing agents. With the ability to be powered by a lithium battery, this miniaturized diagnostic device makes portable biosensors a real possibility for the future of medicine and personalized health care.

Team members
Lingyu Hong, graduate student in the Department of Electrical Engineering

Collaborators
Haw Yang, professor of chemistry; Hao Li, graduate student in the Department of Chemistry

Development status
A patent has been issued, and another patent application is pending. Princeton is seeking outside interest for further development of this technology.

Funding sources
National Science Foundation, Qualcomm Innovation Fellowship



Kaushik Sengupta (right) and graduate student Lingyu Hong

Invention

Medical imaging using methods from geosciences

Jeroen Tromp, the Blair Professor of Geology and professor of geosciences and applied and computational mathematics

This new technology transforms traditional ultrasound images into three-dimensional images that could improve the diagnosis of tumors, osteoporosis and other disorders. It combines recent advances in computational power with techniques originally developed for the study of earthquakes and subterranean structures.

A geoscientist by training, Jeroen Tromp has pioneered methods for mapping the subterranean world using naturally occurring seismic waves, the same waves caused by earthquakes. The waves speed up when they pass through a solid structure and slow down when they travel through underground pockets of magma. In the past several years, Tromp and his team have applied new computational methods to extract as much information as possible from seismic waves.

Now they are applying the same techniques to ultrasonic waves, which share many of the same characteristics. Today's ultrasound imaging devices work by sending sound waves through the body and constructing an image from the waves that bounce off internal structures.

With Tromp's technique, the researchers first model the sound waves traveling through the body. Then, a computer algorithm compares these modeled waves to the measured waves, identifies discrepancies between the model and the real waves, and improves the model accordingly.

The resulting computer-enhanced model contains far more information about the imaged body structure than does traditional ultrasound, and can provide clinicians with detailed images that are comparable to more expensive techniques such as magnetic resonance imaging (MRI) at a fraction of the cost.

Team members

Etienne Bachmann and Ryan Modrak, postdoctoral research associates in the Department of Geosciences

Collaborators

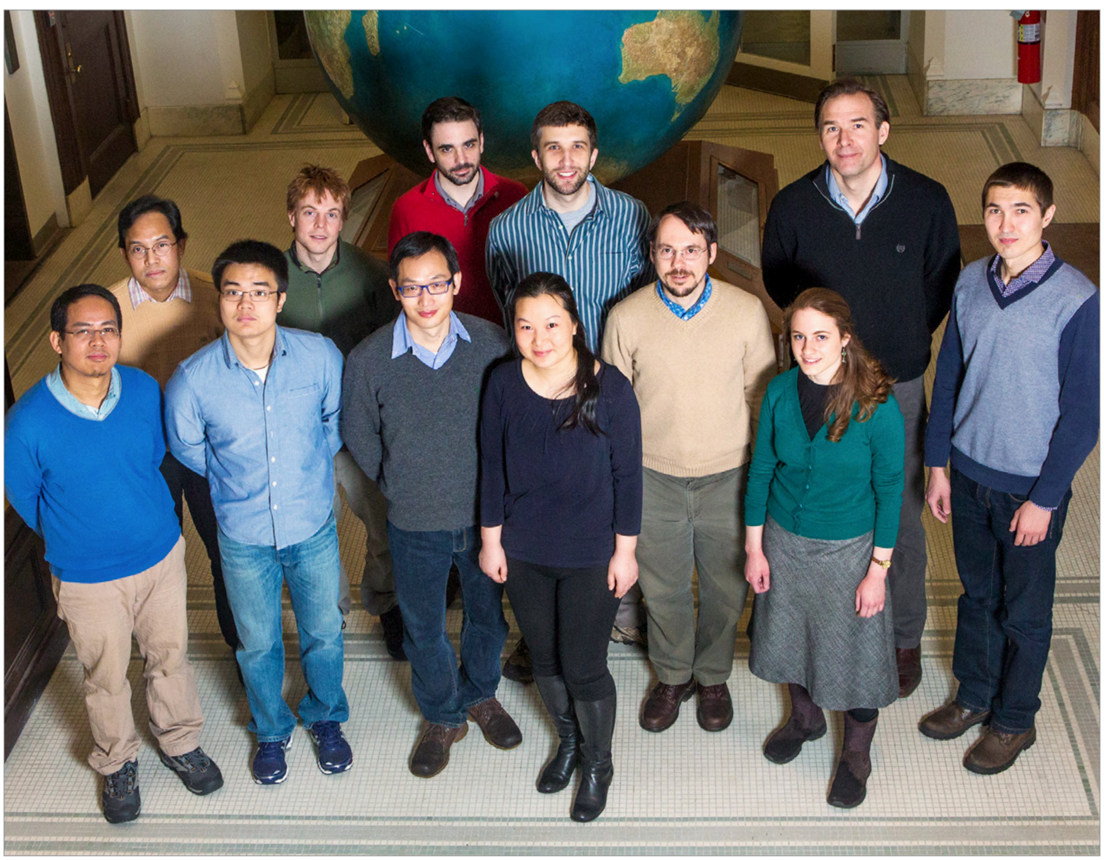
Greg Davies, graduate student in the Department of Mechanical and Aerospace Engineering; Daniel Steingart, associate professor of mechanical and aerospace engineering and the Andlinger Center for Energy and the Environment

Development status

Patent protection is pending. Princeton is seeking outside interest for further development of this technology.

Funding source

Princeton University's Eric and Wendy Schmidt Transformative Technology Fund



Jeroen Tromp (back row, second from right), with his laboratory team

Invention

Big-data approaches to precision medicine and drug development

Olga Troyanskaya, professor of computer science and the Lewis-Sigler Institute for Integrative Genomics

Olga Troyanskaya and her team have developed techniques to comb large collections of genomic and other data to make fundamental discoveries and identify new therapeutic targets. These "big data" methods can be applied to numerous disorders for which people can have genetic susceptibilities, from cancer and chronic kidney disease to autism and neurodegenerative diseases such as Alzheimer's.

Many of the disease-related genes previously identified have been found by analyzing the genomes of affected individuals and their families. While powerful, this approach generally reveals genes with a strong tie to the disease and can miss those that act together. This is a challenge for the study of autism, which has a strong genetic basis and may involve up to 1,000 genes. "It is like looking for your keys under the light post because that is the only place you have light," said Troyanskaya, who is also appointed at the Simons Foundation's Flatiron Institute.

Big-data methods allow Troyanskaya's team to search the entire genome, including noncoding regions that are not genes but rather regulate gene expression. In a study published in 2016 in the journal *Nature Neuroscience*, the team used these computational methods to identify roughly 2,500 genes that are likely linked to autism among the almost 26,000 known human genes. This vastly reduces the number of genes that need to be sequenced for quantitative genetic studies, Troyanskaya said. "Instead we can focus on the set of genes that are likely to be autism-related, so we can screen a lot more families or use this information to help interpret whole-genome studies," she said. "This approach can allow us to find the 'keys' that are very far from the 'light.'"

That study leveraged what was known about autism-related genes to discover new ones, but Troyanskaya and her team have also created methodologies for searching for disease-related genomic factors even when no existing information is available. In a 2015 paper in *Nature Methods*, the researchers describe a deep-learning approach called DeepSEA that mines large data sets to predict the effects of mutations in the noncoding region of the genome. "We can use that information to give a single impact score that indicates whether or not a mutation appears to be a human-disease mutation and whether it is likely to be functional," Troyanskaya said.

Olga Troyanskaya

Team members

Arjun Krishnan, associate research scholar in the Lewis-Sigler Institute for Integrative Genomics; Ran Zhang, graduate student in the Department of Molecular Biology; Jian Zhou, graduate student in the Lewis-Sigler Institute for Integrative Genomics

Collaborators

Alex Lash, chief informatics officer, and Alan Packer, senior scientist, at the Simons Foundation Autism Research Initiative

Development status

Princeton is seeking outside interest for further development of this technology.

Funding sources

National Institutes of Health, Simons Foundation

Student companies take on new challenges

As an undergraduate and later a graduate student in mathematics at Princeton, John Stogin wanted to share handwritten equations and notes via the internet, but there was no easy way to do it. So he wrote his own software tool. To bring his technology into wider use, he connected with Princeton's Keller Center, which educates students in entrepreneurship, innovation and leadership through classes and programs.

Stogin's idea is one of a select group chosen each year to work with the Keller Center's eLab Summer Accelerator program. Over a period of 10 weeks, student teams work intensively on their startups, attend a series of targeted workshops, and receive valuable mentorship and advising through a network of seasoned entrepreneurs and technology experts. Housed in downtown Princeton at the Princeton Entrepreneurial Hub, the program culminates with presentations to investors, inventors, experts and others from the entrepreneurial community at Demo Days held in Princeton and New York City.

"Entrepreneurship is about much more than starting companies, it's about translating aspirations to meaningful impact," said Margaret Martonosi, Princeton's Hugh Trumbull Adams '35 Professor of Computer Science and director of the Keller Center. "Princeton students are eager to engage in the larger entrepreneurial ecosystem as a way to bring their ideas and discoveries forward for the benefit of humanity. Our goal is to support them in this, and to educate the leaders of our technology-driven society to solve critical societal challenges."

Among the Summer 2017 eLab companies were:

Scratchwork

Through their startup company, Scratchwork, Stogin and a team of six current and former Princeton students will develop Stogin's beta-version software into a product, while exploring how to market it to higher education institutions. "Our product will make digitizing equations and sharing them via the internet easy for anyone with no special computer or stylus required," said Stogin, who earned his doctorate in spring 2017 on the mathematics of black holes. "You can discuss your ideas with colleagues and friends around the world, all in real time."

HomeWorks

To bring the benefits of boarding programs to under-resourced communities, Natalie Tung, Class of 2018, and Brenaea Fairchild, Class of 2016, founded HomeWorks. The nonprofit company aims to provide afterschool academic and community enrichment to high school girls who are underserved or may be living in unstable environments. "Our afterschool boarding program is the step between boarding schools and public schools that allows us to take advantage of both worlds for a fraction of the cost," Tung said.

Flux Marine

Growing up, Benjamin Sorkin spent summer vacations refurbishing boat engines as a hobby. At Princeton, the Class of 2017 student combined his passion for marine engines with his education as a mechanical and aerospace engineering major to build outboard motors that are better for the environment. With fellow students, Sorkin started Flux Marine, a company that is developing a line of zero-emissions electric outboard motors with the goal of bringing marine engines into the clean energy future.

Members of the HomeWorks eLab team from left to right: Elijah Sumners, Rutgers University Class of 2018; Mofopefoluwa Olarinmoye and Jordan Stallworth, Princeton University Class of 2020; Natalie Tung and Shohini Rakhit, Princeton University Class of 2018; and Aurelio Ayala, University of Richmond Class of 2020

Building an ecosystem: The Princeton Entrepreneurship Council

In May 2015, Princeton President Christopher L. Eisgruber and then-Provost David S. Lee authorized a broad list of actions to foster "entrepreneurship the Princeton way," defined as the initiation of transformations through risk-taking actions and value-creating organizations. In response, the Princeton Entrepreneurship Council (PEC) was formed to create new entrepreneurial initiatives and partner with existing campus organizations.

"Entrepreneurship at Princeton is moving at entrepreneurial speed," said Anne-Marie Maman, executive director of the Princeton Entrepreneurship Council and a member of the Class of 1984. "Since PEC's inception, we have launched a certificate in entrepreneurship, initiated alumni engagement programs around the country, and are opening a new innovation center to provide space where early-stage companies can flourish."

The Princeton Entrepreneurship Council hosts a number of programs to foster entrepreneurship, including TigerTalks in the City, a series of panel discussions with alumni, faculty and students. Among the panelists at a recent event on design thinking was Annie Cardinal, Class of 2015, a product design engineer at Produktworks in Austin, Texas.

Engaging entrepreneurs

PEC programs cultivate a vibrant entrepreneurial ecosystem by bringing students, alumni, faculty and community entrepreneurs together. Each quarter, a discussion series called TigerTalks in the City brings the innovative research of Princeton faculty to New York City through panel presentations and networking receptions. Another program, Office Hours in the City, connects students, faculty and early-career alumni with alumni mentors who have experience in industries and areas such as law, marketing and business development. Startup Roadshow in Silicon Valley gives Princeton-affiliated early- and growth-stage companies the opportunity to present their concepts to world-class venture capital firms. Tiger Entrepreneurs Conferences, such as one held in Boston, showcase Princeton startups, feature alumni involved in entrepreneurship and innovation, and present faculty-led discussions.

In addition to its own programming, PEC works closely with the University's Office of Technology Licensing and Office of Corporate Engagement and Foundation Relations to help faculty get their entrepreneurial endeavors off the ground.

Entrepreneurship education

In the fall of 2016, PEC and Princeton's Keller Center, which focuses on student entrepreneurship education, jointly launched an undergraduate certificate program in entrepreneurship. The program exposes students to different ways of understanding and building enterprises that create value by developing an informed understanding of the social and global challenges to which entrepreneurship can seek to contribute. In addition to course work, each student completes a "learning by doing" practical field experience under the guidance of alumni mentors.

Alumni Entrepreneurs Fund

Young alumni entrepreneurs who earned their Princeton degree in the past five years are eligible to apply for support from the Alumni Entrepreneurs Fund. The program provides matching funds of up to $100,000 to promising entrepreneurs. Supported through donations from Princeton's entrepreneurial alumni, the Alumni Entrepreneurs Fund provides ongoing alumni mentorship and education in addition to the funding.

The New Jersey Ecosystem

The Princeton Entrepreneurship Council works with its many campus partners — including Corporate Engagement and Foundation Relations, Technology Licensing, Community and Regional Affairs, Public Affairs and others — to actively engage with the regional innovation community. Through relationships with other groups in New Jersey and the region, PEC and its partners seek to cultivate collaborations that foster the open exchange of ideas, with the goal of translating these ideas into technologies that serve humanity. As momentum behind entrepreneurship at Princeton continues to grow, PEC will continue to support entrepreneurs, on campus and beyond.

Startups bring innovative ideas to life

University inventions can provide the starting point for new companies and sometimes entire industries. To help those ideas along, Princeton's Technology Licensing office provides guidance and expertise to make the transition from research project to startup easier and smoother. Entrepreneurship is growing rapidly across Princeton as a whole, with more companies being spun out in 2017 than in any previous year. Three new ventures developing potentially groundbreaking Princeton technologies are:

Optimeos Life Sciences

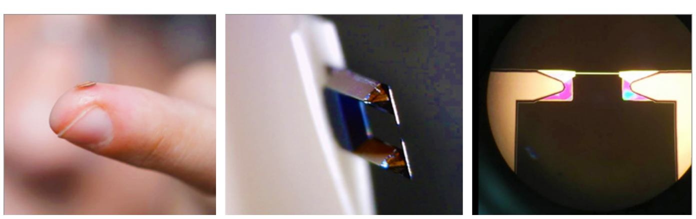
Biologics are a rapidly growing area in therapeutics due to their higher selectivity, potency and reduced side effects. However, many biologics, which are usually composed of proteins, amino acids or other biologically based compounds, are not long-lived in the body.

To transform the delivery of biologics, Optimeos Life Sciences has developed an encapsulating technology that can enhance stability and control the release of these compounds. The technology packs biologics into small particles using a method called inverted flash nanoprecipitation, which involves rapidly mixing compounds and trapping them in a polymer-stabilized delivery vehicle. The company grew from research funded in part by the National Science Foundation in the laboratory of Robert Prud'homme, professor of chemical and biological engineering.

The method can encapsulate biologics with over 90 percent efficiency, whereas competing technologies only approach 10 percent, said Optimeos co-founder and CEO Shahram Hejazi, who also teaches entrepreneurship at Princeton. "With this method, biologics can be released over weeks or months, and this could allow for a single injection over months rather than days or weeks," he said. "Our technology is well suited to deliver the right amount of biologics for extended release over time, in a manner targeted to the right part of body. There is no other technology that can do that."

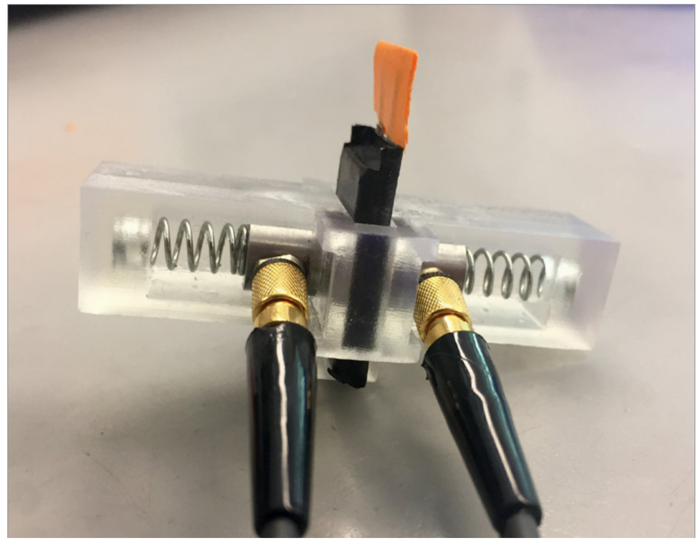
Instrumems

As we progress toward an increasingly connected world, sensors will play an essential role in improving personal comfort, industrial manufacturing, transportation and more. Instrumems, a company that sprang from work in the laboratory of Marcus Hultmark, an assistant professor of mechanical and aerospace engineering, is building tiny lightweight sensors that can measure temperature, humidity and air velocity. Each sensor consists of a nano-size wire that spans two electrodes.



Instrumems sensor. From left to right: Two-millimeter sensor on a finger, sensor on a glass side in a closer view, sensor under a microscope showing the nanowire between the two electrodes.

Gilad Arwatz, who earned his Ph.D. at Princeton working with Hultmark, co-founded the company and is its CEO. "What makes these sensors so unique is their small size as well as the fact that these devices respond to changes very quickly," Arwatz said. "They are about one to two orders of magnitude faster than the sensor technologies currently available."



An early prototype of part of Feasible's apparatus for testing battery health.

Feasible

Every consumer knows the frustration of not knowing whether a household battery is fully charged or empty. It is even more problematic in industry where battery technology is essential for electric vehicles, renewable energy storage, consumer electronics and many other developing areas.

Battery researcher Daniel Steingart, associate professor of mechanical and aerospace engineering and the Andlinger Center for Energy and the Environment, and his team have developed a technology for using sound waves to determine the health and charge level of batteries. Three postdoctoral researchers from Steingart's lab, Shaurjo Biswas, Andrew Hsieh, and Barry Van Tassell, formed the company Feasible to expand the project, which arose from research funded by the Advanced Research Projects Agency-Energy.

Feasible has already won a Phase 1 Small Business Innovation Research grant from the National Science Foundation, and was selected to participate in the Cyclotron Road incubator, which is a partnership between the U.S. Department of Energy's Lawrence Berkeley National Laboratory and the nonprofit organization Activation Energy. "I am amazed by how much excitement and interest we've received from industry since spinning out a year and a half ago," Hsieh said. "There are a lot of companies that need more reliable battery technology and are interested in what we are doing."

Corporate engagement leads to long-term solutions

Princeton researchers have a reputation for exploring some of the biggest questions in science. Industry has a reputation for turning those explorations into real-world solutions. Together, industry and academia can create the synergy that propels new discoveries in areas such as health, the environment and technology.

To support basic and applied research, Princeton's Office of Corporate Engagement and Foundation Relations helps connect faculty members with companies that want to collaborate on open questions. "A core value of Princeton's mission is ensuring that research benefits humanity," said Coleen Burrus, director of Corporate Engagement and Foundation Relations. "Collaborations between faculty and industry make this possible because industry is focused on finding solutions to societal challenges."

Collaborations with industry scientists also help Princeton researchers identify unanswered questions and find new avenues of research, Burrus said. "The flow of knowledge is not just in one direction, from university to corporation," she said. "These are true collaborations."

Research is just one of several ways that industry can engage with Princeton. Companies can also license technologies, support fellowships, recruit students, and get involved in entrepreneurship through the Princeton Entrepreneurship Council and the Keller Center.

The University provides support for research collaborations with industry through the Dean for Research Innovation Fund for Industrial Collaborations. To qualify for the award, Princeton researchers must secure a commitment from a company to provide matching funds in the second year of the project. This year, funding was awarded to three university-industry projects:

Assuring security for computer-based services

A collaboration between Princeton and Amazon is enabling researchers to develop solutions for security challenges that threaten current and future computer systems. To address problems in computing security, Aarti Gupta, professor of computer science, and Sharad Malik, the George Van Ness Lothrop Professor in Engineering and professor of electrical engineering, will team with industrial partners to develop novel techniques for verifying security across hardware and software, with the goal of providing protected foundations on which computer-based services can depend.

Decarbonization of the grid

A collaboration between Princeton's Andlinger Center for Energy and the Environment and NRG Energy, the largest competitive power producer in the U.S., aims to study how to "decarbonize" the U.S. electrical power grid by transitioning the nation's power supply from its reliance on high carbon-emitting power sources to a greater use of renewable and low carbon-emitting fuels. The collaboration, which includes Princeton scientists Thomas Kreutz, energy systems modeler; Eric Larson, senior research engineer; and Robert Williams, senior research scientist, builds on the shared interests of the Andlinger Center and NRG Energy to create a low-carbon future for the U.S. power sector.

Personalizing the user experience through algorithms

When people browse online, algorithms are at work behind the scenes to serve content tailored to users' needs and interests. A new collaboration between Robert Tarjan, the James S. McDonnell Distinguished University Professor of Computer Science, and researchers at Microsoft led by Siddhartha Sen, who earned his doctorate at Princeton in 2013, aims to enhance the browsing experience by creating data structures and algorithms that eliminate performance bottlenecks and advance machine learning applications such as personalizing news, identifying viral content, and optimizing data storage and retrieval.

Princeton IP fund accelerates new technologies

Each year, a select group of projects receives support through Princeton's Intellectual Property Accelerator Fund, which helps transform promising discoveries from the laboratories into widely available products and services.

The projects are chosen for their potential to make a meaningful impact and are ones for which additional research will make the projects attractive for further development by outside entities, including startup companies. The funds can be spent on additional proof-of-concept research, prototype development, or other activities tailored toward expanding the potential for innovation.

"Our aim is to help faculty members and their research teams see their discoveries reach the public where they can have a real-world effect, either through improving people's health, providing technological capabilities that boost our productivity and experiences, or through innovations that can improve our lives in ways that we haven't anticipated," said John Ritter, director of Technology Licensing at Princeton. "That is what is exciting about university research."

Some of the projects funded in 2017 were:

A non-invasive glucose sensor for diabetes management

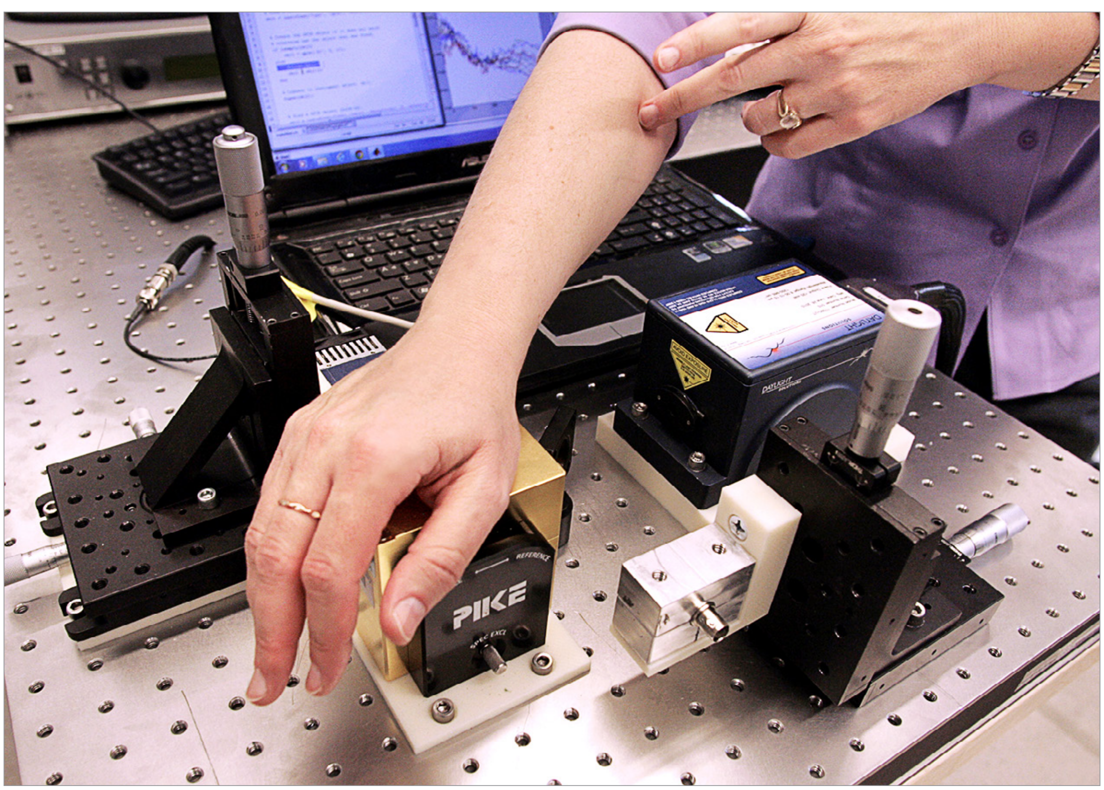
Diabetes can lead to major health issues, yet many people find it difficult to measure their blood sugar levels due to the pain, cost and inconvenience associated with finger pricking to draw blood. Researchers led by Claire Gmachl, the Eugene Higgins Professor of Electrical Engineering, have developed a laser-based system that measures blood glucose levels through the skin. The system, which shines a pulsed, mid-infrared quantum cascade laser on an individual's wrist or finger, has been tested on patients with diabetes with promising results.

X-ray enhancement brings out details

Since their discovery in 1895, X-rays have become an essential tool for diagnosing broken bones, cancer and internal injuries. But X-ray images can be fuzzy and indistinct, which can lead to misdiagnosis and, in turn, unnecessary biopsies and treatments. Jason Fleischer, professor of electrical engineering, and graduate student Jen-Tang Lu are enhancing these images using a technique that relies purely on post-image processing, without requiring changes to the X-ray machinery or to technicians' techniques. Instead, the technology provides automated image enhancements based on models of physiology, machine learning, and the use of a proprietary database of information that is specific to the part of the body and the type of image.

A strategy that targets tumor cell metabolism

A promising class of new anticancer agents could help the body fight off the disease by robbing tumor cells of the ability to make proteins and DNA. Researchers led by Joshua Rabinowitz, professor of chemistry and the Lewis-Sigler Institute for Integrative Genomics, are exploring the creation of new small-molecule therapies that target certain enzymes involved in "one-carbon metabolism"—so named because each reaction involves the transfer of chemical groups containing a single carbon. The team is modifying the small molecules to improve their activity with the goal of eventually providing new treatments for cancer.



A laser-based system for measuring blood glucose levels through the skin could replace painful pricks to draw blood.

New innovation center opens its doors

A new facility, the Princeton Innovation Center, will provide incubation space for startup companies formed by faculty, students and alumni, as well as the wider New Jersey community. Located at Princeton Forrestal Center, about three miles from campus, the 31,000-square foot space will offer shared wet lab space for chemical, biological and pharmaceutical development and shared dry lab space for engineering development, as well as shared office and desk space for related ventures. The center will be equipped with a broad array of premium scientific equipment and will offer additional services and amenities for resident companies.

The newly finished space is strategically designed to promote collaboration, both in formal, communitywide programming and networking events and in the daily work interaction between residents. The Princeton Innovation Center will also host regular educational programming and community networking events. Look for seminar series on topics ranging from new technologies to commercialization strategies, venture funding, grant writing and more. Take advantage of networking and social events to meet academic researchers, local members of the innovation community, and scientific and business leaders. This is the newest effort by Princeton University to promote innovation and to support and grow the regional entrepreneurial ecosystem. The facilities will be managed by a professional accelerator management group.

To discuss the application process and sponsorship opportunities, or for more information, contact Anne-Marie Maman, executive director of the Princeton Entrepreneurship Council, at amaman@princeton.edu.

Inventors 2017

A list of Princeton inventions by current and former members of the University research community for fiscal year 2017

Key: **D** = Disclosure **A** = Application **P** = Patent **L** = License

Faculty member or lead inventor

Invention Title + Invention Status (D, A, P, L)

All inventors, alphabetical by last name

Adriaenssens, Sigrid

Pneumatic Deployable Tsunami/Storm Surge/Flooding Barrier (D, A)
Sigrid Adriaenssens

Aksay, Ilhan

Conducting Elastomers (A)
Ilhan Aksay, Kevin Sallah

Conductive Circuit Containing a Polymer Composition Containing Thermally Exfoliated Graphite Oxide and Method of Making the Same (P)
Ilhan Aksay, Robert Prud'homme

Electrohydrodynamically Formed Structures of Carbonaceous Material (A)
Ilhan Aksay, Valerie Alain-Rizzo, Michael Bozlar, David Bozym, Daniel Dabbs, Nicholas Szamreta, Cem Ustundag

Functionalized Graphene Sheets Having High Carbon to Oxygen Ratios (A, P)
Ilhan Aksay, Sibel Korkut Punckt, David Milius, Robert Prud'homme

Graphene-Ionic Liquid Composites (A, P)
Ilhan Aksay, Sibel Korkut Punckt, Michael Pope, Christian Punckt

Multifunctional Graphene-Silicone Elastomer Nanocomposite, Method of Making the Same, and Uses Thereof (A, P)
Ilhan Aksay, Shuyang Pan, Robert Prud'homme

Printed Electronics (A, P)
Ilhan Aksay, Chuan-Hua Chen, Katherine Chiang, John Crain, Sibel Korkut Punckt, John Lettow, Robert Prud'homme

Sol-Gel Coated Polarization Vessels (L)
Ilhan Aksay, Gordon Cates, Daniel Dabbs, William Happer, Ming Feng Hsu

Thermal Overload Device Containing a Polymer Composition Containing Thermally Exfoliated Graphite Oxide and Method of Making the Same (A)
Ilhan Aksay, Robert Prud'homme

Arnold, Craig

Device and Method for Mechanically Detecting Anomalous Battery Operation (A, L)
Craig Arnold, John Cannarella, Xinyi Liu

Device to Improve Lithium-Ion Battery Life and Safety (D, A)
Craig Arnold, Xinyi Liu

Mechanical Measurement of State of Health and State of Charge for Intercalation Batteries (P, L)
Craig Arnold, John Cannarella

Three-Dimensional (3-D) Tissue Scaffold With Cell Alignment (A)
Craig Arnold, Stephen Bandini, Jeffrey Schwartz, Joshua Spechler

August, David

Pluggable Trust Architectures - Hardware/Software for Checker Module (D)
David August, Stephen Beard, Soumyadeep Ghosh

Trust Architecture and Related Methods (A)
David August, Jordan Fix, Soumyadeep Ghosh

Austin, Robert

Methods and Devices for Multi-Step Cell Purification and Concentration (A)
Lee Aurich, Robert Austin, Roberto Campos-Gonzalez, Curt Civin, Joseph D'Silva, Khushroo Gandhi, Michael Grisham, Alison Skelley, James Sturm, Anthony Ward

Methods and Systems for Processing Particles (A)
Robert Austin, Yu Chen, Curt Civin, Joseph D'Silva, Michael Grisham, James Sturm

Nanochannel Arrays and Their Preparation and Use for High Throughput Macromolecular Analysis (A, P)
Robert Austin, Han Cao, Stephen Chou, Jonas Tegenfeldt, Zhaoning Yu

Avalos, José

Light Activated Gene Transcription of Metabolic Enzymes for Metabolic Pathway Tuning and Induction of Promoter Cascades (D, A)
José Avalos, Jared Toettcher, Evan Zhao

System and Method of Optogenetically Controlling Metabolic Pathways for the Production of Chemicals (A)
José Avalos, Jared Toettcher, Evan Zhao

Barstow, Buz

System for Isolating DNA Molecules (A)
Oluwakemi Adesina, Isao Anzai, Buz Barstow, Michael Baym, Lev Shaket

Basile, Allan

Support Mechanism for the Pivoted Structure on the Opposite Side of the Pivot (D, A)
Allan Basile, Russell Feder, Andrei Khodak

Bassler, Bonnie

Broad Spectrum Pro-Quorum-Sensing Molecules as Inhibitors of Virulence in *Vibrios* (P)
Bonnie Bassler, Jian-Ping Cong, Wai-Leung Ng, Lark Perez, Martin Semmelhack

Diagnostic and Therapeutic Quorum-Sensing-Manipulation Molecules That are Trackable for Health-Care and Industrial Systems (D, A)
Bonnie Bassler, Minyoung Kim, Tom Muir, Howard Stone, Aishan Zhao

Inhibition of Quorum-Sensing-Mediated Processes in Bacteria (P)
Bonnie Bassler, Lee Swem

Novel Antimicrobial Compositions and Methods of Use (A)
Bonnie Bassler, Nina Hoyland-Kroghsbo, Jon Paczkowski

Small Molecule Antagonists of Bacterial Quorum-Sensing Receptors (P)
Bonnie Bassler, Colleen O'Loughlin, Lee Swem, Scott Ulrich

Surfaces Comprising Attached Quorum-Sensing Modulators (A)
Bonnie Bassler, Minyoung Kim, Howard Stone

Berry, II, Michael

System and Methods for Facilitating Pattern Recognition (A)
Michael Berry, II

Bitter, Manfred

Multi-Cone X-Ray Imaging Bragg Crystal Spectrometer (A)
Manfred Bitter, Luis Delgado-Aparicio, Philip Efthimion, Lan Gao, Kenneth Hill, Novimir Pablant

Precise Proton Positioning Method for Proton Therapy Treatment, and Proton Therapy Treatment Method (A)
Manfred Bitter, Philip Efthimion, Lan Gao, Kenneth Hill, Dale Meade

Boumal, Nicolas

Mapping Heterogeneous or Time-Varying Objects Using Low-Order Moments (D, A)
Tamir Bendory, Nicolas Boumal, Roy Lederman, William Leeb, Nir Sharon, Amit Singer

Bozlar, Michael

Electrohydrodynamically Formed Structures of Carbonaceous Material (A)
Ilhan Aksay, Valerie Alain-Rizzo, Michael Bozlar, David Bozym, Daniel Dabbs, Nicholas Szamreta, Cem Ustundag

Brangwynne, Clifford

Disordered Protein-Based Seeds for Molecular Clustering (D, A)
Dan Bracha, Clifford Brangwynne

Light Activatable Multi-Valent Protein Repeats for Rapid and Reversible Clustering (D, A)
Clifford Brangwynne, Yongdae Shin, Jared Toettcher

Optogenetic Tool for Rapid and Reversible Clustering of Proteins (A)
Clifford Brangwynne, Yongdae Shin, Jared Toettcher

Burrows, Paul

OLEDs Doped With Phosphorescent Compounds (P)
Paul Burrows, Stephen Forrest, Andre Shoustikov, Scott Sibley, Mark Thompson, Yujian You

Buschman, Timothy

Adaptive Cognitive Prosthetic and Applications Thereof (A)
Timothy Buschman

Cai, Feng

Two-Phase Flow Approach to Turbomolecular Pump Cooling (D)
Feng Cai

Carlsson, Johan

A Full-Duplex, Electroacoustic Plasma Transducer for the Sonic and Ultrasonic Frequency Ranges (D, A)
Johan Carlsson

Carrow, Brad

Transition Metal Catalysts for Olefin Polymerization (A)
Brad Carrow, Wei Zhang

Tri-(Adamantyl)Phosphines and Applications Thereof (A)
Brad Carrow, Liye Chen

Carter, Emily

Multiple Band Gap CO-NI Oxide Compositions and Applications Thereof (A)
Nima Alidoust, Emily Carter, Martina Lessio

P-Type Transparent Conducting Nickel Oxide Alloys (A)
Nima Alidoust, Emily Carter

Caspary, Kyle

Removal of Oxides From Galinstan (Gallium Indium Tin Eutectic Alloy) by Reaction With Elemental Aluminum (D, A)
Kyle Caspary, Erik Gilson, Hantao Ji

> The creative and collaborative approach to discovery, entrepreneurship and community engagement at Princeton is best in class and a model for all. The commitment of their team to making a mark in this important arena and bringing discoveries forward is palpable and exciting and making a difference in our ecosystem. I can't wait to see what the future will bring.
>
> **Debbie Hart**
> *President and CEO, BioNJ*

Cava, Robert

Electronic Interconnects and Devices With Topological Surface States and Methods for Fabricating Same (P)
Robert Cava, Nai Phuan Ong, Ali Yazdani

Gigantic Surface-Lifetime of an Intrinsic Topological Insulator (A)
Robert Cava, M. Zahid Hasan, Madhab Neupane, SuYang Xu

Chaikin, Paul

Quasicrystalline Structures and Uses Thereof (A, P)
Paul Chaikin, Weining Man, Paul Steinhardt

Chiang, Mung

Adaptive Video Streaming From Networked UAV Cameras (D, A)
Mung Chiang, Aakanksha Chowdhery, Xiaoli (Shirley) Wang

CYRUS (Client-defined privacY-protected Reliable cloUd Storage) (L)
Mung Chiang, Jaeyoon Chung, Sangtae Ha, Carlee Joe-Wong

Methods for Optimizing Discussions in Social Learning Networks (D)
Christopher Brinton, Swapna Buccapatnam Tirumala, Mung Chiang, H. Vincent Poor, Felix Wong

Quota Aware Video Adaptation (P)
Jiasi Chen, Mung Chiang, Amitabha Ghosh

System and Method for Pricing and Exchanging Content (L)
Mung Chiang, Hazer Inaltekin, H. Vincent Poor

System and Methods for Time Deferred Transmission of Mobile Data (A)
Mung Chiang, Sangtae Ha, Carlee Joe-Wong, Soumya Sen

Chirik, Paul

Dehydrogenative Silylation, Hydrosilylation and Crosslinking Using Pyridinediimine Cobalt Carboxylate Catalysts (A)
Julie Boyer, Paul Chirik, Johannes Delis, Kenrick Lewis, Aroop Kumar Roy, Christopher Schuster

Dialkyl Cobalt Catalysts and Their Use for Hydrosilylation and Dehydrogenative Silylation (A)
Paul Chirik, Johannes Delis, Tianning Diao, Kenrick Lewis, Aroop Kumar Roy

Enantiopure Base-Metal Catalysts for Asymmetric Catalysis and Bis(imino)pyridine Iron Alkyl Complexes for Catalysis (P)
Paul Chirik, Max Friedfeld, Jordan Hoyt, Sebastien Monfette

Iron and Cobalt Catalyzed Hydrogen Isotope Labeling of Organic Compounds (A)
Paul Chirik, Renyuan (Pony) Yu

Chou, Stephen

Nanochannel Arrays and Their Preparation and Use for High Throughput Macromolecular Analysis (A, P)
Robert Austin, Han Cao, Stephen Chou, Jonas Tegenfeldt, Zhaoning Yu

Systems and Methods for Personalized Sample Analysis (A)
Stephen Chou

Choueiri, Edgar

A Method for Measuring Low-Noise Acoustical Impulse Responses at High Sampling Rate (A)
Braxton Boren, Edgar Choueiri, Rahulram Sridhar, Joseph Tylka

Spectrally Uncolored Optimal Crosstalk Cancellation for Audio Through Loudspeakers (L)
Edgar Choueiri

System and Method for Producing Head-Externalized 3-D Audio Through Headphones (P, L)
Edgar Choueiri

System and Method for Virtual Navigation of Sound Fields Through Interpolation From an Array of Microphone Assemblies (D, A)
Edgar Choueiri, Joseph Tylka

Cohen, Samuel

Magnetic Dipole Cancellation (D, A)
Samuel Cohen, Michael Paluszek, Stephanie Thomas

Cuff, Paul

Tunable Oblivious RAM (A)
Paul Cuff, Prateek Mittal, Sameer Wagh

Dabbs, Daniel

Electrohydrodynamically Formed Structures of Carbonaceous Material (A)
Ilhan Aksay, Valerie Alain-Rizzo, Michael Bozlar, David Bozym, Daniel Dabbs, Nicholas Szamreta, Cem Ustundag

Sol-Gel Coated Polarization Vessels (L)
Ilhan Aksay, Gordon Cates, Daniel Dabbs, William Happer, Ming Feng Hsu

Davis, William

Miniature Integrated Nuclear Detection System (MINDS) Algorithms for Radionuclide Identification (D)
William Davis, Charles Gentile, Kenneth Silber

Delgado-Aparicio, Luis

Multi-Cone X-Ray Imaging Bragg Crystal Spectrometer (A)
Manfred Bitter, Luis Delgado-Aparicio, Philip Efthimion, Lan Gao, Kenneth Hill, Novimir Pablant

Dogariu, Arthur

Detection Systems and Methods Using Coherent Anti-Stokes Raman Spectroscopy (L)
Arthur Dogariu

Dooley, Stephen

System and Method for the Determination of Mixture Averaged Molecular Weight of Complex Mixtures (P)
Stephen Dooley, Frederick Dryer, Sang Hee Won

Dryer, Frederick

System and Method for the Determination of Mixture Averaged Molecular Weight of Complex Mixtures (P)
Stephen Dooley, Frederick Dryer, Sang Hee Won

Dural, Nezih

Anodically Bonded Cells With Internal Optical Elements (L)
Nezih Dural, Michael Romalis

Atomic Magnetometry Using Pump-Probe Operation and Multipass Cells (L)
Nezih Dural, Shuguang Li, Michael Romalis, Dong Sheng

Ebrahimi, Fatima

Helicity Injection Plasmoid Thruster (D, A)
Fatima Ebrahimi

Efthimion, Philip

Multi-Cone X-Ray Imaging Bragg Crystal Spectrometer (A)
Manfred Bitter, Luis Delgado-Aparicio, Philip Efthimion, Lan Gao, Kenneth Hill, Novimir Pablant

Precise Proton Positioning Method for Proton Therapy Treatment, and Proton Therapy Treatment Method (A)
Manfred Bitter, Philip Efthimion, Lan Gao, Kenneth Hill, Dale Meade

Feamster, Nick

Sonata: A Scalable Streaming Analytics Platform for Network Monitoring (D, A)
Nick Feamster, Arpit Gupta, Walter Willinger

Feder, Russell

Support Mechanism for the Pivoted Structure on the Opposite Side of the Pivot (D, A)
Allan Basile, Russell Feder, Andrei Khodak

Fiebrink, Rebecca

GPS Connected Time Server for High-Accuracy Musical Tempo Synchronization (D, A)
Rebecca Fiebrink, Reid Oda

Fisch, Nathaniel

Backward Raman Amplifier With Plasma Wave Seed (D)
Ido Barth, Nathaniel Fisch, Kenan Qu

Laser Pulse Compressor Using Magnetized Plasmas (D)
Nathaniel Fisch, Hong Qin, Yuan Shi

Laser Pulse Sharpening With Electromagnetically Induced Transparency in Plasma (D)
Nathaniel Fisch, Kenan Qu

Wave-Driven Electro-Rotational Toroid Confinement Device (D)
Nathaniel Fisch, Jean-Marcel Rax

X-Ray Burst Generation and Control Through Sudden Viscous Dissipation in Compressing Plasma (A)
Seth Davidovits, Nathaniel Fisch

Fleischer, Jason

Apparatus and Methods for Determining State of Change (SOC) and State of Health (SOH) of Electrical Cells (L)
Shoham Bhadra, Jason Fleischer, Peter Gjeltema, Alexandre Goy, Benjamin Hertzberg, Andrew Hsieh, Clarence Rowley, III, Daniel Steingart

Improved-Resolution Light-Field Imaging (P)
Jason Fleischer, Chien-Hung Lu, Stefan Muenzel

Method and System for Generation of Entangled Photons Using Stimulated Emission and A4-F System (A)
Jason Fleischer, Xiaohang Sun

Method and System for Measurement of Entangled Photons (A)
Jason Fleischer, Chien-Hung Lu, Matthew Reichert, Xiaohang Sun

Method and System for Quantum Information Processing and Computation (A)
Jason Fleischer, Chien-Hung Lu, Matthew Reichert, Xiaohang Sun

System and Method for Nonlinear Self-Filtering via Dynamical Stochastic Resonance (P)
Dmitry Dylov, Jason Fleischer

Florescu, Marian

Narrow-Band Frequency Filters and Splitters, Photonic Sensors and Cavities Having Pre-Selected Cavity Modes (A, P)
Marian Florescu, Paul Steinhardt, Salvatore Torquato

Non-Crystalline Materials Having Complete Photonic, Electric or Phononic Band Gaps (A, P)
Marian Florescu, Paul Steinhardt, Salvatore Torquato

Floudas, Christodoulos

Compstatin Analogs (P)
George Archontis, Meghan Bellows Peterson, Christodoulos Floudas, Ronald Gorham, Jr., George Khoury, Dimitrios Morikis, Phanourios Tamamis

Forrest, Stephen

OLEDs Doped With Phosphorescent Compounds (P)
Paul Burrows, Stephen Forrest, Andre Shoustikov, Scott Sibley, Mark Thompson, Yujian You

Freedman, Michael

System and Method for Improving Streaming Video via Better Buffer Management (A)
Matvey Arye, Michael Freedman

Gao, Lan

Multi-Cone X-Ray Imaging Bragg Crystal Spectrometer (A)
Manfred Bitter, Luis Delgado-Aparicio, Philip Efthimion, Lan Gao, Kenneth Hill, Novimir Pablant

Precise Proton Positioning Method for Proton Therapy Treatment, and Proton Therapy Treatment Method (A)
Manfred Bitter, Philip Efthimion, Lan Gao, Kenneth Hill, Dale Meade

Gentile, Charles

Miniature Integrated Nuclear Detection System (MINDS) Algorithms for Radionuclide Identification (D)
William Davis, Charles Gentile, Kenneth Silber

Transition-Edge Sensor X-Ray Fluorescence (TES-XRF) for High Resolution Material Identification (A)
Charles Gentile, Christopher Tully

Gerakis, Alexandros

Active Protection of Optical Surfaces From Contaminations (A)
Alexandros Gerakis, Alexsandr Merzhevskiy, Yevgeny Raitses, Vladislav Vekselman

Anti-Fogging Apparatus for Glass Elements (D, A)
Alexandros Gerakis, Vasileios Selamis

Car Seat/Cabin Ejection System for Autonomous Road Vehicles (A)
Alexandros Gerakis

Minimum Backreflection Laser Beam Dump (D, A)
Alexandros Gerakis

Plasma Based, Laser Assisted Manufacturing by Additive Layers in 3-Dimensions (P.L.AS.M.A. 3-D) (D, A)
Alexandros Gerakis, Yevgeny Raitses

Self-Aligning Deflector Device for Transmission Line Offset Correction (A)
Cara Bagley, Mary Demetillo, Alexandros Gerakis, Michael Gomez, Benjamin Tobias, Ali Zolfaghari

Self-Aligning Translation Mechanism for Laser Beams (D)
Mary Demetillo, Alexandros Gerakis

Gilson, Erik

Removal of Oxides From Galinstan (Gallium Indium Tin Eutectic Alloy) by Reaction With Elemental Aluminum (D, A)
Kyle Caspary, Erik Gilson, Hantao Ji

Gitai, Zemer

Compounds Having Antibacterial Activity and Methods of Use (A)
Zemer Gitai, Hahn Kim, Maxwell Wilson

Devices and Methods for Inhibiting or Preventing Colonization of Fluid Flow Networks by Microorganisms (A)
Zemer Gitai, Minyoung Kim, Yi Shen, Albert Siryaporn, Howard Stone

Glisic, Branko

System and Method for Interfacing Large-Area Electronics With Integrated Circuit Devices (P)
Branko Glisic, James Sturm, Naveen Verma, Sigurd Wagner

Gmachl, Claire

Noninvasive Mid-Infrared *In Vivo* Glucose Sensor (L)
Claire Gmachl, Sabbir Liakat, Anna Michel

Goldston, Robert

Clamp-On Flow Meter Based on Heat Transport (D)
Robert Goldston, Michael Jaworski, Marc Sibilia

Non-Intrusive, Non-Spoofable Thermal Flow Meter (D)
Robert Goldston, Andrei Khodak

The Neutron Bloodhound (Directional Neutron Detection) (D)
Robert Goldston, Evan Leppink

Gomez, Michael

Self-Aligning Deflector Device for Transmission Line Offset Correction (A)
Cara Bagley, Mary Demetillo, Alexandros Gerakis, Michael Gomez, Benjamin Tobias, Ali Zolfaghari

Groves, John

An Efficient, Catalytic and Scalable Method to Produce Chlorine Dioxide (P)
John Groves, Thomas Umile

Compositions and Methods for Hydrocarbon Functionalization (A, P)
Nicholas Boaz, George Fortman, John Groves, Thomas Brent Gunnoe

Iron Porphyrazines as Efficient, Catalytic and Scalable Method to Produce Chlorine Dioxide (A)
John Groves, Roy Xiao

Isotopic Fluorination and Applications Thereof (A)
Xinyi Chen, John Groves

Happer, William

Alkali Metal Hybrid Spin-Exchange Optical Pumping (L)
Gordon Cates, Christopher Erickson, William Happer, Michael Romalis

Coatings for Production of Hyperpolarized Noble Gases (L)
Gordon Cates, Bastiaan Driehuys, William Happer

Cryogenic Accumulator for Spin-Polarized Xenon-129 (L)
Gordon Cates, Bastiaan Driehuys, William Happer, Eli Miron, Brian Saam, Daniel Walter

High Volume Hyperpolarizer for Spin-Polarized Noble Gas (L)
Gordon Cates, Bastiaan Driehuys, William Happer, Hunter Middleton, Eli Miron, Brian Saam

Magnetic Resonance Imaging Using Hyperpolarized Noble Gases (L)
Gordon Cates, William Happer

Polarized Xenon Accumulator with Separate Condensation and Storage (L)
William Happer, Nicholas Kuzma

Sol-Gel Coated Polarization Vessels (L)
Ilhan Aksay, Gordon Cates, Daniel Dabbs, William Happer, Ming Feng Hsu

Hasan, M. Zahid

Gigantic Surface-Lifetime of an Intrinsic Topological Insulator (A)
Robert Cava, M. Zahid Hasan, Madhab Neupane, SuYang Xu

Method for Production and Identification of Weyl Semimetal (A)
Nasser Alidoust, Ilya Belopolski, M. Zahid Hasan, Shuang Jia, Madhab Neupane, SuYang Xu

Hazan, Elad

Method for Online Learning of Linear Dynamical Systems (D, A)
Elad Hazan, Karan Singh, Cyril Zhang

Hecht, Michael

DEEPs-*De Novo* Expression Enhancer Proteins (D)
Michael Hecht, Shlomo Zarzhitsky

Hill, Kenneth

Multi-Cone X-Ray Imaging Bragg Crystal Spectrometer (A)
Manfred Bitter, Luis Delgado-Aparicio, Philip Efthimion, Lan Gao, Kenneth Hill, Novimir Pablant

Precise Proton Positioning Method for Proton Therapy Treatment, and Proton Therapy Treatment Method (A)
Manfred Bitter, Philip Efthimion, Lan Gao, Kenneth Hill, Dale Meade

Hultmark, Marcus

Bending Filament Velocity Sensor (A, L)
Clayton Byers, Yuyang Fan, Matthew Fu, Marcus Hultmark

Fast Response Humidity Sensor (P)
Gilad Arwatz, Yuyang Fan, Marcus Hultmark, Margit Vallikivi

Fast Response Temperature Sensor (A)
Gilad Arwatz, Carla Bahri, Yuyang Fan, Marcus Hultmark

> I've licensed technologies from several universities, and my experience with Princeton has been the most 'entrepreneur-friendly.' The staff in the Technology Licensing office is excellent. They are really amazing people—honest, open, communicative and highly skilled.
>
> **Shahram Hejazi**
> *Co-founder and CEO, Optimeos Life Sciences*

Multi-Component Fast-Response Velocity Sensor (D, A, L)
Clayton Byers, Yuyang Fan, Matthew Fu, Marcus Hultmark

Nano-Wires Integration for Real-Time Compensation (A)
Gilad Arwatz, Marcus Hultmark

System and Method for Monitoring Injection Site Pressure (D, A, L)
Clayton Byers, Yuyang Fan, Matthew Fu, Marcus Hultmark

Hvasta, Michael

Processes to Calibrate Rotating Lorentz-Force Flowmeters (D, A)
Michael Hvasta

Jamieson, Kyle

Design and Implementation of a Mobile RFID Tag Sorting Robot (D, A)
Kyle Jamieson, Longfei Shangguan

Pantomime: Enabling Gesture-Based Interactions With Objects (D, A)
Kyle Jamieson, Longfei Shangguan

Rapid Picocell Switching for Wireless Transit Networks (D, A)
Kyle Jamieson, Longfei Shangguan, Zhenyu Song

Jaworski, Michael

A Resettable, Explosive Opening Switch (D)
Michael Jaworski

Clamp-On Flow Meter Based on Heat Transport (D)
Robert Goldston, Michael Jaworski, Marc Sibilia

Method and Device for Rapid Reproduction of a Metallic Implosion Liner (D)
Michael Jaworski

Resettable Magnetic Flux Compression Device (D)
Michael Jaworski

Jha, Niraj

A Hierarchical Health Decision Support System Based on Wearable Medical Sensors and Machine Learning Ensembles (D, A)
Niraj Jha, Hongxu Yin

Continuous Authentication System and Method Based on BioAura (A)
Niraj Jha, Arsalan Mosenia, Anand Raghunathan, Susmita Sur-Kolay

Safety-Driven Architecture for Implantable and Wearable Medical Devices (A)
Niraj Jha, Younghyun Kim, Anand Raghunathan, Vijay Raghunathan

Secure Optical Communication Channel for Implantable Medical Devices (D, A)
Niraj Jha, Arsalan Mosenia

Sensors With Compressed Signal Processing on Nyquist-Sampled Signals (D, A)
Niraj Jha, Jie Lu, Naveen Verma

Stress Detection and Alleviation System (SODA) (D, A)
Ayten Akmandor, Niraj Jha

System and Method for Energy Efficient Sensors With Compression, Artificial Intelligence and Security (D, A)
Niraj Jha

Tracking a Smartphone User Around the World (A)
Xiaoliang Dai, Niraj Jha, Prateek Mittal, Arsalan Mosenia

Ji, Hantao

Removal of Oxides From Galinstan (Gallium Indium Tin Eutectic Alloy) by Reaction With Elemental Aluminum (D, A)
Kyle Caspary, Erik Gilson, Hantao Ji

Ju, Yiguang

Method for High Temperature Synthesis of Functional Nanoparticles Using Sub-Micron Sprays (D, A)
Christopher Abram, Yiguang Ju, Maksym Mezhericher

Process for Generating Cool Flame and Flameless Fuel Oxidation Using Non-Equilibrium Plasma Activation (A)
Yiguang Ju, Weiqi Sun, Sang Hee Won

Kaganovich, Igor

Feathered Surface Geometry for Reducing Secondary Electron Yield (D, A)
Igor Kaganovich, Charles Swanson

Kahne, Daniel

Modified Lipopolysaccharide Glycoform and Method of Use (A, P)
Dorothee Andres, Marcin Grabowicz, Daniel Kahne, Thomas Silhavy

Kang, Yibin

Cell Lines With MTDH KD or KO and Rescue Expression of WT or MT MTDH or SND1 (L)
Yibin Kang, Minhong Shen, Liling Wan, Yong Wei

Expression Constructs for Various Mutants Forms of MTDH and SND1 for *In Vivo* Analysis Through Transient Expression in Cells (L)
Yibin Kang, Minhong Shen, Liling Wan, Yong Wei

Gene Expression Profile Dataset of Cell Lines or Tissues With Different MTDH or SND1 Status (L)
Yibin Kang, Liling Wan, Yong Wei

***In Vitro* and *In Vivo* Assays to Test MTDH and SND1 Function in Tumor Initiation, Growth and Treatment Resistance (L)**
Yibin Kang, Liling Wan, Yong Wei

Metadherin Gene as a Therapeutic Target for Chemoresistant Metastatic Cancer (L)
Guohong Hu, Yibin Kang

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> *Vice President,*
> *Process Research and Development,*
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Cover illustration

Lightweight, flexible organic solar cells could someday lead to new applications such as clothing that generates electricity from the sun, which is not possible with today's heavy and rigid silicon-based solar panels.

Michael Fusella, a graduate student working with Barry Rand, an assistant professor of electrical engineering and the Andlinger Center for Energy and the Environment, creates crystalline thin films made from a small organic hydrocarbon molecule known as rubrene. Normally red in color, the rubrene in this image has been photographed using polarizing filters that strip out the color and allow Fusella to distinguish individual crystal grains.

The image was featured in the School of Engineering and Applied Science's "2017 Art of Science" exhibition.

Fusella, M. A. *et al.* Homoepitaxy of crystalline rubrene thin films. *Nano Lett.* 2017, 17 (5), 3040–3046.

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Architectural renderings (page 13) by Gensler

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