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NQPI
OHIO UNIVERSITY

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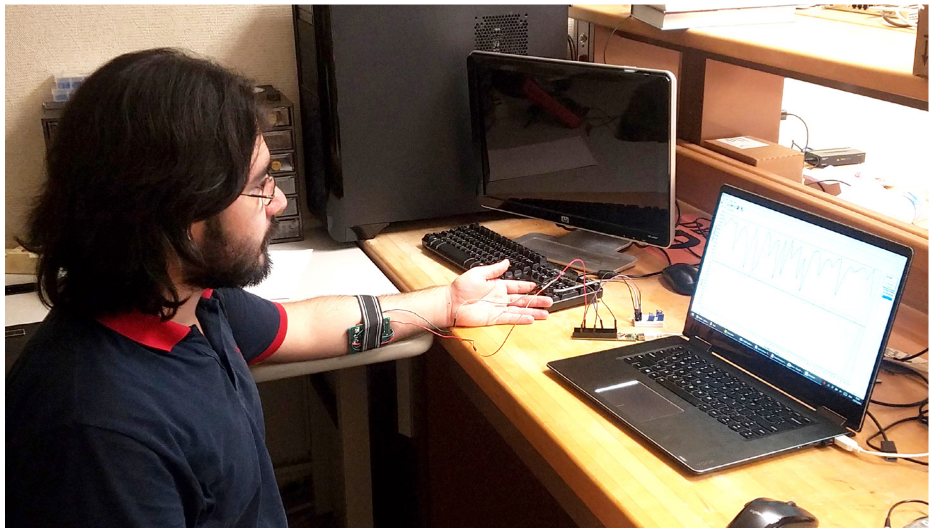
Engineering "Smart" Monitors for Patients with Diabetes

For patients with diabetes, needles and syringes are a staple of everyday life. Yet in the near future, glucose monitoring may be as simple as reading a text message.

Electrical Engineering and Computer Science professor and NQPI member Savas Kaya, post-doctoral researcher Soumyasanta Laha, and graduate student Yunus Kelestemur are currently working to develop a "smart watch" that is capable of monitoring glucose levels in real time.

Many companies, such as Apple and FitBit, are also working to develop wearable glucose monitors. Yet these devices often lack accuracy, Kaya said. His team has adopted an approach to improve device comfort and practicality.

"This is a unique market," Kaya said. "Nobody's going to wear a five-pound dangling unit. It has to be compact, wearable (and) low-cost. We are working



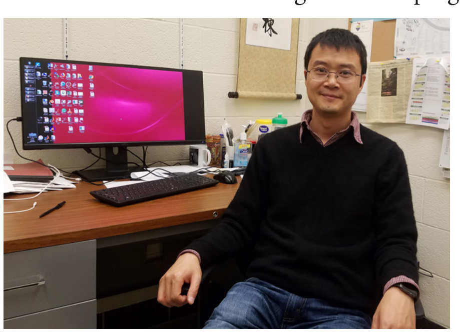
Engineering doctoral student Yunus Kelestemur tests a component for a new wearable device that his group is currently developing. This technology may one day make it easier for patients with diabetes to continuously monitor levels of glucose in the blood.

See **Smart Monitor,** page 4

Chen Receives NIH Grant to Enhance Optical Mapping

The Human Genome Project was declared complete in 2003, but the challenge to fully understand our DNA, the helical duplex that contains our genetic information, is far from finished. Researchers are now applying modern techniques to better understand this fundamental component of life and nature.

Chemistry & Biochemistry professor and NQPI member Jixin Chen has been awarded $450,000 from the National Institutes of Health to take on the challenge of developing



Jixin Chen is utilizing a novel technique to visualize genome sequences more effectively.

molecular tools to improve the reliability of genome sequencing.

Researchers typically sequence portions of DNA and use software to stitch the pieces together. However, this method is prone to error, Chen said. The alignment is dependent on a reference sequence that may not account fully for variation among individuals.

Optical mapping has been used to improve reliability of genome sequencing. In the first generation, researchers used restriction enzymes to cleave DNA at specific sites. Next, the DNA is treated with a dye, allowing researchers to visualize the regions where it was cut. They then compare the optical map to a reference sequence. In the second generation, a different fluorescent labeling strategy is used to label the duplex DNA by cutting only one strand and applying a dye to the cut.

"The idea is that you see a map." Chen said. "You don't know the whole sequence except for very small pieces of known sequences scattered within the whole genome. This is already very useful."

Current mapping methods are limited, Chen said. If too many restriction enzymes are used, the helix becomes unstable. Thus, making a high density optical map is challenging. Chen's graduate students, Joseph Pyle and Dinesh Gautam, are working to create fluorescent tags that identify and bind to specific regions of DNA, similar to the restriction enzymes but without cutting any strands. With this technique, the helix structure is not compromised. Chen's former postdoctoral fellow, Lei Wang, helped collect preliminary data for the proposal.

"This will be an alternative to traditional optical mapping," Chen said. "The field has moved from cutting the whole DNA to cutting half of the DNA. Now it's time to cut no DNA."

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Directors Corner

Dear Colleagues and Friends of NQPI:

Welcome to our 20th edition of the NQPI newsletter. For nearly 10 years, this publication has highlighted many advancements and activities in nanoscience at OHIO. I was honored to serve as the first editor of the NQPI newsletter. Today, as the director of NQPI, I am very proud to see how much our Institute has grown.

This newsletter is packed with exciting research news and accounts of recent accomplishments by our students and faculty members. As you browse this issue, you will read about the development of a functional monitor for diabetes, a model for cell differentiation, and a report on a visit to the Royal Society in London guided by OHIO Physics alumnus and Nobel laureate Venkatraman Ramakrishnan.

Since its establishment, NQPI has supported cross-disciplinary nanoscience research and education efforts at OHIO. These efforts were complemented by the existing Condensed Matter and Surface Science Program (CMSS), which provided graduate fellowships, undergraduate research support, common equipment and facilities, and research seminars.

It is my pleasure to report the successful completion of the merging of CMSS and NQPI, first announced in the last issue. The current infrastructure is inherited from NQPI, while the membership and the goals have been expanded to include the broad research interests of our new members from CMSS.

The new NQPI now operates through the Office of the Vice-President of Research and Creative Activity. Our new membership includes faculty from the College of Art and Sciences as well as the Russ College of Engineering and Technology.

The Institute now combines the strengths of both the former NQPI and CMSS by consolidating expertise on nanoscience and materials research. These exceptional opportunities for interdisciplinary collaborations in areas of high technological impact are combined with our traditional efforts toward education and training of young scientists.

Furthermore, let me congratulate the recipients of the 2018-19 Graduate Research Student Fellowship as reported in the back page of this issue. The work carried out by these students is just a sample of the quality and variety of research pursued in our Institute.

In addition, I want to recognize Dr. Jixin Chen for his recent NIH award that supports the development of techniques aimed at enhancing optical mapping of DNA strands.

In closing, I look forward to working with our members to enhance our core strengths and open the door to new and exciting discoveries.

Best,
Eric Stinaff, NQPI Director

NanoBytes

- Environmental and Plant Biology professor and NQPI member Allan Showalter was recently recognized as the 2017 Kopchick Faculty Support Awardee at the OHIO Molecular and Cell Biology (MCB) retreat on November 10. Read the full article at *www.ohio.edu/cas/nqpi*.
- Chemical and Biomolecular Engineering professor and NQPI member Amir Farnoud was also among the presenters at the MCB retreat.
- Farnoud was also recently featured in a local podcast, in which he spoke on the future of nanoscience. Listen to the full interview at *www.woub.org*.
- Thirty-six NQPI students presented their research to faculty in the biennial poster competition on November 15.
- Physics & Astronomy professor and NQPI member Nancy Sandler has partnered with the Patton College of Education to launch a new program to assist STEM teachers in rural Appalachia.

NQPI Members Team Up to Characterize Dewetting

A new finding from the lab of Physics & Astronomy professor and NQPI member Martin Kordesch has altered the scientific community's understanding on the fundamental properties of materials in thermionic cathodes.

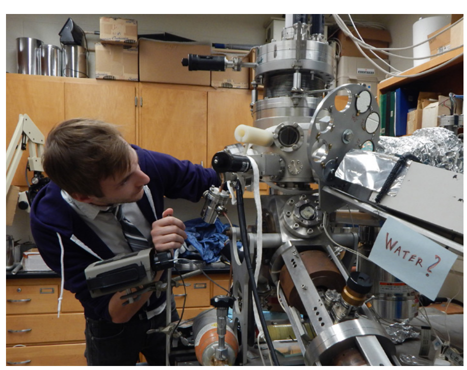
In a paper published in *AIP Advances* last June, Kordesch and doctoral student Michael Mroz collaborated with Mathematics professor and NQPI member Tatiana Savin to examine the properties of scandium on a tungsten surface.

Scandium is used in thermionic cathodes, a fundamental technology for satellites and space communication. For years, researchers assumed this material diffused freely across the cathode tube. However, Kordesch observed that scandium droplets actually form on its surface. This process is known as "dewetting."

"Things that dewet can't diffuse, but others have assumed that they are (diffusing)," Kordesch said. "This is so contrary to what people think is going on that we needed to get it on the record."

This particular case was unusual, Kordesch said, because the dewetting occurred at a solid-solid, rather than a liquid-solid, interface. The scandium clusters had formed in a crystalline state.

Puzzled by this finding, Kordesch reached out to Savin, who studies mathematical properties of materials. He spoke with Savin and her collaborator Alexander Nepomnyashchy, a professor at the Technion-Israel Institute of Technology & Northwestern University, who had visited Athens last January for the Condensed Matter and Surface Science Colloquium.



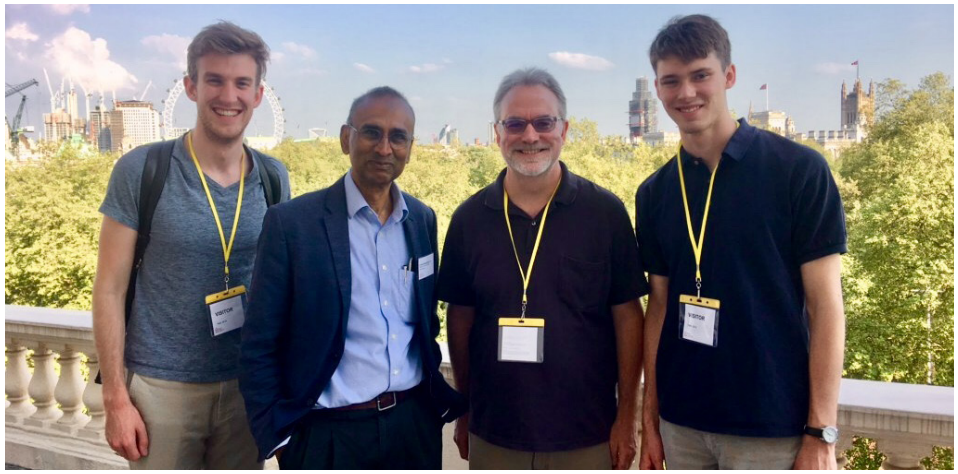
Physics doctoral student Michael Mroz uses a low-energy electron microscope to examine the physical properties of compounds that make up thermionic cathodes.

Based on Savin and Nepomnyashchy's advice, Kordesch and Mroz tried altering the thickness of the scandium film. They found that dewetting was enhanced in thicker films.

"It was an eye-opener," Kordesch said. "It was exactly the right thing to do. We stumble on these things because we have to deal with them (as experimentalists)."

Kordesch is currently working to examine how the addition of barium, a liquid-solid dewetter, alters the dewetting process. He said he hopes to continue to work with Savin's group in the future, using mathematical computation to characterize physical phenomena.

Cambridge Sabbatical Mingles Research, Networking



NQPI member David Drabold (center right) poses in Cambridge, England with Nobel laureate Venkatraman "Venki" Ramakrishnan (center left) and his sons, Will (left) and Edward (right). Drabold spent last spring at Trinity College during his sabbatical. (Photo courtesy of David Drabold)

One might not think history and physics regularly coincide. However, Distinguished Professor of Physics and NQPI member David Drabold steeped himself in both this past spring by taking sabbatical at Trinity College in Cambridge, England.

While in Cambridge, Drabold met with long-acquainted colleagues and enjoyed the rich, historical landscape of a city where the likes of Sir Isaac Newton, Bertrand Russell, Francis Bacon and other great minds have gathered for centuries. "It's an everyday event to eat lunch or dinner with a Nobel Prize winner," Drabold said.

He reconnected with many long-standing associates, such as his past collaborator, Trinity College professor of physical chemistry Stephen Elliott. In Cambridge, Drabold and Elliott worked on the theory of amorphous silicon this year, focusing on its electronic structure.

As a visiting fellow commoner, a title given to visitors of Cambridge who are within the school's highest standings, this was Drabold's third visit to Trinity College. He spent six months there in 2001, and from 2008 to 2009 Drabold was a Leverhulme Professor of Chemistry. The position included a grant by the UK Leverhulme Academic Trust to enhance the skills of academic staff within the institution.

Drabold submitted two academic papers while in Cambridge. He and his collaborators studied amorphous carbon and showed that it consists of interconnected pieces of an exotic material, amorphous graphene. A two-dimensional crystal variant, amorphous graphene is comprised of carbon atoms arranged in rings of pentagons, hexagons and heptagons. In a different project, Drabold researched the transport of charge through alumina materials alloyed with copper to understand how conducting-bridge RAM works; a form of memory storage that can retrieve stored data without requiring a continuous power source.

In November, Drabold submitted a paper on Machine-Learning-derived, melt-quench models of amorphous silicon and its associated electronic properties to *Angewandte Chemie*. This paper is a direct outcome of his UK work.

Another old friend in Cambridge was OHIO alumnus, 2009 Nobel laureate Venkatraman "Venki" Ramakrishnan. Ramakrishnan was knighted by the Queen in 2012 for services to molecular biology. He invited Drabold and his family to the Royal Society in London, where he is currently president, and gave them a private tour.

"That was fascinating because we saw lots of history of the Royal Society," Drabold said. The Royal Society, founded in 1660, is the oldest national scientific society in the world. Drabold said Ramakrishnan's invitation was "the kind of thing one never forgets."

Drabold summed up the rewards of his sabbatical succinctly: "It's always fantastic to work with the scientific group of Stephen Elliott," Drabold said. "Of course it was great seeing Venki. And frankly, I just love being in Cambridge."

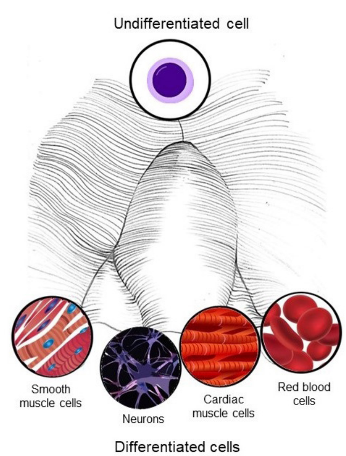
Stem Cells: From Classical Model to Modern Computation

The human body is home to more than 200 different types of cells, each performing a unique function. But what makes a blood cell a blood cell, or a neuron a neuron?

All cells in an organism are derived from a single embryonic stem cell. Cells exhibit different patterns in their gene expression throughout the life of the organism. This allows for cellular reprogramming, modifying the gene expression to convert one cell type into another. This offers potential for therapeutics in numerous diseases such as cancer and neurodegenerative diseases.

Physics & Astronomy professor and NQPI member Horacio Castillo and recent alumnus Sai Teja Pusuluri have developed a novel approach to characterize cell differentiation. Working with Boston University professor Pankaj Mehta and alumnus Alex Lang, they simulated a computational model to describe patterns of gene expression in mouse fibroblast cells.

For decades, scientists have described the process of cell differentiation using the "epigenetic landscape" image, which visualizes a differentiating cell as a sphere that travels across a landscape and eventually settles into a "valley," representing a differentiated cell type.



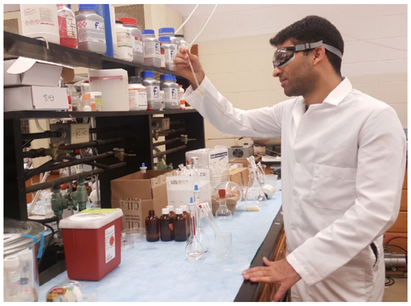
According to Waddington's epigenetic landscape, cell differentiation is determined by the movement of a cell through a series of paths that lead to basins, representing its possible mature forms. (Image adapted from Wikimedia Commons)

"The landscape has been in principle just an image," Castillo said. "(But our work) seems to indicate that a model based on a landscape actually can be used to describe how these genes work."

Castillo's group implemented the landscape model into their approach, converting a classical metaphor into a quantitative tool. They constructed a spin-glass model, which fits specific patterns of gene expression to a discrete cell type. Spin-glass models have been used previously to describe neural networks. With this model, the group described how landscapes govern cell differentiation.

The group is now characterizing the correlation structure of gene expression patterns among different cell types. They are constructing random trees to visualize the hierarchy of cell types, with embryonic stem cells as the root and differentiated cells as the branches. With this approach, Castillo said, the group is working to better understand the dynamics of this complex, yet fundamental phenomenon.

Thermosensing at the Nanoscale



Chemistry doctoral student Ali Rafiei Miandashti is designing a thermosensing system that may one day be applied to cancer treatment. (Photo courtesy of Ramin Rabbani)

When it comes to developing more effective therapeutics for cancer, doctoral student Ali Rafiei Miandashti emphasizes the key is to think small.

Rafiei, who works under the supervision of Chemistry & Biochemistry professor and NQPI member Hugh Richardson, is studying a nanoscale technology that may one day be used in cancer treatment.

Traditionally, chemotherapy is used in conjunction with radiation therapy to combat the growth of cancerous cells. A fundamental flaw of this approach is that the treatment also damages healthy cells. Photothermal therapy, a novel approach that employs the use of tiny plasmonic nanoparticles to heat cells at the nanoscale, may help to overcome this limitation.

In this approach, the nanoparticles are injected into the patient's bloodstream, where they bind to cancer cells in the body. Next, the tissue is irradiated with a laser. This process causes the nanoparticles to generate heat, targeting the cancer cells while leaving healthy tissue intact.

Photothermal therapy has been tested in animal models but has not yet been applied clinically, Rafiei said.

In a paper published recently in *Nanoscale*, Rafiei, recent Ph.D. alumnus Susil Baral, and Richardson characterized the absolute temperature and heat dissipation parameters from single gold metal nanoparticles. In this study, the team adhered gold metal nanoparticles on a photoluminescent film. The film functions as a thermosensor and detects the temperature, measured as the change in internal energy, of the nanoparticles.

Rafiei is now designing a system in which a second, larger nanoparticle is used as a substrate in place of the film. This approach, Rafiei said, is more applicable for clinical methods because it allows him to decrease the size of the system and measure temperature directly at the nanoparticles. The results of this study were published in *MRS Advances* last February with Richardson and Martin Kordesch, a Physics & Astronomy professor and NQPI member, as coauthors.

Rafiei said by understanding heat generation and decay from plasmonic nanoparticles, medical researchers will be able to advance the field of photothermal therapy.

"Much of our research is fundamental," Rafiei said. "To optimize this new technique … it is important to understand how plasmonic nanoparticles behave in a biological system."

Smart Monitor

Continued from page 1

on an impossible job with a small group and a small budget, but what counts is the idea."

Their prototypes utilize infrared light that measures glucose levels through the skin via a weak coupling mechanism to glucose molecules. The team's designs are capable of greater accuracy than others' due to high signal-to-noise detection circuitry, multiple measurement points, and integration of different types of measurements. Their approach will account for the effect of external factors on the readings, Kaya said.

The team's project is supported by a seed grant through OHIO's Innovation Strategy. Kaya is collaborating with Electrical Engineering and Computer Science professors Cindy Marling and Razvan Bunescu, who are utilizing their expertise in computational analytics to integrate multiple sensors within the system, and Biomedical Sciences professor Vishwajeet Puri, who has an interest in utilizing the design to monitor lab animals.

"We believe that this approach is promising because we think in multiple angles," Kaya said. "For 20 years the industry has been focused (on one type of approach). If something hasn't been solved in 10 or 20 years, there's a big problem. You need to think out of the box."

2018 NQPI Fellowships Awarded

Bestowed annually on a competitive basis, up to six graduate students are chosen to receive a one-semester stipend.

Yuan Zhang
Faculty Adviser: Allan Showalter
Environmental & Plant Biology
Zhang uses *Arabidopsis thaliana* as a model plant species for her research, applying the CRIPSR/Cas9 gene editing approach to study how different sugar decorations affect arabinogalactan proteins, a class of highly glycosylated plant cell wall proteins.

Saeed Nazemidashtarjandi
Faculty Adviser: Amir M. Farnoud
Chemical and Biomolecular Engineering
Nazemidashtarjandi studies the interaction of engineered nanomaterials (ENMs) with plasma membranes. He studies how different ENMs alter membrane properties and induce damage.

Ahmed Aboelenen
Faculty Adviser: Michael P. Jensen
Chemistry & Biochemistry
Aboelenen is designing a model, non-heme iron complex that can oxidize the dioxygen molecule into more reactive species that are potent oxidants, important for the oxidation of organic substrates.

Uvinduni Ishanti Premadasa
Faculty Adviser: Katherine Cimatu
Chemistry & Biochemistry
Premadasa researches potential relationships between liquid-air interface conformations, polymerization processes, and polymer surface conformations using sum frequency generation spectroscopy. Her research provides a pathway for developing polymer coatings with better physicochemical properties through strategic structural modification of the monomer units.

Ali Khaledi Nasab
Faculty Adviser: Alexander Neiman
Physics & Astronomy
Khaledi-Nasab studies the collective dynamics of excitable elements coupled in tree networks. These networks are relevant to sensory neurons such as touch and pain receptors. His research is aimed at understanding the mechanism of information coding in these networks.

Yahya Taha Ayed Al Majali
Faculty Adviser: Keerti Kappagantula
Mechanical Engineering
Al Majali's research aims to enhance the mechanical and electrical properties of poly-lactic acid polymers by mixing them with two types of carbon nanotubes (CNTs), pristine and functionalized. The functionalized CNTs will make the polymer stronger, whereas the pristine CNTs will increase its electrical conductivity.

Writing, design, editing and photos by Amanda Biederman and Ryan Flynn. Editing by Dr. Nancy Sandler and Jean Andrews. Please email andrewj4@ohio.edu with comments.

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