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Award Winning Innovations
About the UCI School of Physical Sciences

One of the founding academic units established in 1965, the UCI School of Physical Sciences has built an international reputation of distinction in scientific research while also embracing the teaching mission of a public university. The School’s world-renowned faculty members and research scientists teach and perform research with students to explore the ever-advancing frontiers of knowledge. From peering back at the first instants in time of the big bang to predicting the future of our planet, from imaging individual atoms and molecules to modeling living cells and cancer tumors, and from synthesizing new molecules to understanding the evolution of the universe — scientists and mathematicians explore all time scales and all size ranges to learn nature’s secrets and provide the foundation for the tools used by a modern technological society.

The School is comprised of four highly ranked departments: Chemistry, Mathematics, Earth System Science, and Physics & Astronomy. Currently, the School has 159 faculty members, 2,100 undergraduate students, and 500 graduate students. In 1995, the School garnered international prominence when founding faculty members F. Sherwood Rowland (chemistry) and Frederick Reines (physics) each received the Nobel Prize, making UCI the first public university with faculty receiving the award in two different fields in the same year. Building on this foundation, 11 faculty members have been elected to the National Academy of Sciences, and 9 have been elected to the American Academy of Arts and Sciences. Consistently, professors and students are singled out for prestigious awards recognizing their scientific excellence. The school also takes great pride in the rankings by the National Research Council (NRC) that place each of the four departments above the 90th percentile.

The school has 337 active patents worldwide, 95 active inventions, more than 50 licenses, and many more inventions in various stages of patent applications and licensing. The School’s portfolio of patents and inventions are in diverse fields such as energy, biomedical diagnostics, and desalination, with licensing to several companies.
UCI INTELLECTUAL PROPERTY

CUMULATIVE FIGURES

$300 Million in federal funding

130 Invention disclosures

TYPICAL YEAR

140+ License agreements

1000+ Active inventions

>100 Start-Ups based on UCI IP

PORTFOLIO FOR PHYSICAL SCIENCES

FY 15-16(e)

65 Total active US patents

95 Total active inventions

3 Total inventions optioned by fiscal year-end

19 Total inventions licensed by fiscal year-end

272 Total active foreign patents

7 Total inventions obligated under a letter of intent

2 Total active options

4 Total active licenses
UCI Applied Innovation: Vision and Mission

Orange County has a proud history of technological and commercial leadership that continues to this day. Over the past 50 years, UCI has played a significant role in the region’s accomplishments, but there remains a tremendous opportunity to strengthen innovation in the region and beyond through the university’s resources and capabilities. The mission of UCI Applied Innovation is to help the surrounding community reach its full potential as a national and global leader in scalable innovation through public-private collaboration.

3 Main Focus Areas
From a functional standpoint, the transformative potential of UCI Applied Innovation involves three key areas of focus:

1. Fostering industry-faculty alliances, in part through the transfer of UCI Intellectual Property to the business community
2. Fostering UCI Entrepreneurship
3. Strengthening the Orange County startup ecosystem

From the Dean

Open a window on the birth of the universe, or the quantum jitters of a single molecule. Solve the world’s energy problems by developing clean, safe, affordable fusion energy. Forecast high-impact weather events and help mitigate effects of climate change, or create biosensor chips to diagnose early stages of cancer. These are just some examples of how the researchers at the UC Irvine School of Physical Sciences are pushing the frontiers of science while spurring the world of entrepreneurship and commercialization.

The basic research that takes place in physical sciences forms core fundamental knowledge that catalyzes discoveries and inventions across disciplines. Faculty and students dive deep into the trenches of Chemistry, Earth System Science, Mathematics, and Physics & Astronomy.

In addition to being highly recognized for scientific excellence in their fields, our faculty members teach and conduct research with undergraduate students, graduate students, and postdoctoral fellows. Many of our alumni take the research performed at UCI to industry, advancing ideas and inventions in their careers. Our School also transfers research breakthroughs directly to society through technology licensing and collaborations with industry. UCI’s Applied Innovation partners with the School of Physical Sciences to take cutting-edge inventions of our researchers from the lab to the marketplace.

I invite you to explore this brochure to witness curiosity and innovation pushing scientific breakthroughs, and to discover success stories of a few of the companies prospering from research affiliated with the UCI School of Physical Sciences.

Kenneth C. Janda
Professor and Dean
UCI School of Physical Sciences
Tri Alpha Energy, Inc.

Key UCI scientists for starting the company:
Professor Norman Rostoker, Dr. Michl Binderbauer

Technology developed at and licensed from UCI
Founded: 1998
Funding: From the start, the company has relied on private equity

Tri Alpha Energy’s purpose is to deliver world-changing clean fusion energy technology as fast as possible, website at trialphaenergy.com

Tri Alpha Energy, Inc. is the world’s largest private fusion company with the prodigious goal of developing clean, safe, commercially successful fusion energy as fast as possible. Cheap and abundant fusion energy could transform our world economy and help safeguard the future of our planet.

Based in Lake Forest, Calif., TAE has strong ties to UCI. Co-founders include Physics & Astronomy Professor Norman Rostoker and Dr. Michl Binderbauer, his graduate student and protégé who is the company’s Chief Technology Officer. Professor Toshiki Tajima, formerly a Ph.D. student of Rostoker at UCI and now holder of the Norman Rostoker Chair Professorship at UCI, is Chief Science Officer. The company’s technology, based on Rostoker’s work at UCI, is licensed from the university.

The quest by researchers and governments to produce energy by fusing atoms, instead of splitting them by fission — has spanned decades and consumed billions of dollars. The technical challenges are formidable; heating the fuel to astonishing temperatures to enable fusion reactions, stabilizing and containing the superheated plasma gases produced, and getting more energy output than needed to run it.

Tri Alpha Energy is combining particle and plasma physics approaches to address the problem. In a national lab scale experimental facility, TAE fires two bursts of plasma rings at each other at nearly 1 million km/hr (620,000 mph). The shock of the collision superheats the gases to 10 million degrees.

To confine the plasma created, TAE uses a linear field-reversed configuration (FRC) in combination with intense neutral beam injection. It relies on build-up of a fast ion population within the FRC to keep the cloud of plasma rotating without touching the wall of the reactor.

In August 2015, TAE announced it was able to stabilize plasma for 5 milliseconds, since then 11.5 milliseconds — a flicker of time but enough for proof of concept. The blob of superheated gas is kept in check by its own magnetism. A future power plant would be fueled by proton-boron-11 fusion and may require heating to 3 billion degrees to achieve fusion — 200x the temperature of the sun.

Fueled by over $500 million in private capital from high profile investors, the Board of Directors includes representatives from Hawkess Financial Services, Buchanan Investments, RUSNANO Corp., New Enterprise Associates, a Former Chairman of Morgan Stanley, a Former Chairman of US Nuclear Regulatory Commission, a former President of GE Nuclear, and a Partner Emeritus of Venrock. TAE is now building its next generation experimental device to higher energy, aiming ever closer to that 3 billion degree mark — to demonstrate the generator can produce an energy gain.

Longer-lasting batteries and capacitors may be on the horizon, thanks in part to UCI doctoral student Mya Le Thai, a graduate student working with Professor of Chemistry Reginald Penner. After training in nanotechnology at UCLA as an undergrad, Dr. Thai joined Dr. Penner’s team excited by the opportunity to build on her experience and solve problems in physical chemistry — like how to build more durable and powerful batteries and capacitors using nanowires. The problem with using nanowires for energy storage is their limited cycle stability. Nanowires are susceptible to dissolution and corrosion, which rapidly cause erosion of through-wire conduction and loss of energy storage capacity.

At the Penner lab, Dr. Thai, who recently finished her Ph.D., created a solid-state capacitor based upon arrays of thousands of nanowires. She first coated arrays of gold nanowires with a manganese dioxide layer, and then suspended these nanowires in a polymer-based gel electrolyte, creating a capacitor that could be charged and discharged more than 100,000 times, as compared with just 4000-6000 cycles in the absence of the gel electrolyte.

Dr. Thai discovered that the gel electrolyte held the key to long cycle stability. MnO₂ - a Li⁺ insertion metal oxide – is pulverized by the strain caused by Li⁺ insertion and deinsertion into the MnO₂ in just a few thousand cycles. When the gel is present, no degradation of the MnO₂ layer is observed even after 100,000 cycles. This technology holds promise for commercial batteries and supercapacitors used in computers, smartphones, appliances, cars, and spacecraft.

Picture of Dr. Thai holding capacitor.
Emerging Companies

Nanomedical Diagnostics

Breakthrough all-electronic assay based on Field Effect Biosensing (FEB) technology

Nanomed’s mission is developing new cutting-edge products with FEB technology that enable novel life science research, drug discovery applications, and diagnostics and monitoring platforms. Their AGILE biosensor chips leverage the highly-sensitive nanomaterial graphene to unite biology with electronics, delivering the unique ability to sense small molecules down to 1 Da in complex media such as DMSO, and use unprecedentedly small amounts of sample. A focus is to provide real-time, label-free kinetic binding and affinity data.

UCI Connection: Nanoscale electronics and materials have been important research areas for Physics Professor Phil Collins, in whose lab Brett Goldsmith did his doctoral research. Professor Collins has academic and entrepreneurial experience, the Collins Lab often works to discover solutions to engineering problems that future technologies will face. Nanomed employs three UCI alums.

Founding Team: Brett Goldsmith, CTO (UCI Ph.D. 2008) and Ross Bundy, CEO (UCSD graduate)

Funding: Completed Series A financing in late 2015 led by Serra Ventures

PhageTech, Inc.

PhageTech™ technology aims to revolutionize and simplify disease diagnosis by providing actionable, molecular insight to physicians in minutes at the point-of-care.

PhageTech is developing novel point-of-care BioConductor™ chip technology intended for hand-held and bench top blood and urine testing. This multi-channel biosensor for simple, low cost, and scalable diagnostic testing directly from body fluids such as urine and blood does not require any complex sample preparation or reagents and can be used by minimally trained medical staff. The company’s platform employs benevolent bacteriophages (virus that infects a bacteria) bonded to a substrate to detect analytes in urine, blood and most other body fluids. This technology offers equivalent or better performance compared with antibody based assays and does not have the issues of semiconductor-based biosensing.

PhageTech technology could be used for early tests for cancer as well as infectious diseases, markers for cardiac, and other chronic conditions. Low capital equipment cost and long shelf life without refrigeration can enable use in the home testing market and developing countries. PhageTech has exclusive, world-wide rights to the core technology from the University of California.

UCI connection: Technology developed at and licensed from UCI with research funding from NIH, NSF.

Founding and Inventors: Co-Founders of the company and key inventors include Chemistry Professors Gregory Weiss and Reginald Penner.

Founded: December 2013


Atmospheric Data Solutions (ADS)

Founded to assist public and private agencies in developing atmospheric science tools that help mitigate and manage risk from severe weather and future climate change.

ADS provides full-service numerical weather modeling solutions for utility companies and other public agencies which allow for the accurate forecast of high-impact weather events that impact public welfare and safety. Solutions include short- and medium-term automated operational weather forecasting guidance products, tailored regional wildfire prediction guidance tools, utility load and outage forecasting. For more information see: www.atmosphericdatasolutions.com

UCI Connection: Scott Capps, Principal, received his Ph.D. from UCI’s Earth System Science department in 2009

Founded: 2015

Emerging Companies
Innovation Watch
A Guiding Light

The semiconductor and magnetic storage businesses in the electronics industry need finer microscopes to see the new devices they produce at ever smaller sizes and for faster speeds. Amidst the physics of plasmas and lasers explored in the laboratory of Prof. Franklin Dollar a new microscope method is developing, closing in on seeing objects as small as one billionth of a meter (a nanometer) for times as short as a few hundred billions of a billionth of a second. Such bursts are so fast in time, most people have not even heard the name, a few hundred “attoseconds.”

Building ever smaller devices to cram even more of them into our mobile phones and computers has led to devices so small they do not operate the way we understand macroscopic materials to behave. These devices work according to the quantum world where we have far less measured understanding. We now can build devices that are smaller and faster than what our present microscopes can measure well. Prof. Dollar uses an infrared laser pushing nonlinear optics to the extreme. Using an intense laser (100 GW/cm²) as the microscope light source, a simple sheet of glass can be self-phase modulated to produce a 3 femtosecond pulse which can be further focused to make a plasma which briefly radiates high harmonics. The radiation from the plasma will span as broadly as x-rays in a sub-femtosecond pulse in one cycle, a single burst which can be timed. That burst retains laser-like properties which allow coherent diffractive sub-wavelength imaging, closing in on single nanometer resolution.

Companies like Intel, CYMER (an ASML company), and KLA-Tencor need such technology. Fortunately, many Physical Sciences alumni work at these companies to help such technology transfer into our world.

Modulated Imaging, Inc.

UCI connection: Technology developed at the Beckman Laser Institute and licensed from UCI

Date incorporated: 2008

Funding: NIH and DOD, SBIR/STTR grants, raised $9.8 million to date; Seed Funding of $500,000 from Hamamatsu Photonics KK and OC Cove Fund, and a Series A $3,000,000 round, this is in process.

Founder and UCI inventor: David Cuccia, CEO and CTO, UCI alumnus [UCI B.S. and Ph.D. degrees]

Light-based imaging devices that give professionals transformative tools for preventing, diagnosing, and curing medical skin conditions.

Modulated Imaging, based in Irvine, CA, uses spatial frequency domain imaging (SFDI) to look beneath the surface of the skin and diagnose the health of tissue. The company’s product portfolio includes the following research, medical, and aesthetics applications:

• The Reflect RS™, a turn-key hardware and software solution for researchers who need to image optical properties (μs and μd) of tissue or any scattering sample over large fields of view and many mm beneath tissue surface.

• MIS-VS™, a stand-alone software visualization tool for SFDI.

• The Ox-Imager CS™, the medical version of the RS system, offering clinicians a tool for measuring perfusion and can be used during lower limb vascular surgery, managing chronic wounds and identifying diabetics who are at risk for developing a diabetic foot ulcer. The device measures tissue blood oxygen saturation (S(t)O₂), oxy-hemoglobin (HbO₂), and deoxy-hemoglobin (HbR), as well as providing a surface color photograph; measurements are made and displayed in real-time. Modulated Imaging received FDA clearance for its Ox-Imager CS Technology in December 2016. The company is currently working on a low-cost miniaturized version of the device.

David Cuccia company founder, CEO and CTO credits UCI for much of the company’s success. As an undergraduate at UCI, Cuccia began developing the spatial frequency domain imaging technology that became the subject of his doctoral dissertation. He pursued graduate studies at UCI after prior research at the Beckman Laser Institute. As a student at UCI, Cuccia built the first model of his diagnostic technology, the Ox-Imager at the UCI incubator, and then wheeled it next door to the Beckman Laser Institute for testing. Cuccia has 6 patents to his name and has 40 co-authored SFDI publications.

In collaboration with UC Irvine faculty Cuccia raised approximately $9.8 M in SBIR/STTR grants and contracts to bring the technology to market. The company under Cuccia has built out a full management team and has secured equity investment from private industry and venture capital funds. Modulated Imaging collaborated with UCI to clinically validate its technology. The Ox-Imager is now found in numerous research, medical, and academic institutions nationwide.
Beall Innovation Awards
Professors Shane Ardo, Peter Taborek
Win 2016 Beall Innovation Awards

The Beall Innovation Award encourages the entrepreneurial spirit among UC Irvine researchers. Taking discoveries and inventions from the laboratory to the marketplace means imagining the ways in which new technologies could sprout from existing science, as well as keeping close track of research trends that might point the way to the future. Shane Ardo, Ph.D., assistant professor of chemistry and Peter Taborek, Ph.D., professor of physics and astronomy at UCI, received the 2016 Beall Innovation Award for their projects.

The Ardo Group will design and evaluate a polymer ion-exchange membrane that is safe, stable, and conductive. This membrane electrolyte will have a benign, near-neutral pH and rapid ionic conductivity which will allow it to be compatible with inexpensive electrocatalysts for use in next-generation fuel cells and electrolyzers.

Professor Ardo is the lead inventor on five patents and a co-author of over 35 peer-reviewed journal articles. The central theme of the Ardo Lab is to understand and control reaction mechanisms at interfaces, with the goal of maximizing energy-conversion efficiency for realistic applications, including solar fuels devices, photovoltaics, solar seawater desalination, redox flow batteries, and fuel cells. Professor Ardo has been named an inaugural Moore Inventor Fellow by the Gordon and Betty Moore Foundation (https://www.moore.org/article-detail?newsUrlName=gordon-and-betty-moore-foundation-announces-inaugural-moore-inventor-fellows), and a Sloan Research Fellow, and Cottrell Scholar.

Professor Peter Taborek will develop ultra-sensitive acoustic detectors — as sensitive as a dog’s nose — to find trace quantities of explosives. The proposed explosives detector will be based on a novel implementation of a quartz crystal microbalance (QCM). A QCM is an approximately dime-sized piece of quartz that functions as a piezoelectric oscillator with a precisely defined resonant frequency. Attaching a single molecular layer can shift resonance. Professor Ken Shea of the UCI Department of Chemistry will collaborate to synthesize materials that selectively bind target analyte molecules, and form a company — Microsensor Technologies, Inc. that could develop and market these sensors to DoD and other government agencies.

The Taborek Laboratory, part of the Condensed Matter Physics group, studies the fundamentals of phase transitions near a surface, quantum fluids, and quantum solids, including issues of surface dynamics, sticking and growth mechanisms. Projects include development of a vapor phase method for growing diamond films, developing porous glass pH sensors, development of novel methods for measuring conductivity, and the studies of intercalation in bucky ball (C60) films.

Success Stories

ExoAnalytic Solutions

ExoAnalytic Solutions operates a global space situational awareness (SSA) telescope network producing, each month, more than six-million high-quality, real-time, correlated observations of man-made space objects in geosynchronous Earth (GEO), highly elliptical (HEO), and medium Earth (MEO) orbits. Using 140+ telescopes on 5 continents, plus Hawaii, ExoAnalytic passively collects astrometric and photometric measurements for U.S. Government and commercial customers. See https://exoanalytic.com/

In 2008, Doug Hendrix, Holly Bertrand, and Mike Bantel founded ExoAnalytic Solutions. The company now has about 60 employees and is employee owned. Over the last 5 years ExoAnalytic transitioned their Missile Defense capabilities to support Space Situational Awareness (SSA). ExoAnalytic built a global network of telescopes using commercially-off-the-shelf products to track satellites and space debris in geosynchronous and medium earth orbits having visual magnitudes of 18 or less.

ExoAnalytic Solutions President Greg McNeill, CEO Doug Hendrix, CTO Mike Bantel, and Research Scientist Shawn Thorman are among UC Irvine Physics graduates at the company.
**ITG is UCI Applied Innovation’s team dedicated to protecting and licensing for commercialization UCI inventions and discoveries.**

Are you UCI faculty with a promising invention? Visit [http://innovation.uci.edu/licensing](http://innovation.uci.edu/licensing) for information on licensing through ITG or contact Ronnie Hanecak, Ph.D., Assistant Vice Chancellor, Invention Transfer Group, at: rhanecak@uci.edu.

Interested in licensing UCI technologies? Search available technologies at: [innovation.uci.edu/tech](http://innovation.uci.edu/tech).

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**Recent Technologies**
The School of Physical Science laboratories have developed innovations in multiple fields. Below are a selection of recent technologies developed available for commercialization:

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<tr>
<th>Group / Area</th>
<th>Lead</th>
<th>Markets</th>
</tr>
</thead>
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<tr>
<td>Taborek Lab / Physics</td>
<td>Peter Taborek, Professor, Physics</td>
<td>Security: Ultrasensitive explosive detection</td>
</tr>
<tr>
<td>The Shea Research Group / Synthetic Chemistry</td>
<td>Ken Shea, Professor, Synthetic Chemistry</td>
<td>Drug discovery: Synthetic polymer nanoparticle hydrogels for drug screening, green production of fuels and plastics, artificial antibodies, nanoparticles for diagnostics</td>
</tr>
<tr>
<td>The Weiss Lab / Chemistry</td>
<td>Gregory Weiss, Professor, Chemistry, Molecular Biology, and Biochemistry</td>
<td>Drug Discovery: Protein refolding device for industrial production of biologics, cancer and infectious disease detection using phage substrate, virus-derived biosensor technology</td>
</tr>
<tr>
<td>The Guan Group / Organic and Biomaterials Chemistry</td>
<td>Zhibin Guan, Professor, Chemistry and Biomedical Materials</td>
<td>Drug delivery: Dendritic peptide bolaamphiphiles for siRNA delivery. Synthesizing self-healing polymers. Hydrogels for islet encapsulation and implantation</td>
</tr>
<tr>
<td>Ardo Group / Energy Science at the Materials Interface</td>
<td>Shane Ardo, PI</td>
<td>Membrane technology for desalination</td>
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<tr>
<td>The Van Vranken Group / Chemistry</td>
<td>David Van Vranken, Professor, Chemistry</td>
<td>Novel antifungals</td>
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<td>The Penner Research Group / Chemistry</td>
<td>Reginald Penner, Professor, Chemistry</td>
<td>Battery storage technologies</td>
</tr>
<tr>
<td>The Blum Research Group / Chemistry</td>
<td>Suzanne Blum, Associate Professor, Chemistry</td>
<td>Novel chemical molecules</td>
</tr>
<tr>
<td>The Overman Group / Chemistry</td>
<td>Larry Overman, Professor, Chemistry</td>
<td>Epigenetic regulators for cancer therapeutics</td>
</tr>
<tr>
<td>The Siwy Group / Chemistry</td>
<td>Zuzanna Siwy, Professor, Physics, Chemistry, and Biomedical Engineering</td>
<td>Nanoporous inorganic membranes and films</td>
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</tbody>
</table>
Industry Sponsored Research (ISR)

Industry Sponsored Research is UCI Applied Innovation's team of contract officers dedicated to connecting industry with UCI research teams. Interested in sponsoring research at UCI? Please contact the appropriate contract officer based on the areas listed.

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- Biological Sciences
- Education
- Physical Sciences
- Social Ecology
- Beckman Laser Institute and Medical Clinic
- Health Policy and Research
- Reeve Irvine Research Center
- Stem Cell Research Center

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- School of Medicine
- Health-related academic programs in Nursing Science, Public Health, and Pharmaceutical Sciences
- Social Sciences
- Genetic Epidemiology Research Institute
- Institute for Memory Impairments and Neurological Disorders

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- Schools of Engineering, Computer Science, and Business
- Arts
- CALIT2
- Center for Embedded and Cyber-Physical Sciences
- Institutes for Genomics and Bioinformatics, Software Research, and Transportation Studies

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