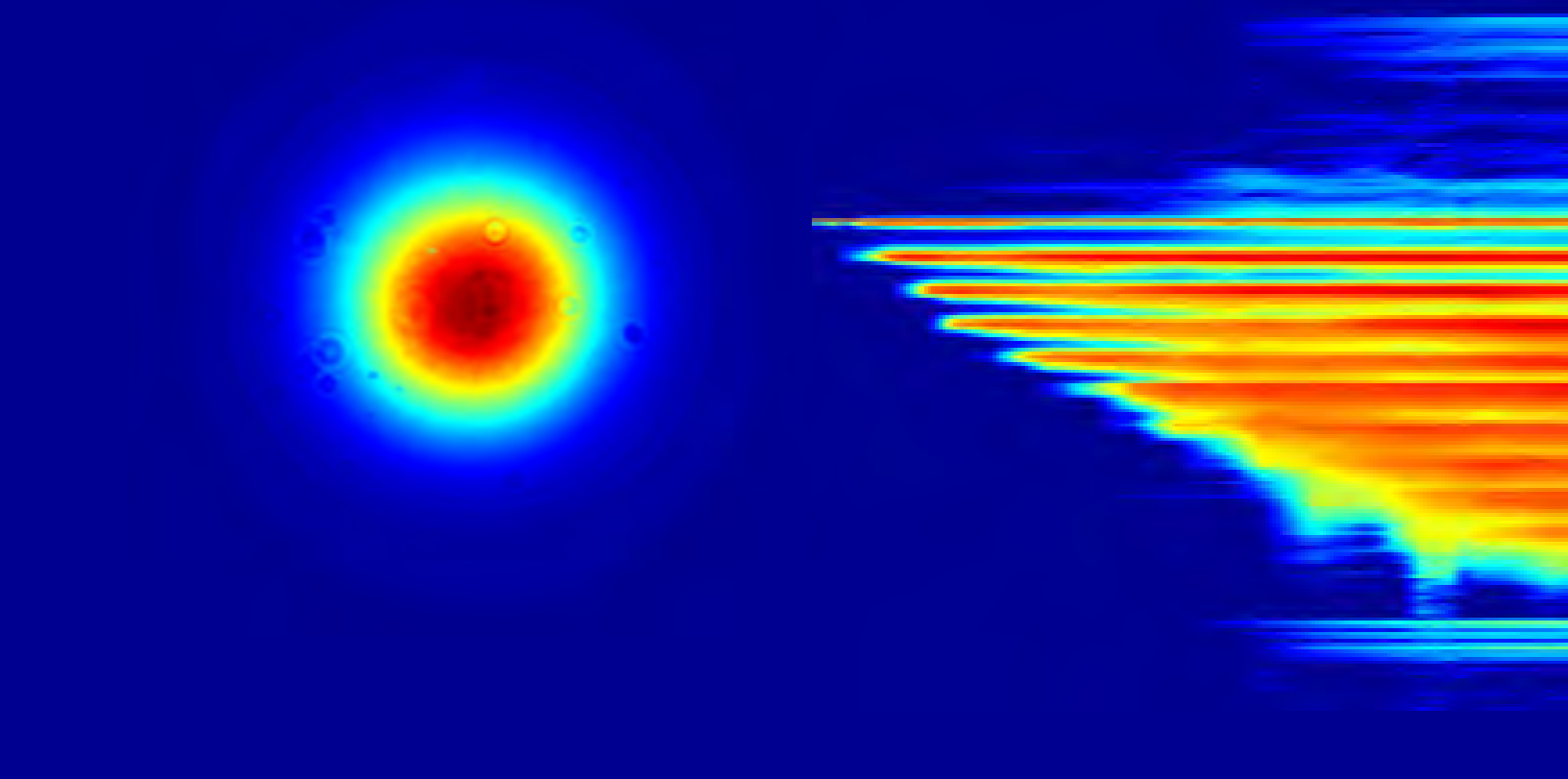
CornellEngineering
Applied and Engineering Physics

AEP

Newsletter
Winter 2019



AEP
MESSAGE FROM THE DIRECTOR

DEAR FRIENDS OF AEP,

There is so much AEP news to share this year. This newsletter brings you some of our highlights, even more are available on our website (www.aep.cornell.edu). I encourage you to follow us on social media. As you can see from the article on page 4, the AEP faculty continues to grow. In 2018 we welcomed Jie Shan and Kin Fai Mak, who bring great research strength in the area of 2D materials. Professors Shan and Mak are jointly appointed in AEP and Physics. We are also excited to bring more active learning into our AEP classes. As a bold first step, Frank Wise successfully 'flipped' a junior level quantum mechanics course. Class time now includes periods of active problem solving. To our most recent graduates, take a look at photos from the 2018 Commencement on pages 14 and 15.

As always, we particularly enjoy hearing from you, our alumni. Email me at aep_director@cornell.edu and let us know what you are doing, or make plans to return for your reunion in June.

With warm regards,
Lois Pollack
Professor and Director

AEP's Alumni Newsletter

is published once a year by the School of Applied and Engineering Physics, Cornell University, Ithaca, New York.

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NEW TO AEP

AEP is pleased to announce three staff hires in 2018.

Nicole LaFave

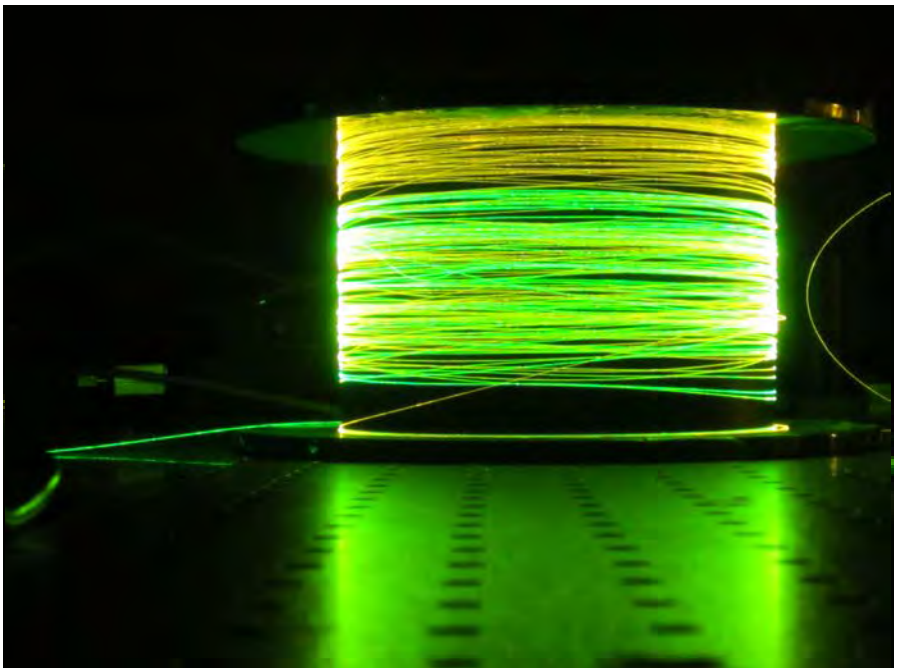
Nicole has a BA in Sociology from Ithaca College and most recently worked at the Public Service Center at Cornell and the Multicultural Resource Center at Tompkins County Cooperative Extension. She joined AEP in the front office in January 2018.

Jenna Powers

Jenna joins AEP as the new NeuroNex Technology Hub Research Support Coordinator. Previously, she studied cognitive science at the SUNY Oswego and managed a therapeutic foster care program. In her free time she enjoys spending time on Cayuga Lake with her family, road biking, camping, and traveling.

Laura Mortelliti

Laura holds a BS from Cornell University in Animal Science and Natural Resources and attended graduate school at Syracuse University Newhouse School of Public Communications. Previously, Laura worked as Multimedia Manager for White Oak Pastures. She joins AEP as the new Communications Specialist.



ABOUT THE COVER

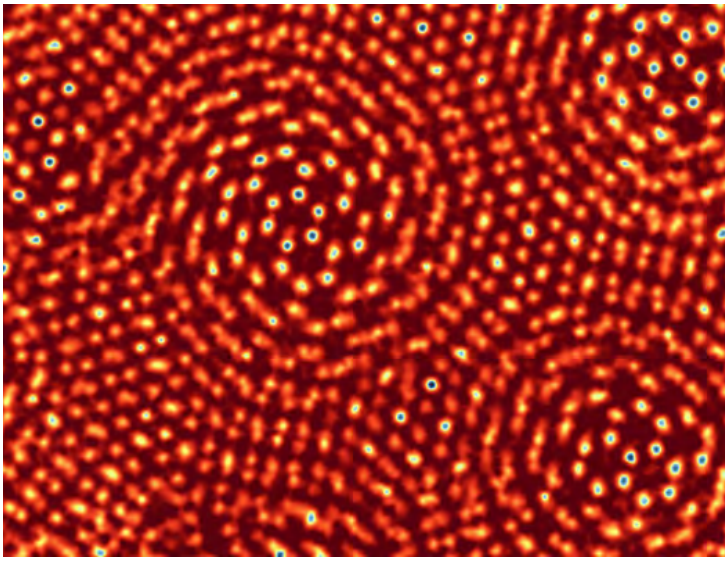
Professor Frank Wise's Group has been researching the propagation of short pulses of light within multimode fibers. In industry and in medicine, lasers based on optical fiber are a rapidly growing market, providing unprecedented performance, low cost, and reliability. However, these technologies currently rely on single mode fibers, and are nearing their fundamental limits. To address this growing concern, Wise Group researchers are studying multimode fibers as a solution. These fibers could potentially be utilized in a multitude of applications such as high-speed internet, neutral networks, and very high-powered lasers.

Above Image: The above image displays a unique phenomenon characteristic to multimode fibers in which the spectrum of light in the fiber changes through its course. This is demonstrated by the light entering at the bottom of the spool and coming out near the top a changed color (green to yellow). Cover Image: An example of the light beam (left) and a graphical depiction of the range of light wavelengths (right) that come out of the above optical fiber after a single wavelength is launched into it.

RESEARCH UPDATE

Professor David Muller has been featured in Wired and Nature News for his lab's July 2018 breakthrough using the transmission electron microscope. These advances allow for high-resolution images as well as the ability to explore invisible properties of materials as never before. Each dot in the image below is a single molybdenum or sulfur atom from two overlapping but twisted atom-thick sheets. Muller's team combined the use of the electron microscope pixel-array detector (EMPAD) with a computational method to process multiple scattering patterns, known as full-field ptychography. This combination enhances image resolution and contrast to a new degree and unlocks new potential for the microscope.

Above: David Muller pictured in his lab, photo by Jesse Winter.



Above: Molybdenum disulfide.

Welcome, Jie Shan

by Christopher Dawson

When Jie Shan was growing up in Zhejiang Province in China's southeast, she did not imagine her future held a career in physics. "I always liked math and chemistry and physics when I was in high school," says Shan. "But when I chose to major in physics for my B.S. I didn't really think I would become a professional physicist."

25 years later, Shan is very much a professional physicist. After 15 years teaching at Case Western Reserve University and the Pennsylvania State University, Shan has joined the faculty at Cornell's School of Applied and Engineering Physics as a full Professor. As of 2013, she is also a Fellow of the American Physical Society (APS).

"Initially, I liked the ability physics gave me to explain things from basic principles," says Shan. "I also love the problem-solving approach I learned by studying physics."

Shan's work at Cornell focuses on the optical and electronic properties of nanoscale materials. She is particularly interested in atomically thin two-dimensional crystals (such as graphene and MoS2) and their heterostructures. Her lab develops experimental techniques to probe, image and control the internal degrees of freedom of electrons and their new phases in these nanoscale systems.

When Shan earned her Diploma in Mathematics and Physics from Russia's Moscow State University she was drawn to experimental physics, but her thesis advisor steered her toward more theoretical work. "There was a hierarchy within the physics department at Moscow," says Shan, "and experimentalists were viewed as a notch below theoreticians."

Shan moved to New York from Moscow and started a doctoral program at Columbia University. "When I got to Columbia, I became an experimentalist," says Shan. "I worked with Professor Tony Heinz on optical spectroscopy." Shan's work at Columbia contributed to a table-top coherent terahertz technology that could be used in imaging and for materials characterization. After earning her Ph.D. from Columbia, Shan joined the faculty of Case Western Reserve University, where she taught for 12 years. "I found colleagues at Case Western so supportive and mentoring and the students so devoted," says Shan. "I had access to a strong research community on biomedical and soft materials. I applied optical spectroscopes to colloids and other soft matter." The next step in Shan's career took her to Penn State, where she moved into a deeper study of 2-dimensional materials. Her work at Penn State focused on collective electronic phenomena such as superconductivity and magnetism in the 2-dimentional limit. At Cornell, Shan has continued the work she started at Penn State.

"Much of our research is driven by fundamentals," says Shan. "We work with new materials and we are trying to discover or engineer new properties. It is very exciting." Shan is especially excited by the possibilities opened up by the ability to integrate 2-dimensional materials of different kinds into heterostructures.

Above: Jie Shan(left), professor of applied and engineering physics (AEP) in the College of Engineering, and Kin Fai Mak, assistant professor of physics in the College of Arts and Sciences; the two hold joint appoinements in AEP and Physics. Shan and Mak are experts on atomically thin materials, particularly their optical and electronic properties. They also are married and were recruited to Cornell in late 2017 from Penn State through the provost's Nanoscale Science and Molecular Engineering (NEXT Nano) initiative. They moved their shared lab and joint research group to Ithaca and have been up and running in the Physical Sciences Building since January 2018.

Lena Kourkoutis

AEP Associate Professor Lena Kourkoutis was awarded the 2018 Burton Medal, a major award from the Microscopy Society of America. The Burton Medal honors distinguished contributions in the field of microscopy and microanalysis of scientists under the age of 40. Kourkoutis was chosen for her "pioneering work in developing and applying spectroscopic and cryogenic methods to image the atomic-scale composition and bonding of interfaces and nanoscale materials."

The Kourkoutis electron microscopy group focuses on understanding and controlling nanostructured materials, from complex oxide heterostructures to materials for battery and photovoltaic applications to biological systems. Electron microscopy is at the heart of each of their projects; the advancement of existing or the development of new electron microscopy techniques is therefore an integral part of Kourkoutis' research.

Frank Wise

Frank Wise, Samuel B. Eckert Professor of Engineering in AEP, has become the 10th director of the Cornell Center for Materials Research (CCMR), taking the reins from Melissa Hines, professor of Chemistry in the College of Arts and Sciences, after she served 12 years in the role.

Wise said one of the things he likes most about the CCMR is that it fosters the type of research – collaborative work, across campus and disciplines – for which Cornell is known.

"It specifically supports interdisciplinary research – the kinds of things that no individual research group could do alone," he said. "In addition to faculty producing world-class science, it has contributed enormously to materials infrastructure at Cornell. This includes the strong culture of cooperation and collaboration on campus."

The CCMR, funded by the NSF and New York State, is an interdisciplinary research center whose mission is to advance, explore and exploit the forefront of the science and engineering of advanced materials. This objective is pursued through fundamental, experimental and theoretical studies.

Chris Xu

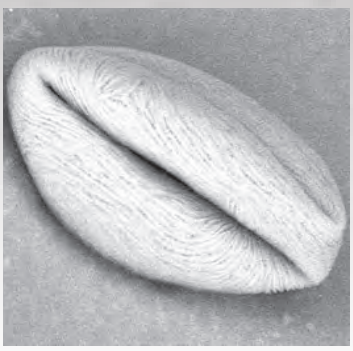
Professor Chris Xu received a College of Engineering Research Excellence Award. The award is given in recognition of his research contributions and leadership in path-breaking science and technical innovation. Xu pioneered long wavelength nonlinear microscopy for deep brain imaging, and led the effort in establishing Cornell Neurotech and the Cornell NeuroNex Hub, an NSF funded center for developing and disseminating neurotechnology. Nominated by the school, Xu was selected by a committee of recognized senior researchers within the college.

AEP
SEM IMAGE CONTEST

CLOSEUP

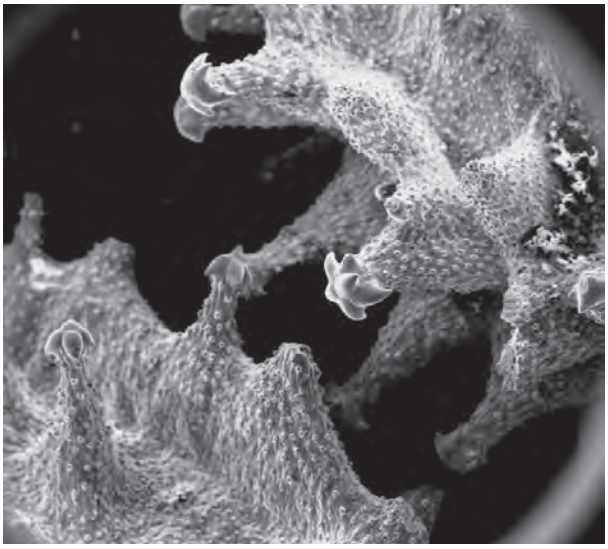
Undergraduate students in *Intro to Nanoscience and Nanoengineering*, a course taught by Assistant Professor Guillaume Lambert, submitted their best images taken with the Phenom XL Scanning Electron Microscope (SEM). With an electron microscope it is possible to observe objects or details that are too small to be seen with optical microscopes. AEP recently purchased this instrument for the Nanoscience and Nanotechnology Lab through the generosity of Mr. Lee Berlin, '58.

Prizes were awarded in the following categories: Nano Prize for scientific merit and technical challenge, and Artistic Prize for artistic merit and aesthetics. Here are some of our favorites.



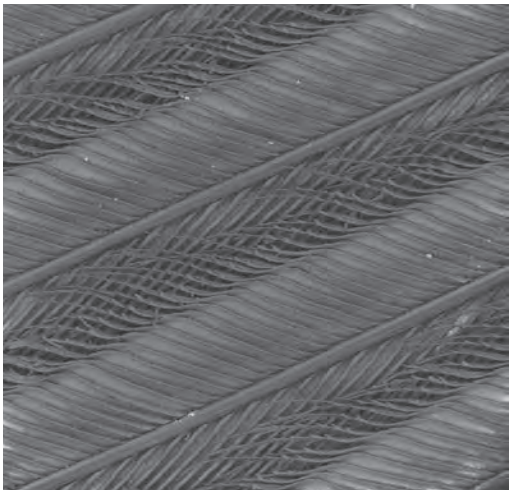
Artistic Prize: Jesse Smith

Pictured is a single pollen grain from Prunus × yedoensis, a hybrid cherry tree (cloned internationally through grafting from a single organism). Regularly bifurcated, intricately ridged, and oblong in shape, it clearly looks like a delicious fortune cookie. If you could open it up, it would say "spring has arrived!"



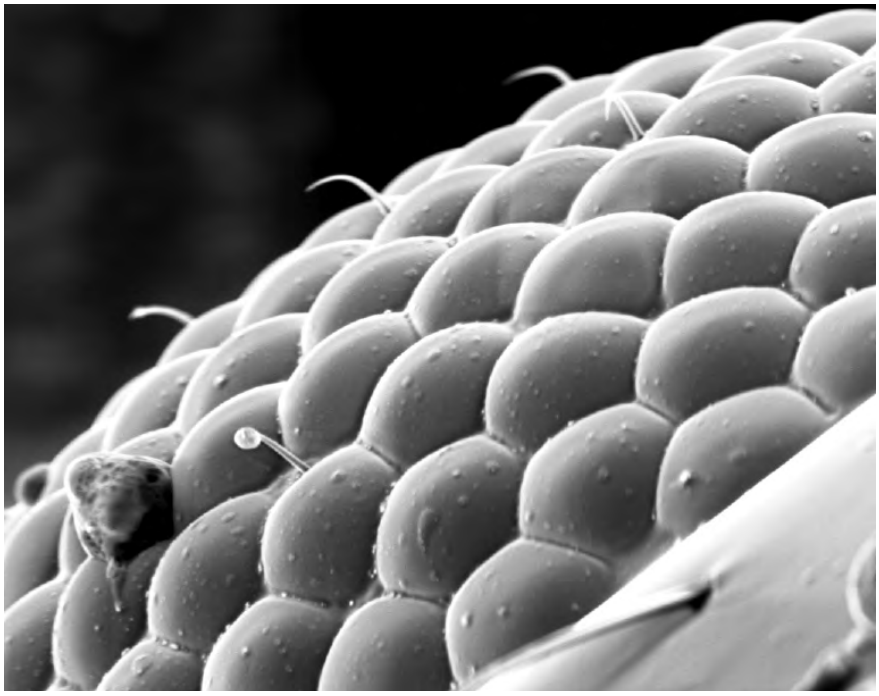
Ivana Terziyska

This image is of two Forget-Me-Not (Myosotis) seeds side by side. Some interesting features are the cavities and ridges on their surfaces, which help the seeds stick to things and disperse. The surfaces of these tiny seeds almost look like the terrain of another planet.



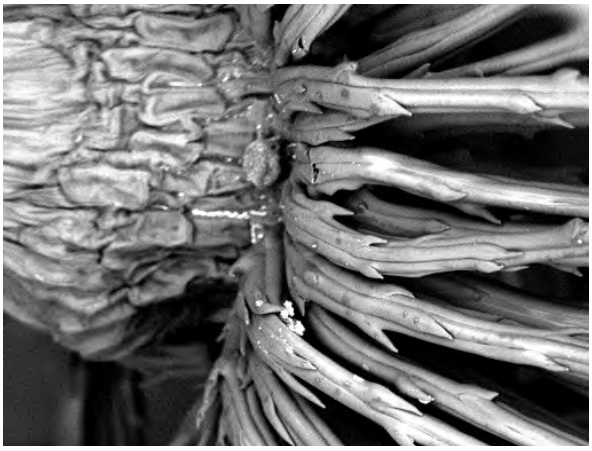
Artistic Prize: Adam Spaulding-Astudillo

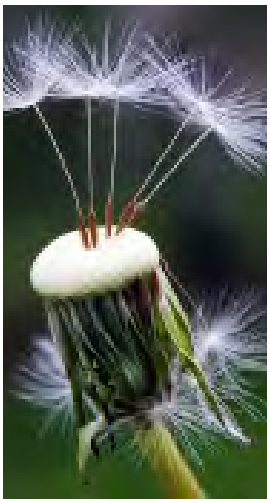
The image captures a parrot's feather, zoomed into the space between individual strands. You're observing the structures which so excellently grip one another to act like a natural Velcro. The image reveals a hidden stacking of sorts, which provides the impressive elasticity found when pulling back on a bird's feather.



Nano Prize: Nathan Zimmerberg

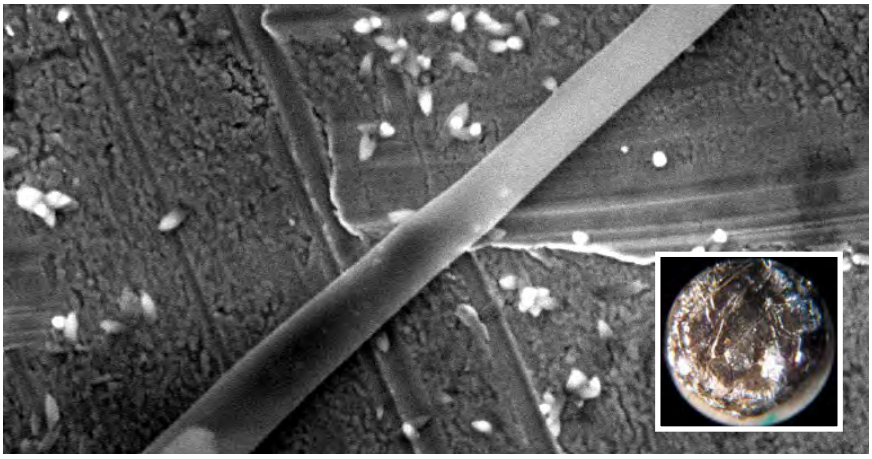
The compound eye of an ant with hair-like setae found on Cornell's Ithaca campus. The hair-like structures help keep the eye clean by diverting air flow and dust away.





Zoe Roberts

Pappus meets beak of Taraxacum officinale (dandelion) cypsela; the bristly hairs of the white "parachute" of a single dandelion seed fruit radiate from the top of the stalk. Each pappus fiber is around 10µm wide—10x smaller than the average diameter of a human hair.

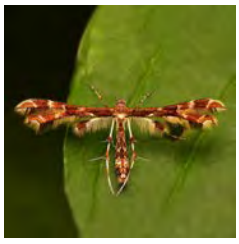


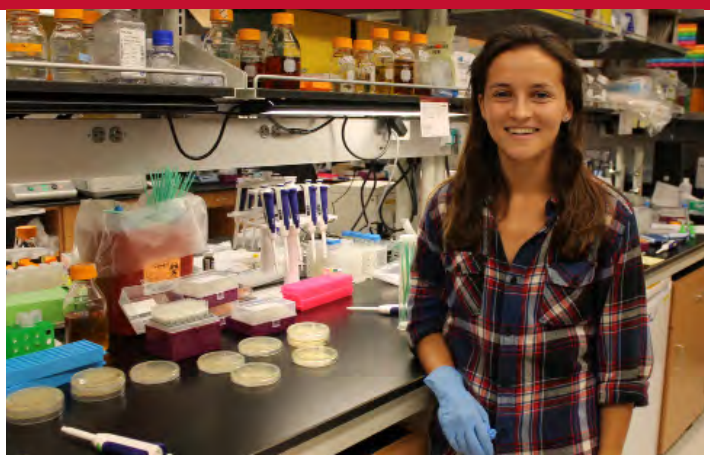
Nano Prize: Riley Jacob

This image shows small microscopic crystals of the superheavy metal americium (Am), which are approximately a micron long. The americium sample came from a smoke detector. Modern smoke detectors use a small amount of americium, contained in a stainless steel button and coated in gold, as a source of alpha particles which are used to detect smoke. The extremely thin layer of gold was removed with a drop of aqua regia, which was quickly washed off a few seconds later, leaving behind the thin layer of americium, including some sparse regions where it exists in crystalline form. These crystals are relatively easy to verify as being Am because their structure is clearly that of a hexagonal close packing.

Matthew Danbury

A dorsal view of the tarsal claw on the rear leg of a Plume Moth (Geina spp.), with honeycomb-like exoskeleton visible between the moth's scales.





STUDENT SPOTLIGHT: ANNIE TAYLOR

Hometown: Charlottesville, VA
Program: Bachelor of Science in Engineering Physics

How did you become interested in engineering and why did you choose Cornell/AEP?
I've always been generally interested in science, probably in large part thanks to my dad, who is a professor of biology at UVA - I've been through many dinner table conversations about genomics. When I was 11, I was a huge fan of Neil DeGrasse Tyson and wanted to study astrophysics. But I think it was when I discovered Elon Musk that I decided I wanted to be an engineer, which is why I ultimately applied to engineering schools and why I considered studying physics. I had listened to interviews where Musk discussed using physics as the ultimate framework for solving problems, in particular, working upwards from fundamental principles rather than reasoning by analogy. That stuck with me. I also wanted to study something difficult. I struggled a bit when I came in as a freshman and I wanted to prove to myself that I could "AEP."

What experiences have contributed to your sense of belonging here?
I really appreciate what a small and close-knit group the AEP department is. The undergraduate group is very supportive and has a lot of fun, while faculty are generally approachable and sympathetic. The cross country and track teams have been a huge part of my experience as well and are an amazing support network.

Can you tell us about the AEP undergraduate organization you helped to establish and the types of events you're coordinating?
The senior class of EP majors is particularly close and I think we all saw an opportunity to formalize and perpetuate the supportive culture that we have been experiencing while affiliated with the department. The undergraduate society, dubbed ExP, mainly seeks to recruit other undergraduates to the department as well as to enrich the experience of affiliated students. We had a bunch of students at the Major Information Fair this fall and plan to do more outreach to freshmen engineers in the next couple of weeks. In addition, we're hoping to provide opportunities for career and grad school advice. On the social end, we have plans for picnics, a formal, a Secret Santa, and some gatherings with other engineering majors. We also set up a makeshift ping pong table in the undergrad lounge, which we are able to use after 5pm.

Above, Left: Annie by her station in the Lambert Lab, Physical Sciences Building. Above: Annie observes a DNA gel under a blue light illumination.

Describe the most current research project you are working on.
My project works with a particular genetic inverter which we have been calling CRISPR-gate. The CRISPR-gate is analogous to an electronic inverter, but rather than converting low voltages to high voltages and vice versa, the CRISPR-gate uses CRISPR/Cas proteins to invert an RNA signal from low to high. More explicitly, if the input gene in the CRISPR-gate is being expressed, the output gene will be repressed. I am working to optimize this inverter so that eventually many CRISPR-gates can coexist inside a cell and ultimately be used to implement complex logic functions.

This research contributes to the design of increasingly orthogonal and modular genetic circuit elements, which is a central project in the field of synthetic biology. The ability to implement any logic function in a gene network will allow researchers to modify any cellular function or evaluate the biological response to various environmental stimuli. In a larger sense, gene circuits have applications ranging from medicine to energy, including drug screenings, biofuels, gene therapy, biosensors, and vaccine development.

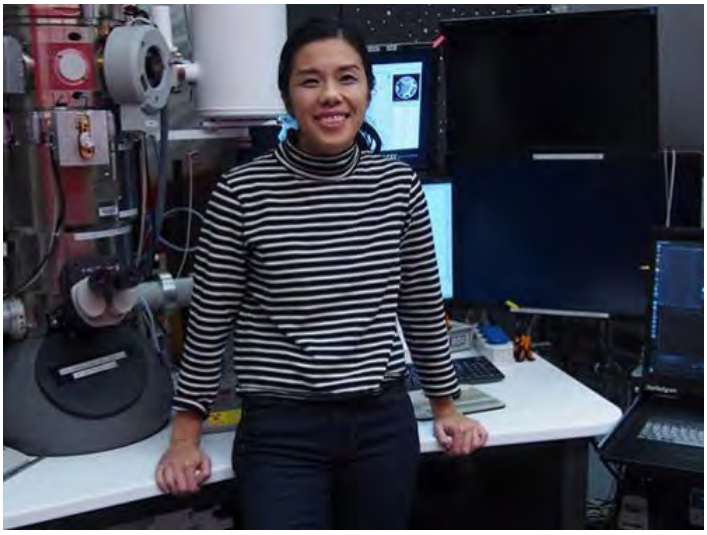
What are your extracurricular interests and how have you incorporated them into your college life?
My dominant extracurricular interest is competitive running. I compete on the varsity cross country team and am one of the track team captains this year. My main events are the 1500m and 800m, with the occasional 3000m. We have practice every weekday afternoon and competitions most weekends, Fall, Winter, and Spring. I find racing incredibly rewarding and appreciate the release and balance training brings every day.

What do you hope to accomplish during your time at AEP and after graduation?
I will be applying to a mixture of masters and Ph.D. programs this fall. I've developed an interest in neuroscience, so I hope to find a niche where I can apply my studies in physics and research in synthetic biology to learn more about the brain.

STUDENT NEWS & AWARDS

YIMO HAN was lead co-author of a cover story in Nature Materials, titled, "Sub-nanometre channels embedded in two-dimensional materials." Han is a Ph.D. student in the David Muller Group, and she presented this work at Materials Research Society (MRS) conference, the largest conference in the material science community. Han and her research collaborators have discovered – a little bit by accident – a method for basically inserting a 1-D semiconductor channel into the "fabric" of a 2-D material. The electronic band structures of these channels exhibit the properties necessary for future electronics applications.

YUNUS KINKHABWALA, AEP Ph.D. student, received the NSF Graduate Research Fellowship. As the oldest graduate fellowship of its kind, the program has a long history of selecting recipients who achieve high levels of success in their future academic and professional careers. Kinkhabwala is a member of the Itai Cohen Group.



KAYLA NGUYEN, a Ph.D. candidate in the Muller research group in the Applied Physics department, was awarded the $15,000 2018 "Use it!" Lemelson-MIT Student Prize for her inventive work in helping to develop new electron microscopy techniques. She developed software, tested and demonstrated a new type of scanning transmission electron microscope (STEM) camera, called an Electron Microscope Pixel Array Detector (EMPAD). The EMPAD camera sensor was based on x-ray detector technology pioneered by the Gruner research group in the Physics department. The Muller and Gruner research groups collaborated to adapt the technology for use on an electron microscope. For this project, Kayla also used an airSTEM, a high-performance and low-cost STEM that allows specimens to be examined in air, rather than in the vacuum of the STEM.

AEP
WHEN SCIENCE MEETS MUSIC

Above: Michael Ndubuisi '14 (left) and Ray Li '14 during a Veserium performance. Below, a detail of the suit's glove. Their music is created using this system, which makes sound through motion and gestures.

FIVE YEARS AGO, Ray Li '14 (AEP) and Michael Ndubuisi '14 (CS) developed a creation called SoundSpace, a simulation system that creates sound out of thin air, using only motions and gestures. Today, the two are still collaborating on the project (now called Veserium), generating distinctly expressive compositions filled with aggressive basslines and virtuosic melodies. When they first launched the system, it consisted of SoundSpace gloves—today, their technology has expanded so that the duo wears full suits that are part of the interactive musical system. Combining creativity and engineering, Li and Ndubuisi are creating sounds which have never been heard before and winning the hearts of many fans within the electronic music scene.

Above, left: The Vindor ES1, an electronic saxophone developed by AEP alum Joel Edinberg '06. Above right: Edinberg (right) visits his former sax teacher, Stephen Moran, to show him the Vindor prototype.

JOEL EDINBERG, B.S. '05 and M.Eng. '06, has also used his engineering physics skills to enhance the music world. Edinberg started his own company, Vindor Music, that designs affordable and easy to play electronic instruments for beginner musicians. Their first instrument, an electronic saxophone called the Vindor ES1, eliminates high-pitched squeaks and out-of-tune notes that often frusterate new learners. The buttons are placed just like they are on a saxophone to facilitate the transition to the real instrument. There is also a headphone jack, allowing students to practice any time—whether in a quiet space or a noisy one. And, the Vindor also has a synthesizer, giving the option for different modes, such as a flute or a clarinet.

"For me," says Edinberg, "a big part of my college experience was playing in the CU Jazz Ensemble, playing in my own band, and doing my senior research under Dr. Chris Xu on applying some theories behind optical physics to sound development, so it's very exciting to incorporate both my engineering background and my love of music into one project."

SPOTLIGHTS ON AEP ALUMNI

Ray and Joel wrote to us last year to tell us about their latest endeavors.
We encourage you to share your story with us as well!
To do so, please submit an alumni note by visiting: **aep.cornell.edu/aep/alumni**
We look forward to hearing from you!



















2018 REUNION BREAKFAST

Applied and Engineering Physics alumni and faculty gather for the 2018 Reunion Breakfast, held June 2018 in the Clark Atrium of the Physical Sciences Building.

Former AEP Postdoc wins shared Nobel Prize in Chemistry

Joachim Frank, former AEP Postdoc, has been awarded the 2017 Nobel Prize in Chemistry, shared with Jacques Dubochet and Richard Henderson, for developing cryo-electron microscopy for the high-resolution structure determination of biomolecules in solution. Frank spent time in Applied and Engineering Physics Professor Benjamin Siegel's microscopy laboratory as part of his Harkness Postdoctoral Fellowship in 1971-1972. During this time, he developed a way to describe how the "partial coherence" of electron waves—their imperfect synchronization—affects how images are formed.

Frank is a Professor of Biochemistry and Molecular Biophysics and of Biological Sciences at Columbia University, and Distinguished Professor of the State University of New York at Albany.

Pinshane Huang '14 receives 2017 Packard Fellowship in Science and Engineering

AEP Alumna Pinshane Huang is one of 18 researchers nation-wide to receive a 2017 Packard Fellowship in Science and Engineering. The Packard Fellowships are among the nation's largest nongovernmental fellowships, designed to allow maximum flexibility in how the funding is used. Each recipient will receive $875,000 over five years to pursue their research.

Huang was member of the David Muller Group. She received her M.S. in 2012 and her Ph.D. in 2014. She is currently Assistant Professor of Materials Science and Engineering at the University of Illinois Urbana-Champaign. Huang's research develops techniques that use electron microscopes to characterize matter with single atom precision, with the ultimate goal of enabling an era in which materials can be designed and perfected at the level of individual atoms.

Four Engineering Physics graduates receive NSF research fellowships

Engineering Physics graduates (clockwise from top left) Nina Andrejevic '16, Matthew Siebert '16, Alison Rugar '17, and Sophie Crisp '18, were announced as recipients of 2018 National Science Foundation (NSF) Graduate Research Fellowships. The NSF Graduate Research Fellowship Program recognizes and supports outstanding graduate students in NSF-supported science, technology, engineering, and mathematics disciplines who are pursuing research-based Master's and doctoral degrees at accredited United States institutions. For the 2018 competition, NSF received over 12,000 applications and made 2,000 award offers.

Ways to Give to AEP

SUPPORT
…the school's activities in any amount
…our undergraduate research symposium
…graduate student networking and research events

SEND
…an undergraduate student to a scientific conference

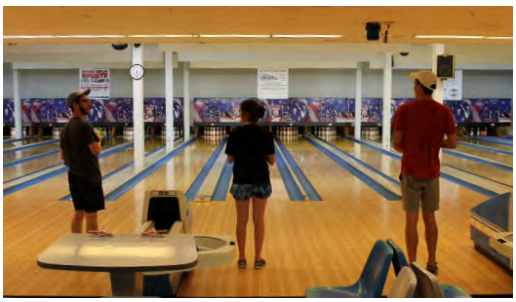
ENDOW
…a graduate TA fellowship
…a professorship

HIRE
…our graduates in your company

CONTACT
Carol Packard
Associate Dean of Alumni Affairs and Development
cap342@cornell.edu
607-255-6094

AEP's Annual Bowl

Every year, AEP hosts their bowling party, where faculty, staff, and students come together to kick off the new semester with some healthy competition, food, and fun.



AEP
COMMENCEMENT AWARDS

Jesse C. Hoke

David Delano Clark Award for Best Master of Engineering Project

Project Title: "Development of Superconducting Tips for Josephson STM"

Henri S. Sack Award for Top Academic Performance by an M.Eng. Graduate

Christian R. Leefmans (LEFT)

Dorothy and Fred Chau Award for Excellence in Undergraduate Research in Engineering Physics

and

Paul Hartman Award for Excellence in Experimental Physics

Gregory Fuchs (RIGHT)
Associate Professor, AEP

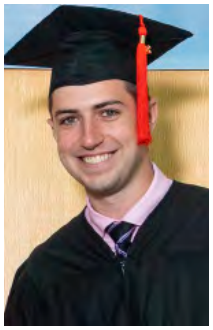
Dorothy and Fred Chau Project Supervision Awards

Varshith Kandula

Trevor Cuykendall Award for Most Oustanding Teaching Assistant

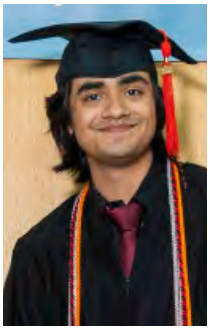
Logan G. Wright

William Nichols Findley Award for Outstanding Graduate Research Paper



Stephen T. Mills

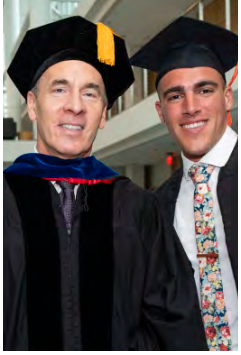
Trevor Cuykendall Award for Most Oustanding Academics



Mustafa A. Ansari

Paul Hartman Award for Excellence in Experimental Physics

Above: Class of 2018, Applied and Engineering Physics





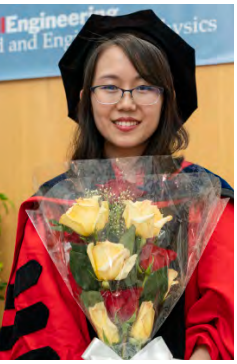
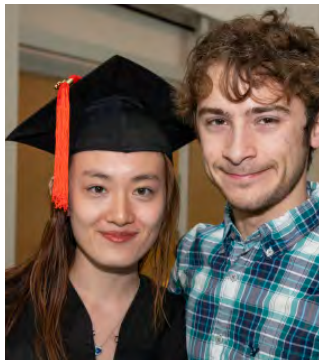



AEP 2018 COMMENCEMENT

Applied and Engineering Physics students and faculty during the 2018 commencement celebration.

Photos by Gary Hodges. To view more, or purchase, please visit: www.garyhodgesphoto.com





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BLAST FROM THE PAST

Professor Harold Craighead examines electron beam written chips with former student Rick Bojko ’01. Bojko was a Research Support Specialist for the National Nanofabrication Facility (NNF) and the Cornell NanoScale Science & Technology Facility (CNF) and he completed his M.Eng. under Craighead. These photos were taken circa 1994 in the NNF clean room, which was located in the previous Knight Lab.