INNOVATION GUIDE
Fall 2017

A first look at 40 disruptive Penn State technologies
Welcome to the Innovation Guide, a first look at 40 disruptive Penn State innovations.

Penn State researchers explore and expand the limits of scientific knowledge every day. Our investigators advance society’s knowledge, educate the next generation of leaders, and contribute to product innovation in a broad array of fields. The Invent Penn State initiative represents Penn State’s first-ever program to organize and nurture these activities across our commonwealth system.

Penn State’s research expenditures totaled $836 million for the 2015–2016 fiscal year, marking the sixth consecutive year topping the $800 million mark. The university has a diverse research portfolio, which reflects our broad base of expertise across all domains.

This Guide provides you with an introduction to 40 of Penn State’s inventions across a variety of fields of research—dive in and get a glimpse of how our scientists are working to improve the future of human health, design and implement future materials and systems, and so much more.

In this guide you will find an introduction to the technologies, an assessment of the potential market applications for the invention, and contact information for how you can continue a discussion with the right people at Penn State who can guide a research or investment collaboration.

The goal of Invent Penn State is to nurture and develop the university’s massive potential to contribute to economic development in Pennsylvania, throughout the U.S., and beyond.

Invent Penn State is a Commonwealth-wide initiative to spur economic development, job creation and student career success. Invent Penn State blends entrepreneurship-focused academic programs, business startup training and incubation, funding for commercialization, and university-community collaborations to facilitate the challenging process of turning research discoveries into valuable products and services that can benefit Pennsylvanians and humankind.

This publication is available in alternative media on request.

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How to Use the Guide

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Technology Readiness Level

Also at the top of each profile is the Technology Readiness Level (TRL) for each technology. Technology Readiness Level (TRL) scale is used to describe the maturity of a technology, and consists of 9 levels. This scale was developed by NASA in the 1970s to assess the maturity of a technology prior to integrating this technology into a system.

Each level designates the stage of development of a technology, from the initial idea (level 1) to the full deployment of the product in the marketplace (level 9). The levels are described at right.

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Efficiently Converting Waste $\text{CO}_2$ to Electricity

Schematic of the pH-gradient flow cell for converting $\text{CO}_2$ into electricity. The flow cell consisted of two $\text{MnO}_2$ electrodes (black) divided by a nonselective membrane (orange) placed between channels. The channels were simultaneously fed by 1 M NaHCO$_3$ solutions with a low pH value (7.7, dark blue) and high pH value (9.4, light blue) that were generated by sparging $\text{CO}_2$ and air.

Technology Summary: One method of reducing global carbon dioxide emissions is to increase the efficiency of energy recovery from fossil fuel combustion. This can be accomplished by exploiting the CO2 concentration difference between ambient air and exhaust gases created by combusting fossil fuels, which theoretically contains an enormous amount of energy. Previously developed systems to capture this energy have faced two challenges: (1) low densities of power production and (2) the need for expensive materials. This new technology is a pH-gradient flow cell that can be used to overcome these two challenges by producing a much higher power density using only inexpensive materials. This technology can convert $\text{CO}_2$ waste streams into electrical power, which would increase the energy efficiencies of fossil fuel power plants.

Application and Market Utility: The technology would be employed at power plants that combust fossil fuels. Previous work has estimated that the theoretical total amount of potential energy that is produced from $\text{CO}_2$ emissions annually is approximately 1,570 TWh, which is more than one-third of the total US electricity demand in 2015 (4,094 TWh). If the researchers can capture a significant fraction of this energy in a cost-effective manner, this technology would have broad applications both nationally and globally.

Patent Status and Licensing: Please contact the Office of Technology Management for more information.

Next Steps: The research team is studying the underlying mechanisms of the process to improve the system before scaling up. They are seeking material scientists to help develop electrode materials, and investment to further develop the technology.

Keywords
- Reducing Emissions
- Fossil Fuel Power Plants
- Waste $\text{CO}_2$ • Carbon Offsets
- Electricity Production

Research Lead
Bruce E. Logan, PhD
Kappe Professor of Environmental Engineering

Logan is Director of the Engineering Energy & Environmental Institute at Penn State, and a member of the US National Academy of Engineering (NAE). He has worked with several large established companies as well as start-ups, and has directed the construction and operation of two pilot scale systems for water treatment.

Christopher Gorski, PhD
Assistant Professor of Civil and Environmental Engineering

Taeyoung Kim, PhD
Postdoctoral Scholar

Research Website
www.engr.psu.edu/ce/enve/logan/

Platform Qualities
- pH-gradient flow cell produced an average power density of approximately 1 W/m$^2$, which was nearly 200 times higher than values reported using previous approaches
- Uses only inexpensive and benign materials, significantly lowering the costs relative to other technologies
- Electrode materials are made from manganese oxides that can be readily synthesized in the laboratory
Technology Summary: This technology provides a high dielectric energy storage density via bismuth zinc niobate films grown by chemical solution deposition. Energy densities exceeding 40 J/cc have been achieved, with good retention of properties to 200 °C. The energy densities are substantially higher than other materials, enabling device miniaturization. This technology enables weight reduction and miniaturization of components for power electronics.

Application and Market Utility: There are numerous applications for which higher power and energy density capacitors are required, including electric vehicles, power electronics, and medical devices such as heart defibrillators. Most materials store modest amounts of energy, and so must be physically large. The much higher energy densities achieved in these novel films enable miniaturization.


Next Steps: There is currently no manufacturing line for these capacitors. The researchers are seeking licensees, collaborators, and investors to conduct additional research to scale up.
Technology Summary: In current technology, liquid plasticizers are added to the solid polymer electrolyte to increase conductivity of Li-ion batteries. This increases risks from the use of current flammable and toxic liquid plasticizers. This technology employs a newly developed electrolyte comprising a crystalline PEO6LiX complex that provides high room-temperature conductivity with minimal temperature dependence and decreased dendrite growth for increased battery life. Currently, Li-ion batteries using solid polymer electrolyte need to be warmed to 80˚C to be functional. With cellulose-polymer composite electrolyte, no pre-warming is needed.

Application and Market Utility: This technology makes Li-ion batteries safer and increases the battery life, operation temperature range, and energy density. It can be used for battery packs for electric cars and electronics.


Next Steps: The research team seeks licensing, collaboration, and investment to commercialize their product and extend its applicability to broader markets.
**Technology Summary:** This invention provides various embodiments of composite cable assemblies with functionally neutral buoyancy in fluid environments. Composite assemblies include an elongated element such as an optical-fiber cable having negative buoyancy plus one or more supplemental filaments having positive buoyancy, connected together as a composite assembly with functionally neutral buoyancy.

**Application and Market Utility:** There are a variety of situations in which it is desirable to submerge an elongated element in a fluid environment with the element suspended between the upper and lower boundaries of that environment; for example, communication cables in the ocean designed for ships to communicate to shore or to other locations at high data rates and with low rates of delay in signal transmission (known as low latency).

Existing solutions have significant drawbacks:
- Communication systems utilizing satellite links generally demonstrate high latency.
- “Raw” optic fiber, lacking components having positive buoyancy, will sink when suspended in a fluid environment.
- Jacketed cable assemblies with neutral buoyancy are expensive and bulky.

This invention overcomes all of these drawbacks.


**Next Steps:** The top priority of the researchers is finding a licensee. However, they are open minded to any collaboration and/or investment relationship that could help advance their technology.
**Technology Summary:** Springback is a common phenomenon that occurs in sheet metal forming when metal is bent but then springs partially back toward its original shape, thus requiring corrections to be made. This sheet metal forming device and process reduces or eliminates springback. The device is a die tool and roller that rotates relative to the die during and/or after forming a piece of sheet metal. The rotation of the roller can be either freely occurring during the forming process or forcibly imposed during and/or after the forming process.

**Application and Market Utility:** Current methods for dealing with the varying amount of springback exhibited by different materials have proven unsuitable in certain situations, making desirable an improved forming process and/or die for sheet metal forming. This new technology provides an accurate solution that can create significant savings in time invested in making corrections. The tool and process are applicable to all material-forming situations in which the material is pushed or stretched over a corner, including all metal forming (mainly sheet metal forming).


**Next Steps:** The researchers are seeking licensing and collaboration.
Technology Summary: At low light levels, human sensitivity to color is reduced, making colors appear duller, less vibrant, and less vivid. This new technology is an engineering development that compensates for the loss of visual sensitivity by intensifying the colors of objects in low light levels, thereby enhancing vision. Specifically, the technology increases the color range of a multi-light-emitting device while the light levels are being dimmed. The technology independently drives each emitter so the total color gamut increases while total lumen output of the light-emitting device decreases.

Application and Market Utility: Color perceptions and dimming are important considerations in lighting for residential uses, museums, and the hospitality market. This invention could be deployed as an LED replacement lamp (e.g., with a conventional base type, such as a medium screw base or pin base), an LED module (e.g., incorporated into luminaires), or a luminaire (inclusive of housing and optics).


Next Steps: To take this technology from the laboratory to a practical product, the inventor is seeking help in the form of licensing, collaboration, and/or investment.
Technology Summary: The researchers have developed a method for conformally coating substrates with semiconductors at lower temperatures than is possible with conventional chemical vapor deposition (CVD). The deposited semiconductor can infiltrate very small voids and spaces so that it is possible to deposit onto very large areas within static, rolled-up substrates.

Application and Market Utility: There are many potential applications for low-temperature CVD methods in electronics and optics, medical devices, and multiple manufacturing technologies.

Patent Status and Licensing: The inventive process is early-stage and applicable to multiple manufacturing technologies. The Penn State Research Foundation will provide additional information about the IP status and availability for commercialization.

Next Steps: The researchers are interested in collaborating with partners interested in applying the technology to specific fields of use. Contact the Penn State Office of Technology Management for additional information.
Technology Summary: Most sintering processes occur at high temperatures >1000˚C. This technology is a protocol to achieve dense ceramic solids at extremely low temperatures (< 300˚C) via integrating particle, particle-fluid interface control, and external pressure to allow the cold sintering process (CSP). CSP uses a transient aqueous environment to effect densification by a mediated dissolution-precipitation process. These temperatures enable co-sintering of ceramic materials with other materials such as thermoplastics to develop unique composites and new functionalities in a single step process.

The researchers have reduced the technology to practice using over 50 compositions, including advanced ceramics such as BaTiO3 and ZrO2, which are used extensively in electronic devices, among many other applications.

Application and Market Utility: The process shows promise for a diverse range of chemistries (oxides, carbonates, bromides, fluorides, chlorides and phosphates), multiple crystal structures, and multi-material applications. The properties of selected CSP samples are demonstrated to have physical properties essentially equivalent to samples made by conventional thermal sintering.

The technology could have widespread application in a variety of materials and would also provide a clear roadmap to guide future studies on ultra-lowtemperature ceramic sintering, ceramic materials integration, printable electronics, bulk ceramics, and sustainable manufacturing processes for electro-ceramics, mechanical components, and refractories.

Patent Status and Licensing: Please contact the Office of Technology Management for details.

Next Steps: Further collaboration and investment is sought via the Center for Dielectrics and Piezoelectrics to target this technology to one or more of its relevant fields of application. Please coordinate contact through the OTM.
Technology Summary: The field of body area network (BAN) systems is predicted to be a huge market in the near future due to widespread applications ranging from health care, wearable computing, battle field survival, and sports body monitoring. The antenna is a key element of the system, and it significantly affects the overall device performance. This new antenna technology provides a novel approach to achieving a low-profile, conformable, wearable antenna using a metasurface concept for 2.4 GHz body area network applications.

While the antenna represents an essential component in any body area network communications system, it has also been the limiting factor due to its large size (especially the ground plane) as well as its low radiation efficiency. This technology removes these limitations and opens the doors to lower-power, more compact, and more practical body area network systems.

Application and Market Utility: The researchers anticipate a wide variety of applications in wearable technology, including (1) wearable medical devices, (2) wearable sports related devices, (3) wearable devices for Internet of Things (IoT) (including smart buildings/cities), (4) wearable computing devices, (5) wearable devices for firefighters and emergency workers, and (6) wearable devices for the military.


Next Steps: The research team seeks further licensing, collaboration, and investment opportunities in order to target this technology to one or more of the six application areas mentioned above.
Technology Summary: When there are two building materials placed next to one another, there must be a joint that addresses air-tightness, water-tightness, load bearing, and/or multiple other requirements. Conventionally, joints are created by introducing a third element that either mechanically fastens the two components or uses an adhesive to create a bond between them. As a result, the coordination is complicated and difficult, many aspects can fail, and the seal is never guaranteed. There is a need for elimination of as many mechanical joints as possible without undermining functionality. The technology is a seamless/transitioning interface(s) between various materials and/or building components that can introduce a progressive transition (a gradience) between these materials.

Application and Market Utility: This technology is developing simultaneously in three funded areas of focus: (1) the development of sustainable materials, processes, and practices; (2) providing solutions for building in harsh conditions where impermeability between and through surface materials is required; and (3) further development and modification of additive manufacturing technologies in the building industry and production of seamless architecture. The technology has many potential applications in the arts, industrial design, and particularly architecture, permitting construction scenarios never imagined before in the creation of spatial conditions, surface conditions, and insulation against sound, water, moisture, gases, or air.

Patent Status and Licensing: Patent pending (provisional patent filed). The technology is available for licensing through the Office of Technology Management.

Next Steps: The team’s immediate plans include continued design and engineering of composite materials, repeating previous kiln-casting experiments using additive manufacturing technology, and scaling up the technologies.
Technology Summary: The investigators have developed and patented a new polyolefin-based hydrocarbon super-absorbent polymer (Petrogel™) that can effectively transform a maritime oil spill into a floating solid (oil-swelled gel), ready for collection (recovery by skimmer) and refining as regular crude oil, with no special disposal requirements and no residual waste in natural resources.

Application and Market Utility: Three standard methods are commonly deployed to combat an oil spill on the open sea today, including booms and skimmers, dispersants, and in situ burning. These methods are either ineffective or have deleterious environmental consequences. Most of the spilled oil is wasted, becoming pollutants in the air and water. Small fractions that are recovered generate a large quantity of solid and liquid waste. The technology provides a system for collection and reuse or recycling of spilled hydrocarbons.


Next Steps: The investigators seek a partner with engineering and marketing expertise, and financial resources necessary to commercialize Petrogel™ products.

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Petrogel™

Keywords
- Oil Recovery
- Polyolefin-absorbent
- Super-absorbent

Research Leads
T.C. Mike Chung, PhD
Professor of Polymer Science in the Department of Materials Science and Engineering

Chung was previously on the Senior Research staff at Exxon Corporate.

Research Website
http://www.matse.psu.edu/directory/faculty/tc-mike-chung

Platform Qualities
- High oil-absorption capacity
- Fast kinetics
- No water absorption
- Easy recovery from water surface and transport to storage tanks
- Recovered oil can be processed as regular crude
- Cost effective and economically feasible
- Scaled up to multi-pound quantities
Technology Summary: The Lear Laboratory provides on-demand thermal curing of polymer systems using nanoscale materials to efficiently convert light to heat. The light-to-heat conversion results in extreme temperatures near the nanoscale materials, which greatly enhances the rate of polymerization. The technology achieves billion-fold enhancements of polymerization rates while preserving desired chemical control over the final products.

Application and Market Utility: Because of the slow time scales associated with bulk heating and cooling, it’s difficult to stop the thermal curing of polymers using traditional approaches. Further, the elevated levels of bulk-scale temperatures can drive unwanted side reactions—which ultimately limits the temperatures that can be used and the rates of curing that can be realized.

The Lear Laboratory’s technology provides on-demand, nanosecond control over the start and stop of the reaction and allows reactions to be driven at much higher temperatures, ultimately allowing much greater rates of polymerization. The research team knows of no competing solutions to this problem.

Applications include on-demand curing of coatings for technological applications, bandages, and 3D printing.

Patent Status and Licensing: Please contact the Office of Technology Management for more information and patent updates.

Next Steps: The technology is currently at the proof-of-principle stage of development. The research team is seeking investors to determine parameters needed for industrial applications. The team is also seeking licensing opportunities.

Keywords
- light to heat conversion
- thermal curing of polymers
- on-demand curing of polymers
- polymerization rate

Research Leads
Benjamin Lear, Ph.D.
Lead Researcher
Associate Professor of Chemistry, Department of Chemistry in the Eberly College of Science
Lear received his bachelor's degree in biochemistry from UC Davis and Ph.D. in chemistry from UC San Diego. He completed postdoctoral research in synthetic inorganic chemistry at Ohio State University before joining the chemistry faculty at Penn State. Independently, he has been working to understand the interplay between inorganic nanomaterials and their chemical environments.

Kaitlin Haas, Ph.D.
Research Partner
Senior Product Development Engineer at 3M

Joseph Fortenbaugh
Research Partner
Doctoral student, Department of Chemistry in the Eberly College of Science

Research Website
http://research.chem.psu.edu/bulgroup/

Platform Qualities
- Billion-fold enhancements of polymerization rates
- Control over the start and stop of polymerization (on-demand curing) with nanosecond and nanometer precision
- Final products indistinguishable from traditionally cured (bulk-scale) films
Tunable Biomimetic Materials


Technology Summary: Recombinant structural repetitive proteins (SRP) are a thermoplastic biodegradable material with a variety of tunable properties, which is competitive with high-end synthetic petroleum-based plastics. The material is semi-crystalline and can be made rigid or soft, exhibiting very high tensile strength. Among other applications, the team seeks to develop smart textiles which are multi-capable and can be used in a variety of applications, while being environmentally friendly and efficient.

Application and Market Utility: Current applications under consideration include: a self-healing, high-strength textile; a wet adhesive for medical/surgical uses; and cosmetic uses. The material has the advantage of being eco-friendly. Polymers like those in SRPs can be manufactured into polyelectrolyte coatings, made up of positively and negatively charged polymers, to impart various functions, such as clothing that degrades toxins from pesticides.

Patent Status and Licensing: IP is owned by the Penn State Research Foundation and is available for field-limited licensing. The technology is protected by US patent applications 15/137,999 “De novo Structural Protein Design for Manufacturing High Strength Materials” and 14/774,410 & 14/850,001 “Compositions and Methods Related to Proteins Capable of Reversible Transition to a Melt.”

Next Steps: The research group is interested in participating in the commercialization of the technology, and is seeking early-stage funding and research collaboration for investigation of commercial applications.

Keywords
• Biomimetic Materials
• Medical Device
• Biological Coating
• Biopolymer
• Wound Dressing
• Self-healing Materials

Research Leads
Melik Demirel, PhD
Director of the Center for Advanced Fiber Technologies (CRAFT); Professor of Engineering Science and Mechanics

Demirel has a decade of experience in biosensors and nanomaterials. His achievements have been recognized, in part, through his receipt of a Young Investigator Award, an Alexander von Humboldt Fellowship, an Institute for Complex Adaptive Matter Junior Fellowship, the Pearce Development Professorship at Penn State, and a Boeing Distinguished Speaker Award.

Research Website
www.personal.psu.edu/mcd18

Platform Qualities
• Tunable family of recombinant proteins
• Naturally derived to improve
• Biocompatibility
• Physical properties can be modified to
• Enhance ductility and tensile strength

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Technology Summary: The researchers have produced robust graphene oxide (GO) fibers with complex architectures and exceptional mechanical and electrical properties. The GO fibers have extremely large elongation to fracture (up to 76%), high toughness (up to 17 J/m3), and attractive macroscopic properties, such as uniform circular cross-section, smooth surface, and great knotability.

Application and Market Utility: The GO fibers can be used for smart textiles and as a heating element. The films could be used for thin transparent coatings on different hydrophilic surfaces. This technology can save a considerable amount of energy for film formation. It can be even coupled to take advantage of low-grade waste heat. The technology could also be used to produce specialty carbon fibers and GO membranes for gas and organic solvent separation technology.


Next Steps: The researchers seek to bring the GO film and fiber technology from research to commercial applications and need investment to develop a pilot scale manufacturing laboratory and to develop potential applications that can have commercial success. Contact the Office of Technology Management for material samples.
Affordable, Milk-Based Foaming and Emulsifying Ingredients that Fulfill Demand for “Clean” Foods

Technology Summary: A growing number of consumers in the U.S. and worldwide are seeking foods that are minimally processed and/or contain familiar ingredients, and rejecting foods containing synthetic components. This technology uses skim milk as an ingredient to impart foaming and emulsifying properties for specific foods that have typically relied on artificial ingredients for these properties. The use of high-pressure jet processing transforms the casein proteins in skim milk into foaming and emulsifying agents. High pressure and stress dissociate the protein quaternary structures (so-called casein micelles) into monomeric forms that express unique interfacial properties in complex food systems.

Application and Market Utility: The “clean eating” trend has been particularly challenging for dispersed food systems (foods requiring homogeneous dispersion of certain ingredients), including foams such as ice cream and emulsions such as salad dressings, for which replacing synthetic emulsifiers has been difficult. Milk-based foaming and emulsifying ingredients offer a solution to food companies that want to deliver these specific characteristics or functionalities while allowing for “clean” labeling. Applications include foods that are consumed either totally or partially as foams, such as ice cream and coffee, and food emulsions such as salad dressings.


Next Steps: The technology is ready to be scaled up. Proof-of-concept experiments have demonstrated the advantage of this technology as compared to alternative solutions. Currently, licensing and industrial partners are sought in order to scale up and adapt the technology for food products that are sold commercially.

Keywords
- minimally processed foods
- clean foods
- foaming properties
- synthetic emulsifiers
- emulsify
- emulsion
- casein
- dispersed food systems
- food processing

Research Leads
Federico Harte, Ph.D.
Lead Researcher
Associate Professor, Department of Food Science in the College of Agricultural Sciences

Harte’s research focuses on improving the functionality of food proteins and novel applications of non-thermal technologies. He has consulted with national and international companies regarding the physicochemical properties of dairy ingredients and processes.

Research Website
URL

Platform Qualities
- Exceptional foaming properties using skim milk, a “clean label” ingredient
- Foams are stable in excess of 24 hours
- Capacity to emulsify oils in aqueous systems in low-fat formulations
Dietary Supplement to Aid Malaria Recovery

Keywords
- Dietary Supplement
- Iron Deficiency

Research Leads
James Connor, PhD
Distinguished Professor of Neurosurgery, Neural and Behavioral Sciences and Pediatrics; Vice Chair of Neurosurgery Research; Director, Center for Aging and Neurodegenerative Diseases

Connor has over 30 years of research experience in iron and biology, has started two companies, and has significant experience working with industry.

Research Website
https://www.huck.psu.edu/users/james-connor

Platform Qualities
- 100% survival in animal model of malaria compared to 0% on a standard diet or 80% on an iron deficient diet
- Limits the inflammatory response associated with malaria without limiting iron availability
- Because iron is available and inflammatory response is blunted, neurological and cognitive development is normal
- Alleviates the trade-off between consequences of iron deficiency and increased risk of malarial infection

Application and Market Utility: There is debate regarding the use of iron supplements in areas where the risk of malaria is high; some argue that iron deficiency protects against malaria by limiting the number of red blood cells that a parasite can infect. The problem is that iron deficiency brings about a number of problems, such as poor cognition, decreased motor skills, increased risk of heart problems and decreased growth rate in children. This technology is designed to manage iron status, thus minimizing the problems associated with iron deficiency without increasing the effect of malaria infection.

Because iron deficiency is the most common nutritional deficiency affecting 1.62 billion people worldwide, and almost 200 million cases of malaria occurred in 2013, this technology addresses two urgent global health needs.


Next Steps: The researchers are interested in developing a licensing, collaboration, and/or investment relationship that will quickly result in a clinical study for the technology.

Kaplan–Meier survival curve shows that all animals on the standard diet die within 8 days of infection. Animals on the custom diet survive to the end of the experiment.
Technology Summary: Through advancement in transgenic manipulation, genetic engineering techniques can be used to manipulate filamentous fungi for 1) ease of cultivation or production; 2) improved culinary, medicinal, or nutritional value; and 3) production of recombinant proteins for harvest.

The proposed technology enables the transgenic modification of a mushroom-forming fungus to confer a transgenic genotype and/or phenotype by independently controlling each. In transgenic breeding of mushrooms, it is possible to manipulate the fruiting body of a fungus, conferring an altered phenotype but having a wild-type genotype. The fruiting body is devoid of the cognate transgene, making it suitable for the marketplace.

Application and Market Utility: The fruiting bodies (mushrooms) of some fungi are widely commercially cultivated for their culinary, nutritional, and medicinal qualities. However, the commercial cultivation of mushrooms is limited by diseases, insect pests, and narrow genetic variation. While genetic transformation technology holds enormous potential for crop improvement, genetically modified mushrooms have low commercial value because they are not currently preferred in the marketplace. Needed are mechanisms for applying transgenic techniques to independently control the genotype and phenotype and commercially increase yield, disease/pest resistance, product quality, shelf life, and culinary/medicinal value.

A. bisporus can be used for expressing recombinant proteins that may be of commercial value to companies creating biopharmaceuticals or industrial enzymes. Currently, numerous scientists are using A. bisporus to grow valued proteins, but they use the traditional approach in which the fruiting has both transgenic genotype and phenotype. This traditional approach to genetic modification often fails to achieve high-level expression of the protein-of-interest. The new of this invention, which maintains the genotype of the budding fruit, results in higher levels of protein production than the traditional approach.


Next Steps: Product development/testing is finished. Interests include licensing only. Companies of interest include mushroom cultivators, pharmaceutical developers, and industrial enzyme manufacturers.
Keywords
• Food Security
• Remote Plant Disease Diagnosis
• Pest Control
• Predictive Data

Research Leads
David Hughes, PhD
Co-Founder
Assistant Professor of Entomology and Biology

Hughes’ primary expertise is in infectious diseases, having worked in 11 countries on 5 continents.

Marcel Salathé, PhD
Co-Founder

Research Website
www.plantvillage.org

Platform Qualities
• Machine learning algorithms that allow computers to diagnose plant diseases
• Social network around crop health
• Allows massively scalable dissemination of highly predictive data

Technology Summary: PlantVillage is a platform that automatically diagnoses plant diseases using computer vision tools and machine learning algorithms. It connects people growing food with the largest social network of crop health solutions. The algorithms for classifying diseases have been shown to work with a 99% accuracy. The researchers collected 150,000 images to train such algorithms. The algorithms are also now being developed on phones. The social networking platform is currently four years old and has over three million users. The annual growth rate for the platform is 250%.

Application and Market Utility: There are 76 land grant institutions as well as multiple Agricultural Research Stations operated by the USDA both in the USA and abroad (to control accidental import of diseases and pests). Each research center requires point-of-care diagnosis and the opportunity for model transfer.

Food security is a massive area of investment at local, state, federal, and international levels that typically involves substantial sums donated by philanthropic organizations (e.g., Bill and Melinda Gates Foundation, Buffett Foundation, Rockefeller Foundation). Congress recently passed the Food Security Act that authorized $1 billion for President Obama’s Feed the Future program.

Last year, $4.1 billion was invested in agriculture start-ups, which was a 98% increase from 2014. Agriculture accounts for 10% of GDP (globally) but has only received 3.5% of investment, which suggests a high potential for growth.

Patent Status and Licensing: None. PlantVillage promotes free dissemination of information to improve agricultural production worldwide.

Next Steps: The research team seeks collaboration and social-entrepreneur investment to expand the reach of the PlantVillage resource.
Technology Summary: The technology analyzes the pixel content of an image to determine the aesthetic quality and composition, and suggests ideal cropping or creates an aesthetically appealing thumbnail for the image. It can be used to help consumers take more appealing photos or better manage their photo libraries. Further, the software can be used by online businesses for analyzing the market potential of their digital advertising materials. While over one trillion photos are taken every year, a vast majority of the photos are being taken without professional skills. Acquine's technologies aim to empower consumers and amateurs with professional photography capabilities without the need for expensive professional equipment or corresponding skills.

Application and Market Utility: The technology can be used to enhance the photo-taking or photo-managing capabilities of mobile phones, making them more useful to consumers. The market potential is estimated to be about $100 million per year, based on the number of smartphones produced every year. The technology can also be used by online social networks or e-commerce businesses to analyze their vast visual content.


Next Steps: Algorithms have been implemented and thoroughly tested, and are ready for commercial applications. The team seeks to collaborate with device makers to enhance the photo-taking experience of consumers, and is also interested in working with e-commerce businesses or social media companies. The researchers seek investment for commercialization and to expand the company.
Bullying Prevention and Social Emotional Learning

Keywords
- Teacher Education
- Curriculum
- Social Emotional Learning
- Educational Technology

Research Leads
Richard J. Hazler, PhD
Co-Principal Investigator
Professor in Charge of Counselor Education and Coordinator of the Elementary School Counseling Program

JoLynn V. Carney, PhD
Co-Principal Investigator

Linsey Covert, MEd
Director of Project TEAM

Research Website
https://ed.psu.edu/project-team

Platform Qualities
- Reports of reduced bullying in current schools
- Significant gains in students’ school connectedness for bottom 25% who initially reported low connectedness
- Reports of strong sense of belonging in current schools

Technology Summary: Project TEAM provides schools a holistic approach to decreasing bullying and other antisocial behaviors in order to create an improved, more collaborative climate. The school-wide programming includes curriculum, materials, training, and software that meet state laws and mandates on bullying and social emotional learning. The programming seeks to instill in students the six foundations of (1) helping others, (2) positive change, (3) anti-bullying, (4) problem solving, (5) resiliency, and (6) leadership.

Application and Market Utility: Schools are mandated by law to have training and a plan for bullying prevention. A combination of bullying prevention and social emotional learning models makes Project TEAM cost effective and appealing to schools.

Project TEAM curriculum and materials are currently being used in elementary schools. Other potential markets for Project TEAM include nonprofit organizations and other organizations that work with children, as well as professional development trainings for teachers to earn Act 48 credits (Pennsylvania-mandated Continuing Professional Education).

Patent Status and Licensing: Project TEAM was copyrighted in 2012 and trademarked in 2015. This technology has been licensed to TEAMology—a start-up company.

Next Steps: With the development of Project TEAM’s web-based software, there is an opportunity to create a first-of-its-kind technology to provide educators a sharing space, interactive games for students to use in and out of the classroom, and lesson plan builders, along with other capabilities. Project TEAM is seeking collaboration and investment to roll out the next stage of web-based software.
Technology Summary: This video game written in Unity 3D teaches the basic concepts of astronomy through an interactive storyline and series of immersive activities framed within stories. It is appropriate for middle school, high school, and non-science collegiate undergraduate students. The 15-to-30-hour game allows students to learn astronomy virtually and brings entertainment to the subject matter, making the learning process more effective and enjoyable.

Application and Market Utility: Students are often intimidated by science, or find reading about the topic dry and boring. Capitalizing on the widespread popularity of video games, our technology makes astronomy more relevant and accessible. By actively participating in quests, students gain a better understanding and appreciation of the cosmos. The experience can be used for courses in schools and home schooling, as well as recreation both for children and adults.

Patent Status and Licensing: Please contact the Office of Technology Management for more information and patent updates.

Next Steps: The video game has been offered as an online course at Penn State for four years. The inventors are seeking to build on initial success and seek opportunities, including licensing, to bring the game to a larger audience.

Keywords
- astronomy education
- astronomy learning
- astronomy video game

Research Leads

Jane Charlton, Ph.D.
Lead Researcher
Professor, Department of Astronomy and Astrophysics in the Eberly College of Science

Charlton has been a professor of astronomy and astrophysics at Penn State since 1992. She led the development of two massive online courses in astronomy, including the immersive video game, for use in undergraduate general education. These two courses have been taken by more than 20,000 Penn State students.

Nahks Tr’Ehnl
Research Partner
Multimedia Specialist, Department of Astronomy and Astrophysics in the Eberly College of Science

Timothy Schneider
Research Partner
Programmer/Analyst, Department of Astronomy and Astrophysics in the Eberly College of Science

Research Website
URL

Platform Qualities
- More than 5,000 Penn State students have taken Astronomy 001 in video game format, more than 1,000 of them through the World Campus
- Student ratings of teaching effectiveness are excellent, among the highest at Penn State for a general education science class
- The video game program is easy to
Technology Summary: The technology is a soft, resilient hemostatic biofoam useful for treating both intracavity and surface wounds. The material conforms to irregular wound shapes to stop bleeding and transitions to a porous gel protecting newly formed tissue. It is naturally bioabsorbable and composed of low cost, FDA-approved ingredients.

Technology provides an improved wound care solution for many applications: traumatic wounds, surgical wounds, surface wounds, and possibly even negative-pressure wound healing. Because the material is also edible and a tissue scaffold, applications may extend into engineered foods involving animal tissue, such as in vivo meat production.

Application and Market Utility: The product can be used as a traditional wound care product (US market $2.3 billion per year), an active wound care product (US market $1.6 billion per year), and an advanced wound care (US market $2.2 billion per year). It may also be an ideal foam for negative pressure wound healing (US market for therapy $1 billion per year).

Patent Status and Licensing: US patent application 14/198,415 “Composite Materials” EV patent application 14760576.0

Next Steps: The researchers seek collaboration on the development of specific product offerings or licensing of the technology to a company established in the wound care space.
Boronic Compounds for Use as Therapeutic Drugs

Technology Summary: A collaboration between Penn State and Cold Spring Harbor Laboratory has identified promising boron-based compounds that can effectively trap phosphatases from the LAR/PTP-sigma/PTP-delta subfamily of the transmembrane PTP. These phosphatases play important roles in neuronal development and pathfinding, and they are potential targets for treatment of diabetes. These phosphatases can switch between the active and non-active forms by changing their redox states.

The investigators found that the boronate-compounds can trap the phosphatases when the proteins are in the oxidized state but not in the reduced state of the proteins. This allows one to chemically manipulate the activity of the phosphatases by keeping the proteins in the oxidized state for a prolonged period of time. Furthermore, this specific interaction between the boronate-compounds and the oxidized state of the LAR/PTP-sigma/PTP-delta phosphatase subfamily can be useful for characterizing the redox regulation of other phosphatases, such as distinguishing the outcomes of cysteine-oxidation in PTPs.

Application and Market Utility: The subject technology may be useful for discovering and developing therapeutic drug compounds for treating human disease, including nerve injuries and therapeutic angiogenesis in diabetes mellitus. The technology may have utility for biotech companies that develop assays to monitor the redox regulation of the PTP family or other sulfenic acid-regulated proteins.

Patent Status and Licensing: This technology is available for licensing, but additional research is required. Please contact the Office of Technology Management for further information.

Next Steps: The research team is interested in exploring research collaboration with field-specific investigators through licensing or joint research.

Keywords
- LAR/PTP Oxidation
- Redox Regulation of Phosphatases
- Diabetes Treatment

Research Leads
Stephen J. Benkovic, PhD
Evan Pugh University Professor and Eberly Chair in Chemistry

Benkovic’s research group is engaged in a variety of projects connected by the general theme of understanding enzyme catalysis at various levels. He has successfully commercialized several of his inventions.

Nicholas Tonks, PhD
Professor, Cold Spring Harbor Laboratory

Research Website
http://sites.psu.edu/benkoviclab/

Platform Qualities
- A broad portfolio of target compounds and analogues
- Methods for attaching PTP samples to beads that allow separation of oxidized proteins for analytical purposes
Inhibitor structures and MIC (minimum inhibitory concentration) values for selected pathogens

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Keywords
• Drug Discovery
• Antibiotics
• HTS Target Identification

Research Leads
Kenneth Keiler, PhD
Professor of Biochemistry and Molecular Biology
Keiler has worked on trans-translation for 20 years, and holds three patents on inhibition of this pathway and others. He has collaborated with Novartis, GlaxoSmithKline, and Microbiotix on drug development projects.

Stephen Benkovic, PhD
Evan Pugh University Professor and Eberly Chair in Chemistry

Research Website
http://sites.psu.edu/keilerlab/

Platform Qualities
• Trans-translation is required in all bacteria, creating a broad-spectrum target
• Technology includes assay compatible with HTS for inhibitors
• Top identified inhibitors kill pathogens with a MIC < 100 ng/ml
• Target-based resistance occurs with frequency less than 1 in 10^9

Technology Summary: The researchers have developed methods and compositions of matter relating to inhibitors of the tmRNA pathway. These potential therapeutics have antibacterial activity with broad species specificity, including B. anthracis and other pathogens of military and civilian interest. Identified compositions have been demonstrated to kill bacterial pathogens when added exogenously. Proof-of-concept animal testing is underway.

Application and Market Utility: Antibiotic-resistant infections are increasingly difficult to treat and cost $20 billion per year in direct healthcare costs. The subject antibiotics provide a new target for antibiotics and new chemical scaffolds with potent efficacy that can be used to treat infections in humans and/or animals. The researchers’ top inhibitors are as effective as antibiotics in clinical use. They do not exhibit cross-resistance with any existing compounds.


Next Steps: Late-stage preclinical and clinical testing is required to bring these new antibiotics to market.
Technology Summary: This invention allows control of the co-translational folding of a protein in a user-prescribed manner through synonymous codon mutations. It uses a Monte Carlo master equation-based framework and generates a large number of degenerate sequences whose translation produces the desired co-translational folding behavior (which is supplied as input) of a nascent protein.

Traditional codon optimization methods are commonly used to enhance the production of overall proteins in heterologous gene expression. However, proteins produced from these optimized mRNA sequences often misfold and aggregate. This invention solves this problem and can enhance the quality of heterologous protein production by maximizing the proper folding, structure, and quality of the protein produced.

In other words, the invention allows control of the folding of newly created proteins within cells through altering the mRNA sequence without changing the amino acid, in order to achieve folding behavior as desired by the user. This method employs an algorithm involving repeated random sampling and generates a large number of sequences with similar mRNA coding. The invention solves problems inherent in traditional methods and maximizes the quality of results.

Application and Market Utility: High-quality proteins are required for commercial and academic applications. This method provides an efficient way to rationally design mRNA sequences based on the folding kinetics of nascent protein. The method can predict its own success or failure through mathematical modeling without actually carrying out an experiment, thus reducing costs and time.

Applications include those for:
- Biotechnology companies that supply high-quality proteins to academic labs and other industries.
- Pharmaceutical companies that produce functional proteins to design monoclonal antibodies or for therapeutic purposes.


Next Steps: The lead researcher’s faculty members have tested this method in silico (computer simulation) for five different proteins. They are currently seeking licensing and collaboration in order to obtain experimental verification of the technology and further develop it.
**Technology Summary:** This technology provides a diagnostic framework to discriminate between the early and late stages of Barrett’s esophagus by testing a biological sample for expression of specific proteins, comparing the amount of those proteins to reference values. The researchers have created prototypes of diagnostic kits for making these protein determinations.

**Application and Market Utility:** Barrett’s esophagus (BE) is a serious complication of gastroesophageal disease (GERD). It is a precancerous lesion that can progress through low (LGD) and high grade (HGD) dysplasia, resulting in esophageal adenocarcinoma (EAC). It can be difficult to obtain an accurate diagnosis of BE with dysplasia as either low or high grade. Since HGD carries a greatly increased risk of developing EAC, many gastroenterologists will aggressively treat it, while LGD patients remain on active surveillance. As such, a misdiagnosis can have dramatic impact on a BE patient’s morbidity and mortality. Despite efforts to identify new diagnostic markers that could accurately stage the high-risk patients, no useful markers are used clinically and the diagnosis of BE is still based on histopathology of the biopsy.

This technology would be particularly useful to producers of diagnostic kits, suppliers to pathologists, and gastroenterologists.

**Patent Status and Licensing:** A PCT application was filed on March 13, 2015.

**Next Steps:** The research team seeks to license the technology to an interested company or to collaborate on a sponsored research program.
Technology Summary: The PIGN gene is a cancer chromosomal instability (CIN) suppressor. Pu’s lab screened 48 MDS/AML patient samples and identified a novel PIGN gene mutation pattern responsible for increased genomic instability and subsequent myelodysplastic syndromes (MDS) transformation to acute myeloid leukemia (AML) and progression. This novel finding was confirmed by examining the mutation status in 55 AML patients evaluated and published for other researchers at other institutions. Standard blood sample analysis results in classification/staging of the AML disease and allows for the prediction of occurrence of the MDS/AML transformation and progression. The discovery enables further development around prognosis, treatment, and prevention of this cancer.

Application and Market Utility: The technology’s ultimate goal is early detection of disease hence better survival rates. Development stages under evaluation include (1) optimizing analytical methods (PCR/Western Blot); (2) clinical evaluation of disease classification; and (3) building a therapeutic platform with collaborators.

The treatment market for AML will rapidly expand in value from $342.7 million in 2014 to reach $932.6 million by 2024. About 15% of children from birth to 19 years of age diagnosed with leukemia have acute myeloid leukemia. The risk of acute myeloid leukemia is closely associated with age. About 90% of acute myeloid leukemia is diagnosed in middle age. Therefore, there is a need for reliable markers of hematological neoplasia which can be used as prognostic indicators for development of hematological neoplasia and advancement of MDS to AML. Patent Status and Licensing: Provisional patent application filed. Contact the Office of Technology Management for additional information.

Next Steps: The research team seeks a licensing partner and/or collaborators for clinical evaluation of the diagnostic test and development of the therapeutic treatment targeting chromosomal instability.

Bone marrow myeloblasts with Auer rods seen in acute myeloid leukemia

Keywords
- Genomic Stability Marker
- Myelodysplastic Syndromes (MDS)
- Acute Myeloid Leukemia (AML)

Research Leads
Jeffrey Pu, MD, PhD
Assistant Professor of Medicine at the Penn State Hershey Cancer Institute and Penn State College of Medicine

Prior to this position, Pu was a senior clinical/research fellow of Hematology at the Sidney Kimmel Comprehensive Cancer Center of Johns Hopkins University and completed an NIH-supported experimental hematology fellowship and a clinical transfusion medicine/blood banking fellowship at the Lindsley F. Kimball Research Institute of New York Blood Center.

Research Website
https://profiles.psu.edu/profiles/display/67935315

Platform Qualities
- Offers a mechanism for early detection and intervention by identifying chromosomal anomalies
- Sensitive detection system allows accurate staging of genetic mutations correlated to MDS/AML
- Provides an analytical framework for development of therapeutic molecules aimed at disrupting disease progression

Contact
Jianbo Hu
Jianbohu@pennstatehealth.psu.edu

Contact
Office of Technology Management
814.865.6277 | otminfo@psu.edu
Flap Jack Surgical Retrator

NDA required to view technology

Technology Summary: This technology provides a diagnostic framework to discriminate between the early and late stages of Barrett's esophagus by testing a biological sample for expression of specific proteins, comparing the amount of those proteins to reference values. The researchers have created prototypes of diagnostic kits for making these protein determinations.

Application and Market Utility: Barrett's esophagus (BE) is a serious complication of gastroesophageal disease (GERD). It is a precancerous lesion that can progress through low (LGD) and high grade (HGD) dysplasia, resulting in esophageal adenocarcinoma (EAC). It can be difficult to obtain an accurate diagnosis of BE with dysplasia as either low or high grade. Since HGD carries a greatly increased risk of developing EAC, many gastroenterologists will aggressively treat it, while LGD patients remain on active surveillance. As such, a misdiagnosis can have dramatic impact on a BE patient's morbidity and mortality. Despite efforts to identify new diagnostic markers that could accurately stage the high-risk patients, no useful markers are used clinically and the diagnosis of BE is still based on histopathology of the biopsy.

This technology would be particularly useful to producers of diagnostic kits, suppliers to pathologists, and gastroenterologists.

Patent Status and Licensing: A PCT application was filed on March 13, 2015.

Next Steps: The research team seeks to license the technology to an interested company or to collaborate on a sponsored research program.
**Technology Summary:** Pancreatic cancer has an unfavorable prognosis, largely due to late diagnosis. Aptamers (APs) provide a means of targeting imaging reagents specifically to pancreatic ductal adenocarcinoma (PDAC), which should enable early diagnosis and thereby improve patient prognosis. This method of early detection of PDAC has the objective of developing AP-targeted nanoparticles (NPs) to deliver near infrared (NIR) and/or magnetic resonance imaging (MRI) agents directly to tumor cells. By coupling the APs to various delivery platforms, this technology should enable: (1) early diagnosis of PDAC (and cancers which uniformly express the CCKB receptor) and (2) efficient targeted delivery of therapeutic reagents.

**Application and Market Utility:** This product would be used in medical imaging facilities, and manufacturing costs would be much lower than current MRI reagents. There were about 49,000 new cases of PDAC in 2015, with 40,560 deaths, and a low 5-year survival rate of 2.4%. Mean healthcare costs for patients with metastatic PDAC were $21,637/month vs. $10,358/month for those without metastatic disease. If 50% of diagnoses are shifted to earlier stages, this would save $2.7 billion annually.

**Patent Status and Licensing:** A provisional patent application (62/279,947) has been filed describing the APs selected for the CCKB (PSU Inv. Disc. No. 20154386) and a separate continuation-in-part has been filed on strategies to encapsulate a variety of compounds into calcium phosphate nanoparticles (PSU Inv. Disc. No. 20164422). Keystone Nano currently has licensed the calcium phosphosilicate nanoparticles.

**Next Steps:** The researchers are seeking funding to further characterize the aptamers and to test them in additional cancer models. It is expected that additional IP will be developed during the course of this work.
A green fluorescently labeled PEDF peptide formulated as an eye drop and applied topically to the eye (cornea). Within 2 hours, the peptide can be traced back to the retina where pathologies occur in diabetic retinopathy, AMD, and other blinding diseases.

**Technology Summary**: In both diabetic retinopathy (DR) and age-related macular degeneration (AMD), patients’ vision is compromised by cell death, inflammation, growth of abnormal blood vessels, and edema. Most available drugs tackle blood vessel complications in late stage AMD but ignore the earlier occurring pathological events. Panoptek Therapeutics has designed proprietary PEDF-derived small peptides to address inflammation and angiogenesis that result in cell death and vascular leakage. This novel topical diabetic retinopathy treatment provides safer, more effective, and noninvasive PEDF peptide treatment at both the early and late stages of the disease.

**Application and Market Utility**: More than 10 million Americans suffer from visual impairment caused by diabetes and AMD, with an expected 26x increase by 2050. 11% of adults with diabetes have visual impairment. Currently, there is no cure or effective biological treatments for diabetic retinopathy. Panoptek Therapeutics’ proprietary topical peptide technology has the following potential advantages over competing products: (1) addresses problems of both early and late stage DR and AMD; (2) is easy to manufacture; (3) is noninvasive; (4) can be used as needed by patients and at different doses; (5) can safely be applied at home; (6) is easy to differentiate its composition; (7) costs ~50% less than competing drugs; (8) is synergistic with other ocular treatments; (9) is likely effective for other retinal diseases.

**Patent Status and Licensing**: Patent application titled “Functional Peptide Analogs of PEDF” filed September 12, 2014 (Serial No.: 14/484,689).

**Next Steps**: *In vitro* studies are completed and preclinical studies are ongoing. Panoptek Therapeutics aims to develop PEDF peptides for other types of blinding retinal diseases. The company seeks licensing, collaboration, and/or investment partnerships.
**Technology Summary:** This invention relates in certain aspects to the metabolism of non-esterified fatty acids (NEFAs), specifically as they apply to the adipose tissue response to changes in circulating insulin. As known, insulin suppresses intracellular lipolysis in adipocytes, and poor suppression of NEFA release is directly related to adipocyte insulin resistance (IR). Until now, it was not known whether the insulin-mediated suppression is uniform for all fatty acids (FAs). We show time that NEFAs are differently trafficked by adipocytes in insulin resistant subjects, relative to NEFA trafficking in healthy control individuals. Thus, providing methods for IR diagnosis by analysis of NEFA trafficking at several time points, or even at a single time point, to identify IR individuals earlier than currently available tests.

**Application and Market Utility:** Current tests for determining insulin resistant glycemic indicators of insulin resistance primarily rely on analysis of glucose metabolism alone. Furthermore, diagnosis of IR does not occur until an individual is already experiencing symptoms and pathology (e.g. obesity and/or diabetes). Thus, there is an ongoing and unmet need for an improved test that could identify IR before symptoms emerge and that does not rely on glucose metabolism alone. This invention is pertinent to these as well as other needs.

**Patent Status and Licensing:** Provisional patent application filed November 2016.

**Next Steps:** The researchers are seeking collaborators/partners to validate the invention in clinical settings.
Keywords
• Autism Research
• Data Mining
• Bioinformatics

Research Leads
Guodong Liu, PhD
Assistant Professor of Public Health Sciences in the College of Medicine

Liu is a computer scientist and bioinformatician with extensive research experience in data mining and knowledge discovery over large electronic medical records (EMRs) and large administrative claims databases.

Research Website
URL

Platform Qualities
• Robust new profile-based ASD risk marker capable of reliably assessing children’s ASD risk as early as 6 months of age
• Adopts an effective surveillance strategy that is easy to use, less intrusive, more time-efficient, and user friendly
• Could be developed as a stand-alone device, app, or web-based tool

Technology Summary: Liu’s technology is an autism spectrum disorder (ASD) prediction model capable of reliably identifying children at high risk for ASD as early as 6 months after birth, well before the manifestation of any well-known ASD behavioral symptoms. The technology uses data from electronic medical records to reliably identify clinical indicators of ASD. This allows for earlier specialist intervention, providing children with ASD a more favorable health outcome.

Application and Market Utility: Currently, 1 out of every 68 US children has ASD, and the prevalence is rising at an alarming rate. The target customers are concerned parents, pediatricians, and social-service/early intervention agencies. Over $435 million in federal funding is provided annually for early intervention agencies. The older a child is when diagnosed with autism, the higher the medical costs required to treat the child. Therefore, insurance companies would be a strong potential customer to obtain early detection of at-risk children to initiate early intervention and reduce medical costs.


Next Steps: The research team seeks collaborators and investment partners interested in supporting commercialization of the technology.
Technology Summary: The technology inhibits certain biological molecules that have been discovered to be up-regulated in patients and animals with cardiovascular diseases associated with type 2 diabetes and involved in the vascular inflammatory process and plaque formation. Specifically, the researcher injected antibodies that block functions of the biological molecules into an animal model for atherosclerosis.

Because of the direct inhibition of the plaque formation, the researcher believes that this technology offers a more effective, safer treatment than current statin therapeutics.

Application and Market Utility: The technology is in the early development stage, with identification of a potential drug target for treatment of type 2 diabetes and associated complications. Given the prevalence of diabetes in Western society, an effective drug to reverse the effects of diabetes mellitus would have a potential market value in the billions of dollars.

Patent Status and Licensing: Patents pending in US (No. 14/850,688), Canada, and Europe. Issued patents in Australia, China, Russia, and Japan.

Next Steps: Development of the technology as a drug would require large investment; the researchers are also interested in developing collaborations that would accelerate development of a diagnostic assay using the technology’s biomarkers as a complementary product extension.

Keywords
- NKG2D Inhibitors
- Cardiovascular Disease
- Metabolic Disease
- Diabetes Research

Research Leads
Na Xiong, PhD
Associate Professor of Immunology, Department of Veterinary and Biomedical Sciences

Xiong’s research interest primarily concerns tissue-resident immune cells in various local tissues and their roles in tissue-specific immune homeostasis and inflammation, particularly understanding molecular mechanisms regulating migration and functions of tissue-specific immune cells under homeostatic conditions and in tissue-specific immune inflammatory diseases.

Research Website
http://vbs.psu.edu/directory/nux1

Platform Qualities
- Detection of soluble NKG2D ligands in blood to predict immune inflammatory status in type 2 diabetes patients
- Antibody blockage of NKG2D/ligand interaction to treat type 2 diabetes and associated complications
Technology Summary: Penn State inventors have discovered and are working to complete pre-clinical research for a novel lectin-like peptide, named Lectin-1. This biologic exhibits potent anti-cancer activity against epithelial cancers. Lectin-1 has been demonstrated to reduce cell viability in range of epithelial tissue cell lines, including lung, colon, bladder, cervical, and ovarian cancer cell lines, with a million-fold reduction of breast cancer cell. Lectin-1 has also been demonstrated to have an IC50 value in or below the picomolar range. The inventors have found no observable effect on non-epithelial or healthy tissues, including blood and lymphocyte cell lines, suggesting Lectin-1 has high specificity. A robust method for Lectin-1 production and purification, via expression in E.Coli, has also been developed.

Lectin-1 may also have a wide range of secondary market applications. Initial trials have demonstrated Lectin-1 may also be used as an antifungal agent for plant pathogens. The protein was shown to be effective in inhibiting spore formation and growth of the plant pathogen responsible for the maize disease, yellow leaf blight. Inventors believe Lectin-1 could be applied topically to treat fungal infections or expressed ectopically to produce a transgenic plant resistant to specific fungal infections.

Lectin-1 originated from a novel library of 85 cDNAs, coding for lectin-like peptides, created by the inventors during the analysis of tropical plant root transcriptome samples. Although the cDNAs contain a variety of lectin domains, the library has less than 60% similarity to known lectin sequences in the nucleotide BLAST database. The phylogenetic source of these cDNAs is currently unknown, but is likely fungi associated with plant roots. Due to its exceptional qualities, the inventors have focused first efforts on peptide Lectin-1. However, due to the unique characteristics of these expected lectin-like peptides, the inventors believe that additional cDNAs in the library may demonstrate utility as therapeutics, diagnostic tools, or research tools/reagents.

Application and Market Utility: Epithelial cancers, including lung and colorectal, rank among the most commonly diagnosed form of cancer in the United States and the market opportunity for these indications is expected to grow over the next 10 years. A key trend in the cancer R&D pipeline has been to focus on the development of such targeted therapeutics due to their enhanced tumor selectivity, increased efficacy, and reduced toxicity. As demonstrated in initial studies, Lectin-1 has the potential to enter as a targeted oncology drug for epithelial cancers. In addition, current chemotherapy drugs for epithelial cancers have IC50 values in the nanomolar range. Lectin-1 reduced IC50 values against epithelial cancers suggests it has the potential to be competitive with current state of the art.

Secondary applications also demonstrate robust market opportunity. The cDNA library for lectin-like peptides could be used in research tools including lectin arrays,
Technology Summary: The technology comprises a method for delivering a particular protein or peptide of interest into the interior of cells using noninfectious virus-like particles (VLPs) composed of paramyxovirus (RNA virus) components. The proteins of interest are modified so they package into VLPs using the same interactions that normally serve to package viral genomes into virus particles. The resulting VLPs contain the foreign protein of interest and, like viruses, are capable of attaching to target cells and delivering their contents to cell interiors.

Application and Market Utility: This technology allows biologically active proteins and peptides to be delivered directly to the cytoplasm inside target cells. Applications include:

- VLP-mediated delivery of proteins to non-transfectable cells (cells not changeable by introduction of DNA) in vitro.
- Development of high-throughput screens for antiviral agents that can inhibit VLP-mediated delivery.

Other nanoparticle-based delivery technologies can deliver cargo to the outside of a cell or to intracellular compartments via endocytosis. These VLP packaging technologies also require large sequences, or entire viral proteins, to be fused with the cargo.

In contrast, the new technology delivers the cargo directly to the cytoplasm inside the cell. The packaging sequences within the paramyxovirus structural proteins are uniquely and conveniently located at the C-terminal ends of amino acid chains, and transplanting just 10 to 20 amino acid residues is sufficient to induce VLP packaging.


Next Steps: The researchers have demonstrated proof-of-concept for VLP packaging and delivery using several test proteins such as green fluorescent protein (GFP), and are now investigating potential applications. They are seeking partners having a need for protein/peptide delivery technologies, as well as licensing and investment.
Technology Summary: Peconic LLC is striving to achieve more advanced medical diagnosis of cancer DNA epigenomes through ultra-high-resolution epigenome monitoring, applicable for research and medical groups. The epigenome, a set of chemical compounds that modify the genome and affect gene expression, constitutes the “readers” of the DNA genome, which instructs all life processes. Monitoring the epigenome provides insight into cell type identification—a critical component in the development of medical diagnostics—and how cells are regulated.

Application and Market Utility: Epigenome profiling is a $25 billion industry. Current first-generation technology involves detecting a few genetic markers in DNA. Rising second-generation technology involves whole genome sequencing to detect thousands of genetic biomarkers.

Peconic LLC is developing third-generation technology to monitor the many thousands of “readers” of these biomarkers. By monitoring the “readers” of biogenetic markers, environmental influences that are integrated with a person’s genetic blueprint—and which affect gene expression—can be observed and tracked, providing a more complete picture of health prospects.

Through these means, Peconic’s ChIP-exo technology has the potential to identify cancer subtypes. Classifying a cancer based on its epigenome may allow for tailored cancer therapies and improved patient outcomes, and may also translate into increased clinical success in drug discovery.


Next Steps: As an early-stage startup company, Peconic LLC is seeking to improve its licensed technology in cell type identification using patient biopsies through partnerships with medical centers and contract research organizations that allow access to patient samples.
Technology Summary: The researchers have developed breakthrough polymeric-based signal amplification that imparts high signal intensities targeted to specific locations using conjugated primary antibodies. The labeling intensities with this method are higher than traditional protein labels. The combination of the targeting antibodies and the DNA polymer fluorescent label make this a novel technique for protein labeling for histology and life cell samples. Moreover, the labeling is reversible if necessary.

Application and Market Utility: The protein labeling market is expected to reach $1,894.5 million by 2020 from $1,089.5 million in 2015, at a CAGR of 11.7%. This market may be further increased if low abundance proteins can be examined with novel protein labeling methods the team is developing. Often, researchers are interested in labeling and detecting low concentrations of cellular proteins or biomarkers for diseased cell types to understand differences from healthy cells. However, while fingerprint biomarkers are useful and important, many cannot be detected.

Because this technology is broadly applicable, researchers in both academic and commercial settings are likely to make up the market for this product. Interested parties have begun working with the investigators to test the technology for their applications. A commercial product could be available rapidly, as the current product does not require FDA approval.

Patent Status and Licensing: A US provisional patent, "Polymer-Based Signal Amplification for Protein and Cell Detection," has been filed.

Next Steps: The researchers seek commercialization partners for field-specific development of the technology.
Technology Summary: For diabetic patients, chronic, non-healing foot ulcers (diabetic foot ulcers, DFUs) are a common problem that can result in complications such as worsening of the ulceration, systemic infection and severe pain, and sometimes amputation. The technology is a method and formulation of topical administration of naltrexone (NTX) dissolved in a cream, to continuously block the Opioid Growth Factor Receptor (OGFr) sites on wounded tissue. Animal studies have demonstrated 25%-30% reduction in time required for wound closure and wound areas with topical NTX treatments. This approach to wound healing specifically enhances new cell replication by increasing DNA synthesis resulting in increased angiogenesis and granulation in epithelial tissue, as well as reducing complications such as infection related to delayed wound closure. NTX accelerates wound closure both in diabetic and non-diabetic patients, making it an optimal treatment to increase the effectiveness of wound repair throughout the population.

Application and Market Utility: There are an estimated 26 million diabetic individuals in the U.S., with an additional 86 million considered pre-diabetic, and 285 million diabetic patients worldwide. Approximately 4.5 million diabetic patients develop DFUs annually with a U.S. DFU healthcare cost exceeding $20B annually. The current commonly prescribed treatment is costly, has side effects, and carries the risk of death following protracted use. Over-the-counter bandages and creams are usually ineffective.

Topical application of NTX provides fast, inexpensive and safe treatment to accelerate closure of cutaneous wounds, particularly as related to complications from diabetes. End users include diabetic persons, healthy individuals, and veterinary practitioners.


Next Steps: The inventors are seeking option or licensing agreements (with funding) for prototype formulation and stability testing, animal bridge study, regulatory consultant and Fast Track Phase 2/3 efficacy trial.
Program models clinical data to allow optimization of surgical techniques.

Technology Summary: This technology utilizes computer-based engineering to simulate and optimize bone fracture repairs through the use of interactive, three-dimensional models personalized for each patient. This technology draws on big data and uses robust statistical methods to generate personalized models of fractured bones that orthopedic surgeons can use to enhance patient outcomes. Prior to surgery, this technology presents surgeons with the fracture repair designs most likely to result in optimal patient outcomes. An interactive model shows how the recommended repair design will impact distribution of physical forces on the implants and bone as it heals. The technology features a training module that orthopedic residents can use to learn how their choice of fracture repair design impacts the risks of complications following surgery.

Application and Market Utility: In orthopedics, mechanics play an important role in determining clinical outcome—implants can fail inside the body, and stability greatly affects healing—but these 3-D mechanics can be complex. Surgeons operate on patients based largely on experience and intuition, sometimes leading to suboptimal treatments, revision surgeries, and time inefficiencies in planning and procedure execution in the operating room. This software enables improved quality and efficiencies in fracture fixation and potentially other procedures.


Next Steps: The technology is in the late research and development stage and has been reduced to an operational prototype. The research team is pursuing commercialization partnerships with industry.

Keywords
- Surgical Simulator
- Orthopedic Surgery
- Surgical Algorithm

Research Leads
Gregory Lewis, PhD
Assistant Professor, Department of Orthopaedics and Rehabilitation

Both lead investigators’ collaborative research has been funded by the AO Foundation, the PA Department of Health, and industry. Lewis has coauthored 35 scientific papers related to orthopaedic biomechanics, including fracture fixation and joint replacement.

J. Spence Reid, MD
Professor and Chief, Orthopaedic Trauma

Reid is principal investigator for the Penn State Core Center for the DoD-funded Major Extremity Trauma Research Consortium.

Research Website
http://www.pennstatehershey.org/web/ortho/research/overview

Platform Qualities
- Functional software prototype
- Simulates physical loading based on thousands of combinations of hardware, materials, and patient data
- Incorporates multivariate data visualization and optimization techniques
Technology Summary: Hydrocephalus is one of the most common reasons for brain surgery. Since being introduced in the 1950s, current systems have remained virtually unchanged over the past 50 years. Current shunt systems drain CSF from the brain fluid pockets into the abdomen, lungs, or heart. This current model is fraught with complications, with up to 50% failure rate in the first two years following shunt placement, followed by a 10% yearly shunt malfunction rate. The technology is an improved shunt that mimics physiologic drainage pathways, overcoming significant limitations of current systems.

Other complications include mechanical obstruction or disconnections, kinking, infections, blood clots, over- or under-drainage, seizures, abdominal pleural, and cardiac complications.

Application and Market Utility: More than 40,000 procedures are performed annually with a medical cost of more than $1 billion in the US. Cost per procedure or additional procedures range between $35,000 and $600,000. Medicare, Medicaid, or private insurance currently covers more than 90% of procedures.


Next Steps: The researchers seek investment to complete animal studies for proof-of-concept.

Keywords
- Surgical Device
- Brain Surgery
- Subarachnoid Catheter

Research Leads
Elias Rizk, MD
Assistant Professor of Neurosurgery

Rizk is a fellowship-trained, board-certified pediatric neurosurgeon with interests in clinical and basic science research, including the treatment of hydrocephalus.

Barry Fell, MS

Research Website:
https://profiles.psu.edu/profiles/display/9253368

Platform Qualities
- Ease of implantation and testing
- Minimally invasive
- Decreased complications
- Improved health outcomes and reduced treatment costs

Left: Cast model of the device; Right: CAD of device shows subarachnoid catheter (green), unidirectional valve (gray), and venous catheter (red)
Technology Summary: Technology Summary: The invention describes a combination of materials and a method of preparation of a biocompatible porous composite functionalized with aptamers that can bind to an active agent (such as chemokines, interleukins, growth factors, or any other biologically active molecule). Existing biomaterials for tissue regeneration contain protein drugs. However, current FDA-approved products release protein drugs too rapidly, which dramatically reduces therapeutic effectiveness and causes significant side effects. An ideal product for clinicians to use needs to release protein drugs on-demand, with prolonged therapy and minimal side effects. By contrast, this technology releases protein drugs in a sustained manner. It can be readily customized to tune the dose of protein drugs by clinicians to meet the needs of treatment.

Application and Market Utility: This technology is a biomaterial that can be developed into different forms such as a solution, a pad, or a cube to match the conditions of wounds and according to the need of clinicians. It is an “off-the-shelf” material that can be shipped and stored at room temperature without the need of a refrigerator. The research team predicts a $6.1 billion annual market value.

Patent Status and Licensing: Please contact the Office of Technology Management for additional details.

Next Steps: Technology has been tested in animal studies, with promising initial results. PPProtein Therapy seeks to partner with companies that produce biomaterial products for tissue repair. The company also seeks a potential business development manager to drive the development of products or partner with large companies.

Keywords
• Protein Therapy
• Tissue Regeneration
• Prolonged Release

Research Leads
Yong Wang, PhD
Professor of Biomedical Engineering
Wang has developed various collaborations with partners in both industry and academia, inventing novel technologies for protein delivery and imaging.

Research Website
http://www.bioe.psu.edu/labs/Wang-Lab/

Platform Qualities
• On-demand release
• Prolonged therapy
• Low toxicity
• Minimal side effects
• Multiple platforms
The Office of Industrial Partnerships (OIP) fosters strategic relationships with industry partners and supports Penn State’s entrepreneurial ecosystem, accelerating the pace at which technologies move from discovery to implementation and delivering new-found value & differentiation to industry and economic impact to Pennsylvania and beyond.

**Partners**

Our relationships with small and large companies allow us to develop novel engagement models to build win-win strategic partnerships. Penn State and the Office of Industrial Partnerships enters into research engagements with over 500 companies every year, several of which are engaged with our Industry Advisory Boards across multiple colleges and campuses. In addition to research partnerships, we welcome over 850 companies to participate in our annual, on-campus career fairs.

**Key Partners**

- United Technologies
- DuPont
- GE
- Dow
- Intel
- IBM
- Boeing
- PPG
- Volvo
- Abbott
- General Dynamics
- Genentech
- Pfizer
- Chevron
- Westinghouse
- Lockheed Martin
Interdisciplinary Research Capabilities

In 2015, Penn State research expenditures exceeded $836 million, with excellence across domains. We received multimillion dollar awards for new or ongoing work in areas as diverse as a Department of Energy supported program for designing energy-efficient buildings, a national data coordinating center for asthma research sponsored by the National Institutes of Health, a federal bus-testing program conducted for the U.S. Department of Transportation, and the design and development of an anti-torpedo torpedo for the U.S. Department of Defense. The university is ranked 17th in total expenditures by NSF and ranked in the Top 10 of 12 STEM fields, with only Johns Hopkins ranking in more.

Below is a sampling of Penn State’s interdisciplinary research institutes.

**Applied Research Laboratory**
www.arl.psu.edu
- Acoustics
- Thermal Energy Systems
- Hydrodynamics
- Hydroacoustics
- Propulsion
- Materials & Manufacturing
- Navigation & GPS
- Systems Engineering

**Materials Research Institute**
www.mri.psu.edu
- Materials Characterization Lab
- Nanofabrication Lab
- Materials Computation Lab
- 2D Crystal Consortium (2DCC) Lab
- Thermally Functional Materials
- Additive Manufacturing
- Humanitarian Materials
- 2D & Layered Materials and Coatings

**Institute for CyberScience**
www.ics.psu.edu
A virtual laboratory to investigate complex problems otherwise impossible or impractical to address, for example:
- Physics of the origins of the universe
- Genomic/molecular basis of disease
- Socio-economic impacts of a digital society

**Huck Institutes of the Life Sciences**
www.huck.psu.edu
- Ecology
- Genome Sciences
- Infectious Disease
- Neurosciences

**Institutes of Energy and the Environment**
www.psiee.psu.edu
- Natural Gas
- Water, Ecology
- Earth & Mineral Science
- Environment & Natural Resource
- Earth & Environmental Systems
- Engineering, Energy, and The Environment
- Rock Ethics

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**Penn State Hershey College of Medicine**
www.pennstatehershey.org/web/college/research
- Cancer
- Neuroscience
- Heart & Vascular
- Pediatric Cardiovascular
- Diabetic Retinopathy
- Clinical & Translational Science

**Social Science Research Institute**
www.ssri.psu.edu
Focuses on critical human and social problems with focus on:
- The Human System
- Social Disparities
- Smart and Connected Health
- Innovative Methods
- Dissemination and Implementation Science
The Office of Technology Management protects Penn State intellectual property, identifies its commercial potential, and stimulates economic development through the transfer of Penn State technologies to the marketplace.

The Office of Technology Management also promotes Penn State technology by protecting, marketing, and licensing university inventions to companies for further development and commercialization.

Tech Transfer at Penn State

Penn State is a major player in the U.S. research community, consistently ranked in the top 10 (by the National Science Foundation in 2016) in the following areas of investigation:

- Materials
- Computer Science
- Engineering
- Psychology
- Sociology
- Earth and Atmospheric Sciences

Penn State inventions have contributed broadly to medical science, space travel, agriculture, and many other fields. Visit psu.edu/ur/about/50ways.html to learn 50 ways Penn State inventions have improved the world.

Penn State IP Policy Among Friendliest in the Nation

Penn State leads universities across the U.S. in having developed one of the most industry-friendly IP policies that enables research partnerships to bring discoveries to the marketplace more easily and efficiently.

- We assign IP to research sponsor upon request
- We don’t seek ownership of IP
- One-page agreements available
Overview of the office

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Business Advisory Group program

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### Innovation Hubs

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