EXECUTIVE VICE PRESIDENT FOR RESEARCH AND PARTNERSHIPS | ANNUAL REPORT 2016 | 2017

EARTH + SPACE

PURDUE UNIVERSITY®

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## AWARDS



"That's one small step for a man, one giant leap for mankind."

Neil Armstrong

above | While millions of people across the United States experienced a total eclipse as the umbra, or moon's shadow passed over them, only six people witnessed the umbra from space. ESA astronaut Paolo Nespoli captured this photo on August 21, 2017.

Photo courtesy of NASA.

cover | On Aug. 21, 2017, skies darkened from Lincoln Beach, Oregon to Charleston, South Carolina, in the first total solar eclipse visible across the United States in 99 years. (iStock)

right | This image records one of the first steps taken on the moon. Neil Armstrong and Buzz Aldrin made their historic walks July 20, 1969.

Photo courtesy of NASA.

**JULY 20, 1969:** Half a billion people around the world gazed into grainy television screens as Purdue University alumnus Neil Armstrong descended the Apollo 11 ladder and bounced onto the surface of the moon, making a giant leap for mankind.

**AUG. 21, 2017:** Millions across North America, South America, Africa and Europe gazed upward as the moon silhouetted the sun for a few brief minutes, casting large portions of the earth into temporary darkness.

More than 200 miles above us, three Americans, two Russians and one European gazed out the windows of the International Space Station, becoming the only six citizens of the world that day to witness the moon's umbra shadowing a large portion of the United States.

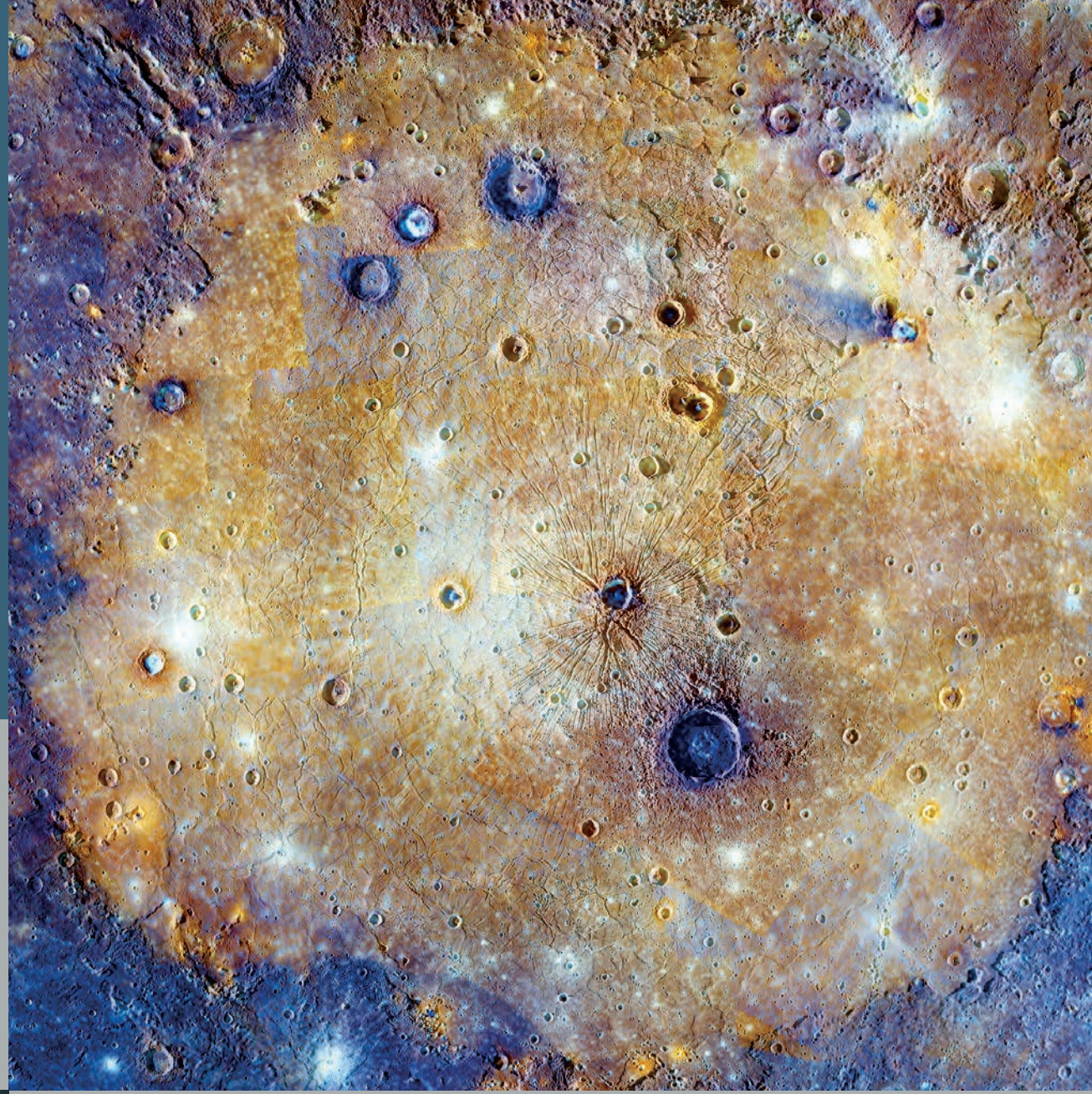
"No words needed," tweeted European Space Agency astronaut Paolo Nespoli, who, along with his fellow travelers aboard Expedition 52, had outfitted his camera with a special filter to capture the eclipse during the ISS's three rotations.

Back on Earth, Buzz Aldrin, the second man to walk on the moon, remarked to a reporter, "It occurred to me that I got to see quite a few solar eclipses — every time we orbited into the shadow of the moon."

Aldrin is, in fact, one of less than 600 people to personally witness Earth from space. And yet humanity's ventures into our solar system have taught us as much about the planet we reside on as they have about what exists beyond our horizon. Thanks to technology developed for interplanetary travel, we can look at the earth today with as much wonder as we gaze into the sky.

"Mystery creates wonder, and wonder is the basis of man's desire to understand," Armstrong said. Gazing up through telescopes, we capture life beyond the earth's atmosphere. Gazing down, satellites record the world at our feet.

"MESSENGER returned a wealth of data that will enable years of analysis. We now have a complete Mercury globe." Jim McAdams



This color mosaic of the Caloris basin on Mercury was made from an image obtained from the MESSENGER spacecraft orbiting Mercury. Date published online: November 15, 2014.

Photo courtesy of NASA/Johns Hopkins University Applied Physics Laboratory/Carnegie Institution of Washington.


PHOTO COURTESY OF JIM MCADAMS

# MERCURY

## ALUM KEY TO MESSENGER SUCCESS

Talk about impressive numbers. NASA's MErcury Surface Space ENvironment, GEochemistry and Ranging (MESSENGER) mission, the first spacecraft to orbit the planet closest to the sun, tallied amazing successes: 8.8 billion miles traveled, 4,105 orbits around Mercury, 10.8 years of operation and 270,000 images sent home.

Among its achievements: characterized Mercury's surface composition, unveiled its geological history, discovered an internal magnetic field offset from Mercury's center and found polar deposits with significant water ice.

On the core team of 20 was Purdue alumnus **Jim McAdams** (BSAAE 1984, MSAAE 1985), then at Johns Hopkins Applied Physics Laboratory. As mission design lead engineer, he created the trajectory and propulsive maneuvers.

McAdams' involvement began in 1996 when the mission was first discussed and continued until after the spacecraft crashed onto Mercury on April 30, 2015. "The talented flight team delivered the spacecraft extremely close to the location and time I predicted months before impact," he says.

His contributions included proposing and designing a shorter-duration extended-mission orbit; designing trajectory targets for launch, close-approach conditions for the six planetary gravity-assist flybys; and planning course corrections. He also alerted leadership of a pending encounter with Encke, which yielded hundreds of images of the comet.

Notable, too, was the mission's technology, including a fixed, steerable antenna; innovative thermal design; and custom software. "The team had to invent, develop and test key capabilities," he says.

Work concluded in May 2017, with final science delivery; its science and technology are highlighted at messenger.jhuapl.edu.

"MESSENGER returned a wealth of data that will enable years of analysis. We now have a complete Mercury globe," says McAdams, now a senior mission design engineer at KinetX Aerospace. "It opened a whole new world of knowledge."

"We are helping the international astronomical community track objects that potentially could cause impact threats here on Earth." Adam Rengstorf

# VENUS

**NIGHT WATCHERS** | Twice every 243 years, eight years apart, the planet Venus travels in front of the sun, appearing as a tiny dot as it moves across the fiery orb.

When it made its last six-hour solar eclipse, called the Transit of Venus, in June 2012, Purdue University Northwest invited students and the community to the top of its Hammond, Ind., campus parking garage for an educational evening.

"We hooked up our portable telescope to a video eyepiece and displayed it on a large screen," says **Adam Rengstorf**, associate professor of physics and astronomy and director of the Northwest Indiana Robotic Observatory.

The next time the transit occurs will be in 2117 and 2125. Purdue astronomers, however, have other educational and research reasons, in the meantime, to keep their eyes on the night sky.

In one ongoing project, Rengstorf's students have so far made 110 new observations of 17 different near-Earth asteroids. Their work has been published by the Harvard-Smithsonian Center for Astrophysics in its weekly and monthly circulars.

That contribution, Rengstorf says, is valuable: "We are helping the international astronomical community track objects that potentially could cause impact threats here on Earth."

For this and other projects, researchers use the Northwest Indiana Robotic (NIRo) telescope, a 20-inch advanced Ritchey-Chrétien reflecting telescope acquired in 2008. Housed at the Calumet Astronomy Center in Lowell, Ind., it can be operated onsite or remotely via the internet.

"This telescope is a great resource, especially for our physics majors," says Rengstorf, who has also developed projects for asteroid spin rates, eclipsing binary timing and exoplanet transits.

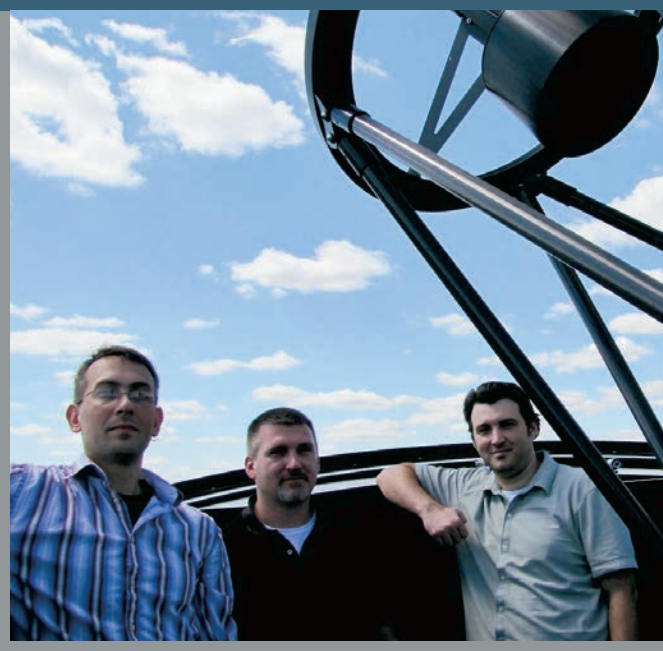
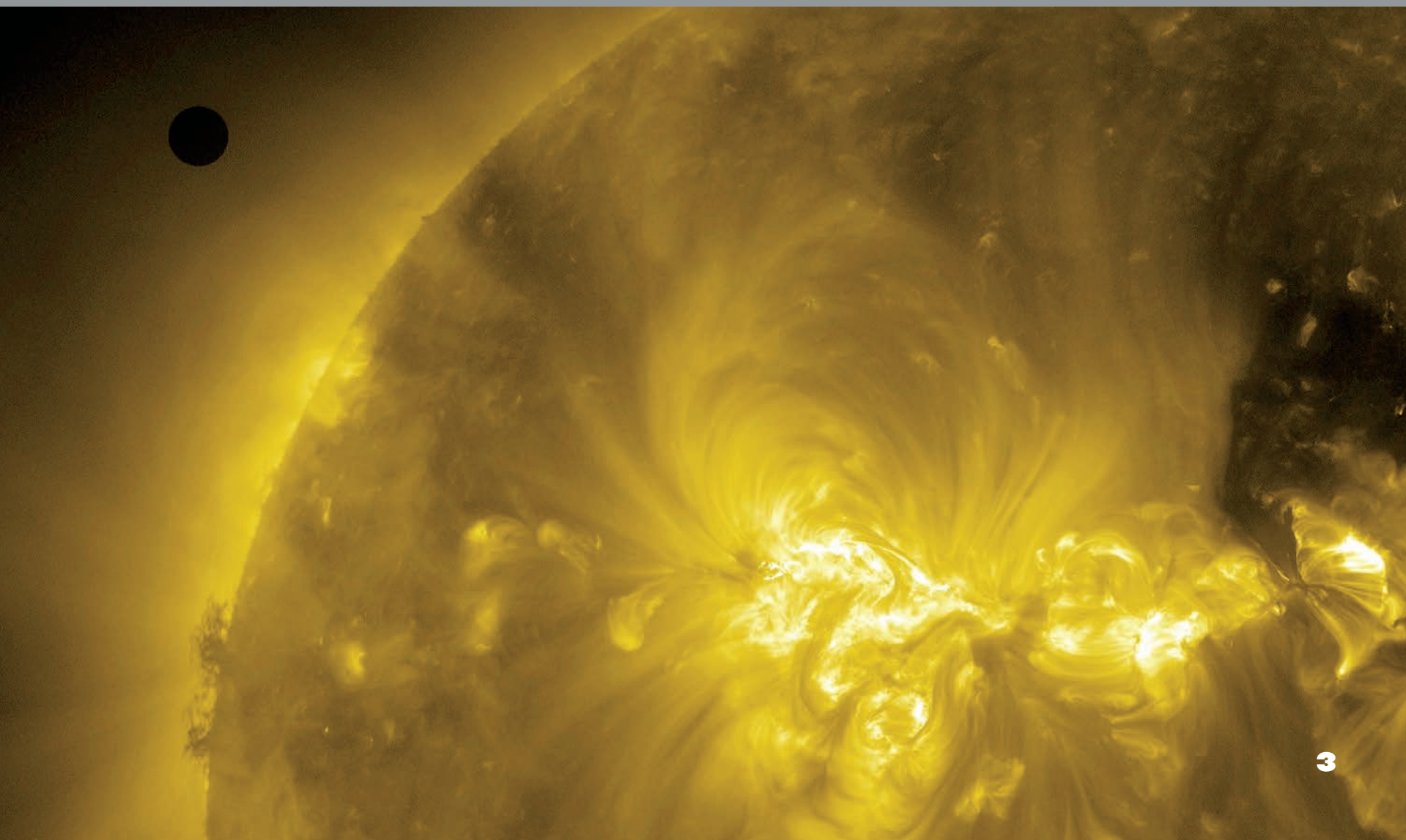


PHOTO COURTESY OF ADAM RENGSTORF

above | The photo, taken circa 2010, shows Adam Rengstorf, former faculty member Shawn Slavin and former graduate student Brent Segally during initial calibration and engineering of a new telescope.

below | The Transit of Venus takes place when Venus travels directly in front of the sun, showing as a small black disc.

Photo courtesy of NASA.



"This is fundamental, not just for solar cells, but nanoelectronics." Libai Huang

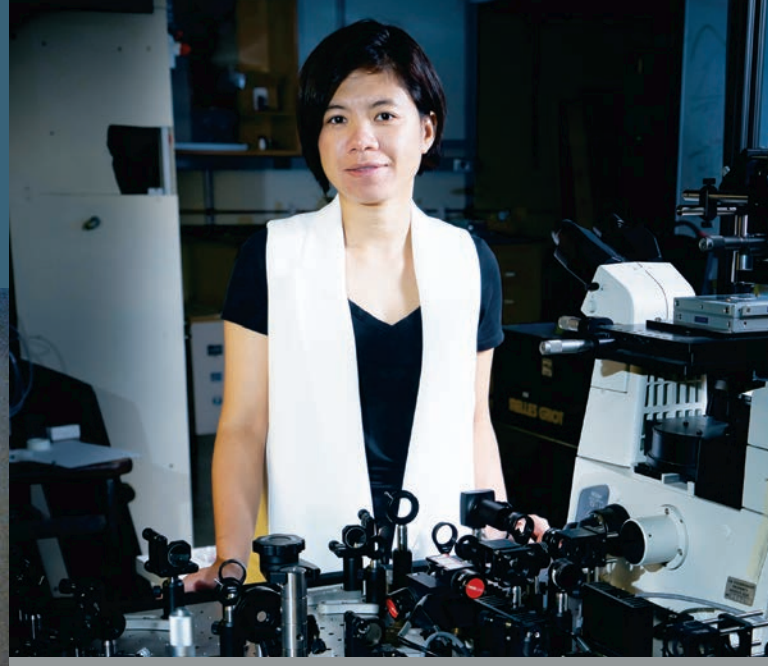


PHOTO BY VINCENT WALTER

# EARTH

**BETTER, FASTER, CHEAPER** | Imagine solar cells molded around our car bodies, the rooflines of our houses and other contoured objects — and producing twice as much electricity without increasing the cost. That scenario may become reality, thanks to the work of Purdue chemist **Libai Huang**.

Huang has identified a new crystalline material that, if used to fabricate solar cells, could make them twice as efficient, thinner, more flexible and less expensive. The new material, known as a hybrid perovskite, could replace silicon as a semiconductor, which is currently used to fabricate cells. Huang, an assistant professor of chemistry, has worked with the National Renewable Energy Laboratory to study how electrons move in the new material.

Enough solar energy reaches the Earth to provide all of our power needs. But silicon cells lose one-third of the incoming energy to heat due to the Shockley-Queisser light-to-power efficiency limit, which governs the amount of energy needed to boost an electron from a bound state to a conducting state that creates electricity.

Huang has developed a new technique to track the range of motion and speed of electrons known as "hot carriers" by using fast lasers and microscopes. She also has shown that perovskite, which contains both inorganic and organic material, offers a new solar cell geometry that can overcome the limit and utilize the energy from light of the hot carriers missed by silicon.

"This is fundamental, not just for solar cells, but nanoelectronics," Huang says. "It can govern how fast computers and electronics run."

View of the sun rising over Earth, photographed from the Earth-orbiting Challenger.

Image courtesy of NASA

# MARS

**MISSIONS TO MARS** | **Briony Horgan** was a junior in college when Spirit and Opportunity burst into the Mars atmosphere three weeks apart from each other in 2004, parachuting down and bouncing across the surface before their air-bag cocoons unfolded to reveal the vehicles inside.

Watching the unmanned vehicles scoot across the butterscotch-colored landscape under the robotic control of NASA engineers 150 million miles away, the physics major thought to herself, "The coolest thing you could do is drive a rover on Mars," and decided to apply to graduate school in planetary science.

Fast forward to 2018, and Horgan is now a scientific member of two Mars rover missions, one launched in 2011 and another slated for 2020. Curiosity, which landed in 2012 and has been slowly making its way up a 3-mile-high mountain inside Gale Crater, is searching for evidence of past habitable environments. The 2020 mission will pick up where Curiosity leaves off, investigating an even more ancient site (3-4 billion years old) for signs of past microbial life.

"Really, the big goal — and not just mine — is to try to understand whether or not life evolved and thrived on ancient Mars," says Horgan, an assistant professor of earth, atmospheric and planetary sciences who uses data from NASA's satellites and rovers, supported by lab and fieldwork at analog sites on Earth, to understand the geologic history of the moon and Mars. "If we really do want to live on Mars — and I think it's humanity's destiny to explore other planets — then it's important to know if life once existed there."

PHOTO BY VINCENT WALTER


This 2017 image from NASA's Mars Reconnaissance Orbiter shows small ripples, about 10 meters apart, located in Her Desher Vallis. Her Desher, the ancient Egyptian name for Mars, translates to "the Red One."

Photo courtesy of NASA/JPL-Caltech/Univ. of Arizona.

"Really, the big goal — and not just mine — is to try to understand whether or not life evolved and thrived on ancient Mars."

Briony Horgan

# JUPITER

**FIFTH PLANET FROM THE SUN** | Covered in bands of gray, gold and white, a 3-D artistic sculpture of Jupiter — solid instead of gaseous — looms large in one of the curved black panels surrounding a 45-foot diameter replica of the sun. On this two-acre site in Purdue's Discovery Park called Visiting Our Solar System (VOSS), Jupiter and its seven planetary siblings are scaled to the model sun's size and placed in an orbital path that mimics the real ones in space.

Seven years in the making, the $1.5 million interactive exhibit was designed by students to put the size of space in perspective and celebrate the contributions of alumna and NASA astronaut Janice Voss.

More than 50 students from the EPICS (Engineering Projects in Community Service) program designed the interactive learning tool, which also serves as a reminder of Purdue's deep roots in space: 24 graduates have been selected for space travel, with countless other alumni working in the space industry.

"The students were challenged to develop a model that would inspire interest in the STEM disciplines as well as space exploration," says **Barrett Caldwell**, an industrial engineering professor and director of the Indiana Space Grant Consortium. "The result is an impressive display."

PHOTO BY JOHN UNDERWOOD

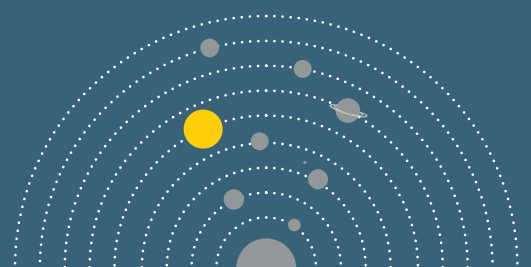
"The students were challenged to develop a model that would promote interest in the STEM disciplines as well as space exploration." Barrett Caldwell

above right | The VOSS Model was created based on a Fibonacci spiral. For every foot you travel around the Fibonacci spiral, you would be traveling approximately 5.4 million miles in space.

Sculpture by Jeff Laramore

right | This 2017 enhanced color view of Jupiter's cloud tops highlights a massive counterclockwise rotating storm that appears as a white oval in the gas giant's southern hemisphere.

Photo courtesy of NASA's Jet Propulsion Laboratory at the California Institute of Technology.



ISTOCK

# SATURN

**ROAD MAP IN SPACE** | When Neil Armstrong took his giant leap for mankind in 1969, young **Kathleen Howell** was one of half a billion viewers worldwide glued to their black-and-white television consoles. But unlike many of her peers, who imagined suiting up and heading into the great beyond as adults, Howell's thoughts were focused on what was happening behind the scenes at Mission Control.

"For me, the question was not so much, 'How can I become an astronaut?' but 'How can I make it happen, and what do I have to study to answer that question?'" recalls Howell, the Hsu Lo Distinguished Professor of Aeronautics and Astronautics.

Those musings took Howell on a career trajectory directly to spacecraft mission design research, in which she and her students analyze the impact of multiple gravitational fields on the motion of a spacecraft and how to leverage those fields for future missions.

Officially, Saturn has at least 61 moons, including the eight provisional moons. To explore them in more depth while optimizing fuel costs, spacecraft will need to exploit the natural dynamics of the gravitational environment instead of simply compensating for their gravitational influence. Working with mathematics and engineering colleagues at Purdue and elsewhere, Howell has developed multiple trajectories that spacecraft could take, depending on the exact nature of their mission.

"Many times when people think of going to Saturn, they think of just one path," Howell says. "I see a whole road map in the solar system that we can leverage." She is applying that same philosophy to designing future missions to the moon, to other planets in the solar system, and even libration points — essentially celestial parking lots where a future space station or habitat could potentially orbit indefinitely.

"For me, the question was not so much, 'How can I become an astronaut?' but 'How can I make it happen, and what do I have to study to answer that question?'" Kathleen Howell

PHOTO BY VINCENT WALTER

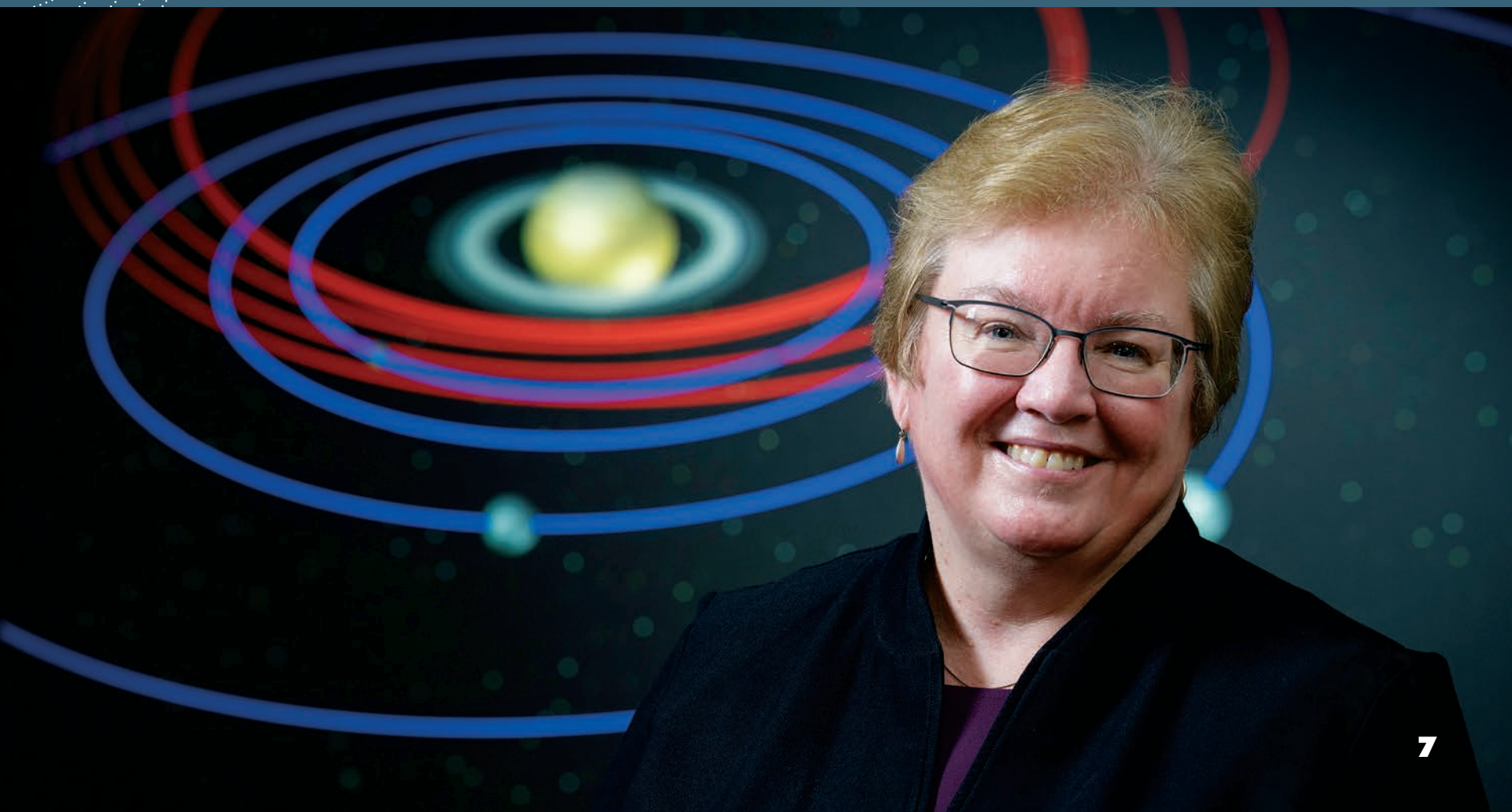
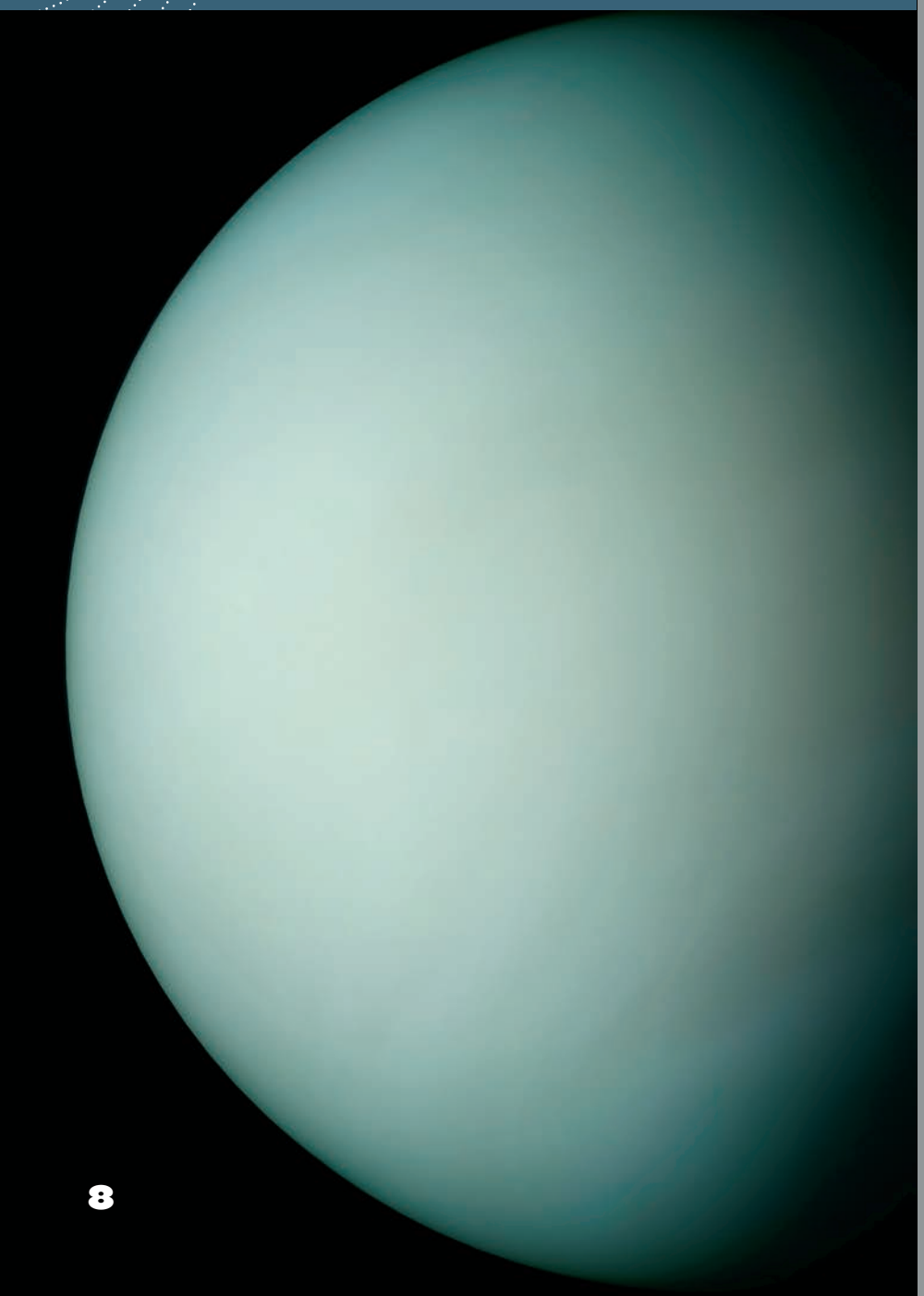


PHOTO BY VINCENT WALTER

"You won't find many other schools with the capability of doing a concept study like this." Justin Mansell



# URANUS

**TWO PLANETS FOR THE PRICE OF ONE** | With a flight time topping 11 years to reach Uranus, **Justin Mansell** says, "It's a bit far for my taste, and for humans, it would be boring and incredibly dangerous."

He and 19 other Purdue aeronautical and astronautical engineering graduate students, however, enthusiastically took on designing an unmanned orbiter and atmospheric probe that could visit the planet known as an ice giant because of its makeup.

Unexplored by spacecraft for more than 30 years, Uranus now holds priority with NASA, prompting **Sarag Saikia**, visiting assistant professor, to create an intense, two-week Maymester 2016 course.

With Mansell as principal investigator, the team worked 10-hour days on computers and white boards in a Neil Armstrong Hall of Engineering team-learning classroom, simulating a real-world research project.

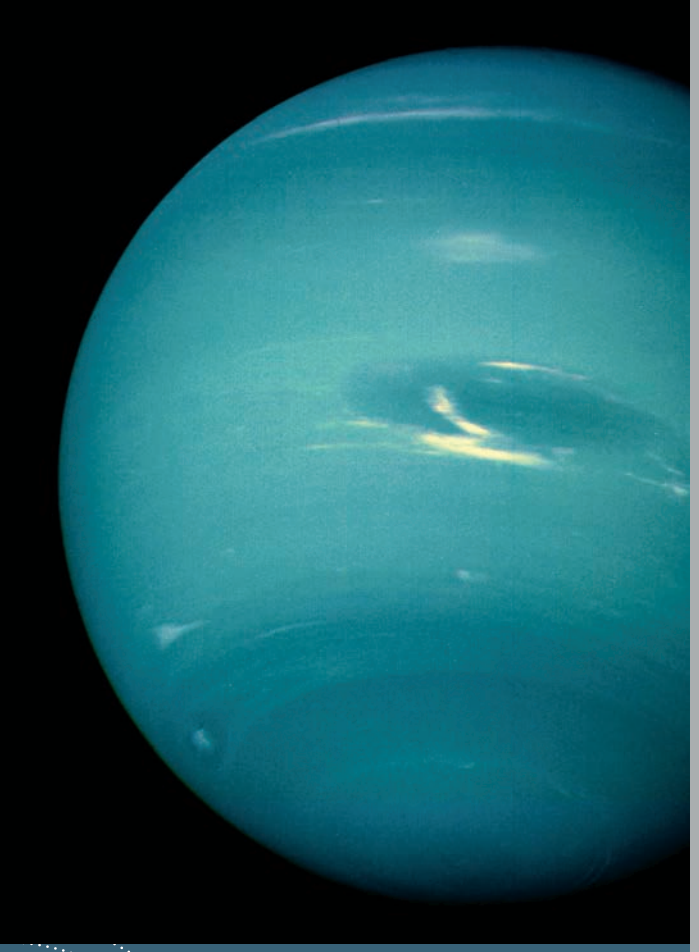
Details for a proposed launch between 2023 and 2037 for the spacecraft they named Oceanus included trajectory, vehicle design, onboard subsystems, atmospheric entry and a swing by Saturn, too, to drop off an entry probe to study its atmosphere — all within a $2 billion budget. That's two planets for the price of one, giving NASA more bang for its buck.

"You won't find many other schools with the capability of doing a concept study like this," Mansell says. "And we received positive feedback and interesting insights on our results."

The team published a 27-page summary of its 160-page report in Advances in Space Research, and also gave three presentations — to NASA and Jet Propulsion Laboratory representatives, at the 13th International Planetary Probe Workshop and at NASA's Outer Planets Assessment Group Meeting.

One of the "ice giants," Uranus has the coldest planetary temperature in the solar system.

Photo courtesy of NASA.



One of the "ice giants," Neptune is dark, cold and windy.

Photo courtesy of NASA.

# NEPTUNE

**TEAM TARGETS NEPTUNE MISSION** | While ground-based telescopic observations offer an inkling of information about the ice-giant planet Neptune, a dedicated mission must occur to unravel its mysteries, says visiting assistant professor **Sarag Saikia**, who co-leads Purdue's Advanced Astrodynamics Concepts research group with **James Longuski**, professor of aeronautics and astronautics.

"Neptune is so far out, technology has been insufficient, and the only exploration was a Voyager 2 flyby in 1989, so our knowledge is extremely limited," Saikia says.

By mass, Neptune is about 65 percent water and "ices"— methane and ammonia, primarily. "If we can better understand this planet, we can know the origin and evolution of the solar system itself," he says, and that could enhance knowledge of similar planetary formations beyond the solar system.

When NASA and the Jet Propulsion Lab chose Purdue as the only university research lab to participate in its Ice Giants Pre-Decadal Survey Mission Study, Saikia and the astrodynamics group quickly consented.

Completed in April 2017, the report eyes a late 2020s or early 2030s orbiter-probe mission and covers needed technology, system reliability, mission implementation techniques, celestial mechanics, costs and other factors.

Saikia served as principal investigator for implementing aerocapture on the proposed mission. "A game-changing technology, aerocapture slows down the spacecraft at the destination using the target's atmosphere, saving propellant mass and travel time," he says.

Besides contributing to the report, Saikia says, "Working closely with people involved in actual missions helped me understand the real-world challenges faced in space flight."

"Working closely with people involved in actual missions helped me understand the real-world challenges faced in space flight." Sarag Saikia

PHOTO BY CHARLES JISCHKE

"We were kind of walking through a minefield by proposing an origin, but that's how science gets done." Jay Melosh

PHOTO BY VINCENT WALTER

## SOLAR SYSTEM

**STONES FROM THE SKY** | For many centuries, scientists dismissed stories of stones falling from the sky as featherbrained peasant tales — until April 26, 1803, when meteorites rained down on the town of L'Aigle in Normandy, France, and were established as fact by a noted French scientist.

For the next 200-plus years, scientists generally believed that asteroids — small, rocky objects that fall from the sky and are called meteorites when they land on earth — are the building blocks of planetary material. Now, a new theory has emerged: that asteroids may actually be the byproduct of planet formation.

The clues lie in the tiny bead-like grains of solidified melted rock called "chondrules" found in meteorites, says **Jay Melosh**, a distinguished professor of earth, atmospheric and planetary sciences and professor of physics and aerospace engineering.

"We've found that an impact model fits extremely well with what we know about this unique material and the early solar system, and this suggests that asteroids are not leftover planet-building material and clumps of chondrules are not prerequisite to a planet," says Melosh, who, along with his colleague **Prof. David Minton** and former graduate student **Brandon Johnson**, published their initial findings in Nature in 2015.

That paper was not without controversy. "We were kind of walking through a minefield by proposing an origin, but that's how science gets done," Melosh says. Now, with further research at Purdue and beyond that has borne out their initial findings, he says, "That opinion is beginning to turn."

above | More than 100 asteroids were captured in this view from NASA's Wide-field Infrared Survey Explorer, or WISE, during its primary all-sky survey. In August 2017 the mission was revived to hunt more asteroids and renamed NEOWISE.

Image courtesy of NASA/JPL-Caltech/UCLA.


# JANICE VOSS

**CATCHING FIRE** | "A book, too, can be a star, 'explosive material, capable of stirring up fresh life endlessly,' a living fire to lighten the darkness, leading out into the expanding universe."

— Madeleine L'Engle, "A Wrinkle in Time"

Purdue alumna **Janice Voss** grew up in Rockford, Ill., where she and her sisters took airplane rides with their pilot father, sailed boats and counted in binary around the dinner table. But it was reading that changed the course of her life.

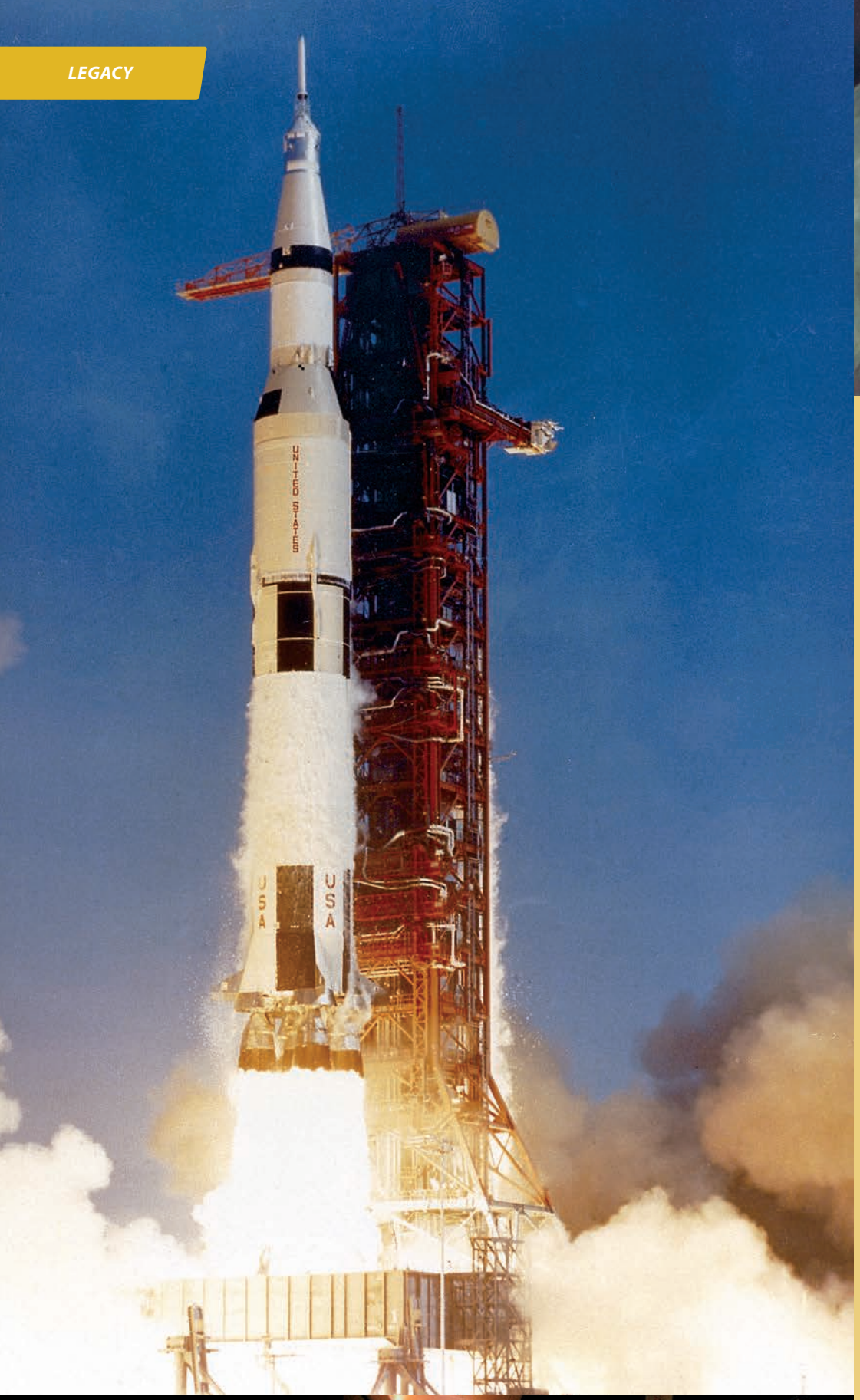
While on a summer trip to her grandparents' farm, nine-year-old Voss picked up a copy of "A Wrinkle in Time," Madeleine L'Engle's novel about a math and science whiz named Meg who travels through space and time to save her father. The book inspired Voss to become an astronaut and also sparked a lifelong love of science fiction, the pinnacle of which may have occurred when Voss read passages from the book while orbiting in the space shuttle Columbia in 1997.

Voss was one of few women ever launched into space. Over five flights, she spent 49 days there, traveling 18.8 million miles in 779 Earth orbits while conducting such experiments as how fire behaves in weightlessness and how plants adapt to extraterrestrial flight.

After hanging up her spacesuit in 2000, Voss continued to champion the space program in other roles with NASA until her death in 2012. In her memory, Purdue students designed the VOSS (Visiting Our Solar System) exhibit, a $1.5 million interactive display in Discovery Park where youngsters can dream up their own adventures. Read more about the exhibit on p. 6.

Purdue's interactive exhibit, Visiting Our Solar System (VOSS), was named after Janice Voss. Students created the exhibit and oversaw construction of the models, which were designed by Jeff Laramore.

PHOTO BY VINCENT WALTER





left | The Saturn V launch vehicle (SA-506) for the Apollo 11 mission lifts off on July 16, 1969, from the Kennedy Space Center. The flight placed the first humans on the surface of the moon on July 20, 1969.

Photo courtesy of NASA.

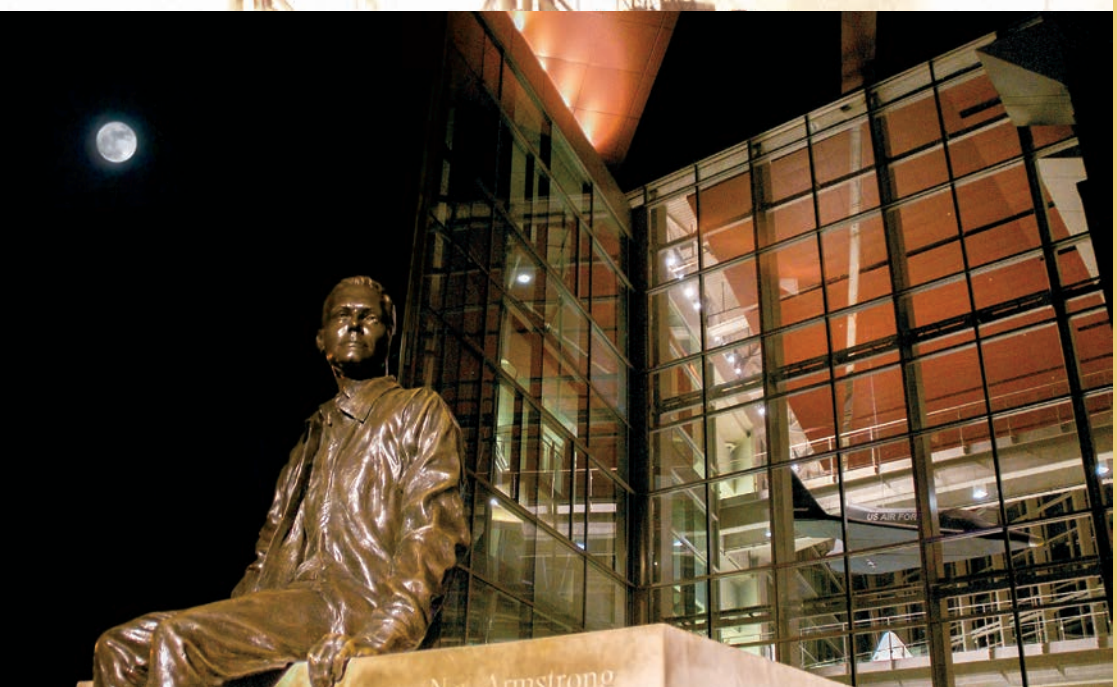


PHOTO BY TREVOR MAHLMANN

# NEIL ARMSTRONG

**FIRST MAN ON THE MOON | Neil Armstrong** may have only spent a few years as a Purdue student, but his career path is intertwined with the university. Starting as a Boilermaker in 1947 on a Navy scholarship, Armstrong left in 1949 to serve in the Korean War as a Navy pilot. Returning to Purdue in 1952, he graduated in 1955 with a bachelor of science in aeronautical engineering.

In 1962, Armstrong became an astronaut and served as the command pilot for NASA's Gemini 8 mission, integral to the success of future NASA missions. On Gemini 8, he carried a ceremonial flag that Purdue President Frederick Hovde had gifted him.

On July 20, 1969 — the year of Purdue's centennial — Armstrong became the first man to walk on the moon; the next year, he received an honorary doctorate in engineering from Purdue. In 1971, following the Apollo 11 mission, Armstrong retired from NASA, moving home to Ohio to work as a professor.

Armstrong regularly visited Purdue the rest of his life, spearheading fundraising campaigns and attending football games. Students he interacted with commented on his genuine interest in their academic pursuits.

In 2007, Purdue officials dedicated the Armstrong Hall of Engineering in a ceremony attended by Armstrong and 14 other Purdue astronauts. The iconic 200,000-square foot building embodies the university's globally renowned engineering program, which to date has fostered the careers of nearly two dozen Purdue astronauts.

Before his death in 2012, Armstrong donated his personal papers to Purdue Libraries' Archives and Special Collections; they chronicle his career in flight and are available for scholarly research. His spirit lives on in other ways at the university as well; outside Armstrong Hall, students and visitors are often seen posing for photographs next to his statue.

## EUGENE CERNAN

**LAST MAN ON THE MOON** | Just three years after Neil Armstrong made a giant leap for mankind, Purdue alumnus **Eugene Cernan** became the last person to walk on the moon.

Cernan, who had graduated from Purdue in 1956 with a bachelor's degree in electrical engineering, commanded the Apollo 17, which blasted off from Kennedy Space Center on Dec. 7, 1972. The lunar module touched down on the moon four days later. Over the course of the mission, he performed three moonwalks, exploring the barren landscape in a lunar rover, collecting about 250 pounds of soil samples and moon rocks, and taking scientific measurements.

On their last vehicular trek, Cernan — who returned to the spacecraft just behind his travel companion Harrison Schmitt — paused at the ladder to say goodbye. "We leave as we came and, God willing, as we shall return, with peace and hope for all mankind," he said.

Years later, Cernan was quoted in the 2003 book, "Wings of Their Dreams: Purdue in Flight," written by journalist and Purdue flight historian John Norberg, "Once you walk on the moon you can never 'unwalk.' You're one of the 12 human beings who have lived and called another planet in this universe home — and I refer to the moon as a planet because that's what it felt like for me after three days."

Cernan was named a distinguished engineering alumnus by Purdue in 1967. Eight years before his death in 2017, he donated his personal papers to Purdue's flight archives.

above | Eugene Cernan jump salutes the U.S. flag on the moon.

Photo courtesy of NASA.

# ANTARCTICA

**DECODING ICE CORES** | In a cavernous 31,000-square-foot basement laboratory, **Marc Caffee**, director of the Purdue Rare Isotope Measurement Laboratory (PRIME Lab) and **Thomas Woodruff**, a postdoctoral researcher, are using a technique known as accelerator mass spectrometry to reconstruct the timing of climate and atmospheric conditions over the last 2,500 years. Their detective work is part of an international effort linking periods of global cooling to societal events, such as documented crop failures and famine, dating as far back as the Ancient Roman period.

The clues needed to sleuth out the linkages between climate and human welfare are found in polar ice cores, volcanic ash and tree rings. The atmospheric concentration of beryllium-10, linked to solar activity, is recorded in ice cores from Antarctica and Greenland.

The two researchers are using the particle accelerator at Purdue to measure the ultra-trace amounts of the isotope in the ice cores and identifying layers of unique volcanic ash signatures in the process. The layers of volcanic ash each possess distinctive, regional composition signatures, allowing the researchers to determine where an eruption took place.

The investigators then compare their findings with carbon-14 levels in trees from the locations of the ash signatures. This comparison lets the researchers develop a timeline by which linkages can be investigated between volcanic explosions, global cooling and societal impacts.

The story is complex, but a key clue was the measurement of the rare radionuclide, beryllium-10 dating. “These ice cores are enabling us to really get the dating right,” says Caffee, who is also a professor of physics and astronomy. “The core samples act as a sort of climate Rosetta Stone, and we’re gaining more confidence in the process.” Further studies of these unique ice cores at PRIME Lab will undoubtedly shed more light on significant processes impacting Earth’s climate.

On June 17, 2017, the Thermal Infrared Sensor on Landsat 8 captured a false-color image of a crack across the Larsen C ice shelf on the Antarctic Peninsula marking the beginning of the calving of the iceberg from the ice shelf.

Photo NASA’s Goddard Space Flight Center.

Thomas Woodruff | Marc Caffee

PHOTO BY VINCENT WALTER

“The core samples act as a sort of climate Rosetta Stone, and we’re gaining more confidence in the process.” Marc Caffee

## ASIA | INDIA

**BUILDING BRIDGES ACROSS GENDER, RACE, CASTE AND CLASS** | If only women's needs could be quickly identified through surveys. If only taboos about sexual health, sexual identity and HIV weren't so silencing. If only helping organizations could easily deliver programs to meet women's needs.

That would simplify the research of **Mangala Subramaniam**, whose projects, many in India, examine inequality, social movements and how those who are disadvantaged organize to claim basic needs and rights, from accessing water to ending violence against women and reducing HIV risks.

Instead, her research in India uses quantitative and qualitative data. "It involves accessing marginalized populations — poor women, lower-caste women, transgender people and women in sex work," says Subramaniam, a professor of sociology and the Butler Chair and Director of the Susan Bulkeley Butler Center for Leadership Excellence. She makes contacts, develops trust, builds relationships, listens and offers empathy. And she writes about the challenges in the data collection process.

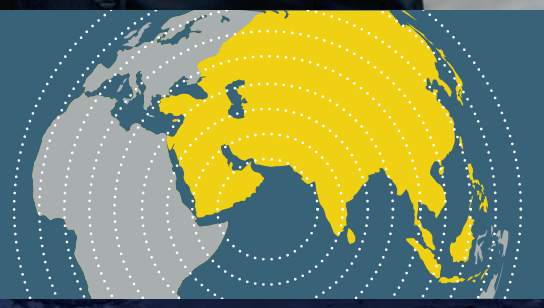
"I need a sense of the place, the people, their lives," she says. One connection can lead to another, such as the time a sex worker invited her to a meeting. There, she sat in mismatched folding chairs with a dozen other women in saris and heard how they address intimate-partner violence and their increased HIV risk.

"What they share is insightful, making learning what they know critical," Subramaniam says. "Policymakers think about this program, this intervention, this workshop, and then evaluate them. My argument is, should we not learn and understand what these women know, then make policy building on that?"

Sociologists often report that change is slow. "I argue it is institutions, the structures embedded in society, that need to change," she says. "Women are learning ways to address power and coercion, and to alter gender relations in their family, home and community."

PHOTO BY VINCENT WALTER

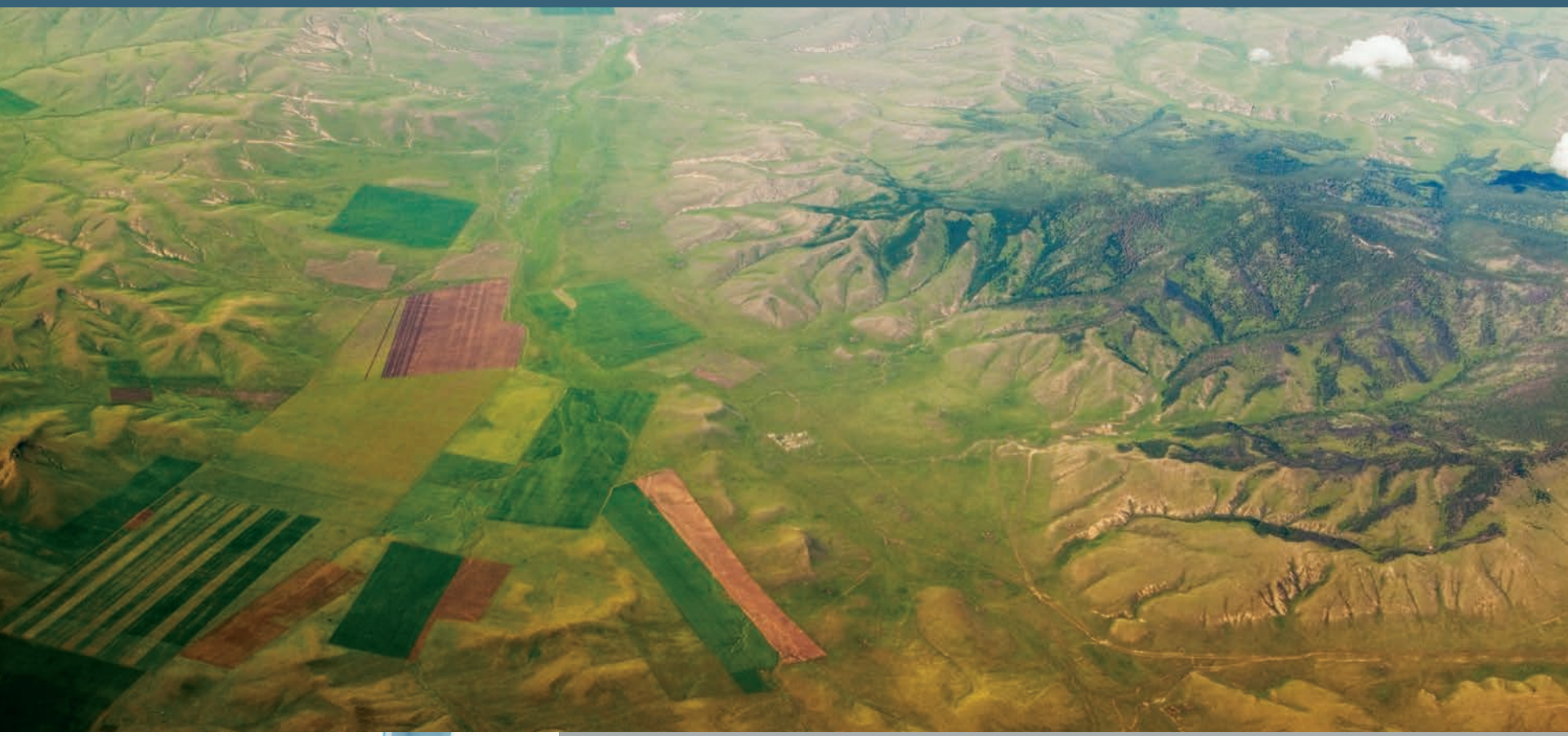
"Should we not learn and understand what these women know, then make policy building on that?" Mangala Subramaniam



Satellite images of Earth at night — often referred to as "night lights" — show how humans have shaped the planet and lit up the darkness. This one taken in 2016 illustrates the population distribution in India.

Photo courtesy of NASA Earth Observatory. Images by Joshua Stevens, using Suomi NPP VIIRS data from Miguel Román, NASA's Goddard Space Flight Center.

"Understanding soil moisture has major implications for agriculture and fresh water supplies." Qianlai Zhuang



Mongolia, landscape with hills and fields. (iStock)

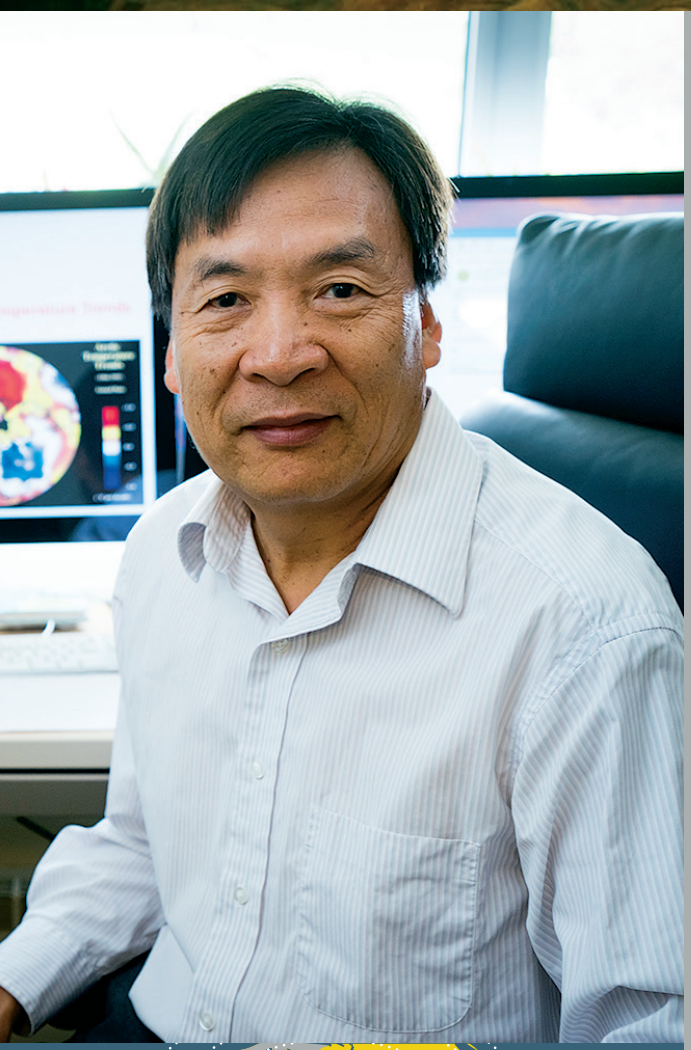


PHOTO BY VINCENT WALTER



## ASIA | CHINA

**SOLVING SOIL MOISTURE NEEDS IN CHINA** | More than a magnifying glass was needed to solve the mystery of dry soil in Inner Mongolia, China.

It took 40 monitoring stations operated by the China Meteorological Administration, where scientific sleuths from Purdue and China Agricultural University gathered and analyzed data from agriculture plots. They tallied fertilizer use and crop moisture requirements, looked at surface water content and terrestrial water storage, made meteorological observations and measured river discharge.

With 26 years' worth of data, the team found the causes were not only hot temperatures and declining precipitation, but also increased planting area, high use of fertilizers and rapid proliferation of crops with high water demands.

"The soil moisture declined by 1.5 percent to 2.5 percent every decade of the study," says leader **Qianlai Zhuang**, Purdue's William F. and Patty J. Miller Professor of Earth, Atmospheric and Planetary Sciences and professor of agronomy. "Understanding soil moisture has major implications for agriculture and fresh water supplies."

Even though droughts have been more intense and long-lasting in Northern China, "The driving forces for dry soil were inadequately understood, especially for those resulting from human activities," says team member **Yaling Liu**, a former Purdue graduate student now at Pacific Northwest National Laboratory.

Mystery solved and counter measures identified, the team published "Agriculture Intensifies Soil Moisture Decline in Northern China" in the July 2015 Scientific Reports journal.

Since then, "Mulching and no tillage have been implemented in this area," Liu says. Next, the project will examine how efficient water use in crop production affects soil moisture.

# ASIA | LEBANON

## A WORLDWIDE ENVIRONMENTAL EPIGENETICS SCREENING PIPELINE

Natural remedies like plants, mushrooms and herbs have been handed down across generations all over the world. They have been known to treat many types of diseases. Unfortunately, these antidotes stay local, and are not often shared outside the community. Also, many countries do not have the possibility to analyze these natural compounds for their influence on known disease pathways, which prevents uncovering new potential treatments. An interdisciplinary global team of researchers is helping to create a global repository network of these local remedies in the hopes of learning more about their health benefits, especially in the prevention of cancer.

**Dr. Sophie Lelièvre**, a professor of cancer pharmacology in the College of Veterinary Medicine; co-leader, drug delivery and molecular sensing program in the NCI-designated Purdue University Center for Cancer Research; and scientific director of the 3-D Cell Culture Core (3D3C) facility in the Birck Nanotechnology Center, is leading the charge in a new screening pipeline that focuses on epigenetics (the analysis of chemical changes on and around genes that are involved in gene expression control) to identify environmental factors with epigenetic impact. "Many life-impacting chronic diseases such as neurodegenerative disorders and cancers are influenced by epigenetic changes," she says.

Some environmental factors, like toxins in the air or water, turn on disease-causing genes. Others, like certain plants and fungi, might have protective effects. Lelièvre's biobank focuses on the latter, documenting the positive health impacts that local specimens have had on regions all over the world. Because many of these beneficial effects are not scientifically understood, scientists cannot test the bioactive ingredients that cause the beneficial effects directly on humans. Therefore, suspected bioactive ingredients must first be identified and tested in an "organ-on-a-chip," a 3-D cell culture method that harnesses advanced engineering to mimic the organization and activities of different organs in the laboratory.

"The work has to be done with the proper model system to accurately identify bioactives that have an epigenetic impact and determine how they are working," says Lelièvre, who is developing the 3-D cell culture models in her laboratory and in the 3D3C.

Already, her team of researchers has organized specimens from locations including Taiwan, France and Lebanon that are part of the International Breast Cancer and Nutrition (IBCN) collaboration. "The beauty of the organ-on a-chip model system is that it can ultimately be used with cells obtained from human populations of different origins, enabling an understanding of how natural compounds of medicinal plants and other natural species might work better in some populations than in others," she says.

"Many life-impacting chronic diseases such as neurodegenerative disorders and cancers are influenced by epigenetic changes."

Sophie Lelièvre

PHOTO BY VINCENT WALTER

Heavy snow in Lebanon and Syria, 2012.

NASA image courtesy of LANCE/EOSDIS MODIS Rapid Response Team at NASA GSFC.

"During our workshops we explain the impacts of illegal poaching on wildlife, how it causes problems in our ecosystem, and why research, protection and conservation are needed." Shaya Honarvar

right | Aerial view of island in Equatorial Guinea in Central Africa. The area beaches are important nesting sites for marine turtles in the Gulf of Guinea region. (iStock)

PHOTO COURTESY OF SHAYA HONARVAR

bottom | Two green turtle hatchlings on Bioko Island's southern beaches.

Photo courtesy of Glauco-Puig Santana.



# AFRICA | EQUATORIAL GUINEA

**SEA TURTLE PROGRAM MULTIFACETED** | For two decades, conservation biologist **Shaya Honarvar** has been studying sea turtles, their habitats, nesting sites and numbers — data needed to assure their survival.

A research associate for the Department of Biology at Indiana University-Purdue University Fort Wayne, she detailed her most recent work in the article, "Assessment of Important Marine Turtle Nesting Populations on the Southern Coast of Bioko Island, Equatorial Guinea," published in 2016 in Chelonian Conservation and Biology.

What she's learned about declining turtle populations is fueling a program to develop local relationships, educate island residents and identify new income sources to reduce poaching. She's even dabbled in marketing, helping local women find a source for the recycled-paper jewelry her program taught them to make.

"You can have all the ideas you want about conservation work in another country, but if you don't provide alternative income, it might not work," she says. "So, we created this artisanal program."

With data on four species at five nesting beaches analyzed, she has gained key knowledge and reports that human aspects of turtle survival are progressing.

Related successes include a printable sea turtle booklet given to 2,000 children in the last three years; community, elementary and university presentations; and five-month field camps for local and IPFW graduate students.

"During our workshops we explain the impacts of illegal poaching on wildlife, how it causes problems in our ecosystem, and why research, protection and conservation are needed," Honarvar says. "We also hire people from the local community to assist with our research and conservation projects."

On the horizon, pending funding, is a satellite telemetry project to identify where turtles go when they leave the beach and how they live.

# AFRICA | NIGERIA

**SIGHT-SAVING MAIZE FOR AFRICA A TASTE TREAT IN U.S.** | With white-kernel maize long their food staple, residents of sub-Saharan Africa didn't immediately chow down on the bright orange corn developed in part by **Torbert Rocheford**, agronomy professor and the Patterson Endowed Chair for Translational Genomics in Crop Improvement.

Even though the deeper-hued corn could boost their bodies' production of Vitamin A, in turn possibly staving off blindness and death, they had their doubts. "Do you eat it in the U.S.?" they asked.

Fair question, says Rocheford, who used natural breeding techniques — rather than genetic modification — to help develop the more nutritious varieties. To dispel their fears, he provided it to a restaurant near Purdue University, and was able to report that diners devoured the chef's creations.

With education and encouragement from various organizations, the biofortified orange maize is now gaining acceptance and grown in Zambia, Nigeria, Zimbabwe and Ghana.

"Adoption in Africa is coming along," Rocheford says. "There is steady progress."

The stateside taste success prompted him to launch NutraMaize LLC, with his son, Evan Rocheford, as chief executive officer, to grow and market it in the United States.

"It has a nutty, buttery flavor. It's creamy and rich tasting, along with being more nutritious," says the younger Rocheford, who honed his entrepreneurial skills through Purdue's startup program, the Foundry.

In 2017, NutraMaize received a $225,000 Small Business Technology Transfer Research Grant from the National Science Foundation to collaborate with Rocheford's research lab at Purdue to prepare high carotenoid orange corn for large-scale commercial applications in the U.S. "It won't be too long before you'll be seeing processed foods, like snacks and cereals, made from our delicious and nutritious orange corn," the CEO says.

top | Satellite map of Enugu, Nigeria, from NASA's Globe Software World Wind.

Photo courtesy of NASA.

bottom | Torbert Rocheford and son Evan Rocheford

PHOTO BY VINCENT WALTER

An aerial view of excavations of the West Settlement at the base of the Tsaghkahovit Fortress in Armenia.

Photo provided by Project ArAGATS

PHOTO BY VINCENT WALTER

## EUROPE | ARMENIA

**BIRD'S EYE VIEW** | The sky is probably not the first place you might think of to begin an archaeological excavation, but for **Ian Lindsay**, it is the logical place to start. Lindsay, an associate professor of anthropology and co-director of Project ArAGATS (Archaeology and Geography of Ancient Transcaucasian Societies), a collaborative American-Armenian research initiative, is using drone technology in order to capture data from Bronze Age sites in Armenia.

Lindsay has found drones to be a good alternative to kites, balloons and cranes, as they offer a more detailed aerial perspective and an immediate sense of the spatial scale of the region's sites. The aerial view provided by the drones has allowed him to collect both still images and video over much of his study area in the Kasakh River Valley of northern Armenia, while the spatial technology has allowed for more detailed 2-D and 3-D observations of ancient fortifications — sites that date back to 1500 B.C. Last summer, Lindsay outfitted one of his drones with a multispectral sensor to detect subsurface architecture with thermal imaging, pushing new boundaries of the use of drones in archaeology.

Lindsay's archaeological fieldwork has been funded by the Executive Vice President for Research and Partnerships Office and the College of Liberal Arts, which culminated in a $220,000 grant from the National Science Foundation in 2016 to study how ancient communities in the South Caucasus thrived 3,000 years ago. Specifically, Lindsay's team is surveying and excavating cemeteries and fortresses to understand how warfare shaped the region's earliest complex societies politically, socially and ritually, as well as the lifestyles of people who lived around the forts.

In addition to his use of drones, Lindsay also uses a tablet-based mobile geographic information system (GIS), a collaborative tool that allows his survey team to add, edit and update data about field sites, helping them to be more efficient in the field.

# EUROPE | ITALY

**LEARNING FROM ITALY'S POPULIST MOVEMENTS** | Studying the rise, effects and tenure of recent populist political movements internationally offers insights about similar groups now emerging.

That focus guides the research and writing of **Dwayne Woods**, professor of political science. In 2015, he published "Riding the Populist Web: Contextualizing the Five Star Movement in Italy," in Politics and Governance. The article explores the populist dimensions of that movement.

It emerged in the early 1990s as an anti-establishment, anti-globalist, Eurosceptic and pro-environmentalist movement. Its populist strategy and rhetoric helped transform it into a major player in the Italian political system in less than five years.

"Populist movements are good at galvanizing people around single issues and aggregating diffused anger or disillusionment," Woods says. "They politicize latent social cleavages," which identify voters as advocates or adversaries on certain issues.

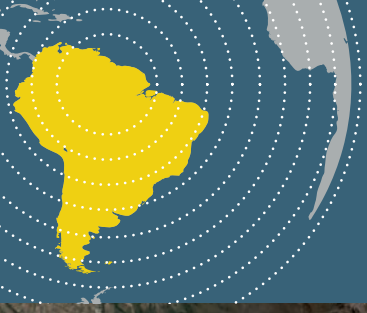
"These movements focus on the feeling that a few benefit more than most, and that fuels a sense of resentment," he's found. "The innate tendency of people to think they are or may be victims contributes to the ability of populist movements to claim that the majority has been ignored and are not truly represented by the minority."

Short-term, the movements disrupt the status quo. "The long-term impact varies," he says. "In some cases, it can lead to a realignment of a party system and voters' behavior, but in other cases, it proves ephemeral."

"Populist movements are good at galvanizing people around single issues and aggregating diffused anger or disillusionment." Dwayne Woods

The diverse and picturesque contours of southern Italy, known for its boot-like shape, take center stage in this Envisat image, acquired on January 25, 2011.

Photo courtesy of the European Space Agency.



The Cotopaxi volcano in Ecuador started erupting the week of Aug. 17, 2015. Volcanic debris had darkened the west flank of the volcano, while airborne volcanic ash and gas continued to move toward the west. This image was acquired on September 15, 2015, by the Operational Land Imager (OLI) on Landsat 8.

Landsat imagery courtesy of NASA Goddard Space Flight Center and U.S. Geological Survey

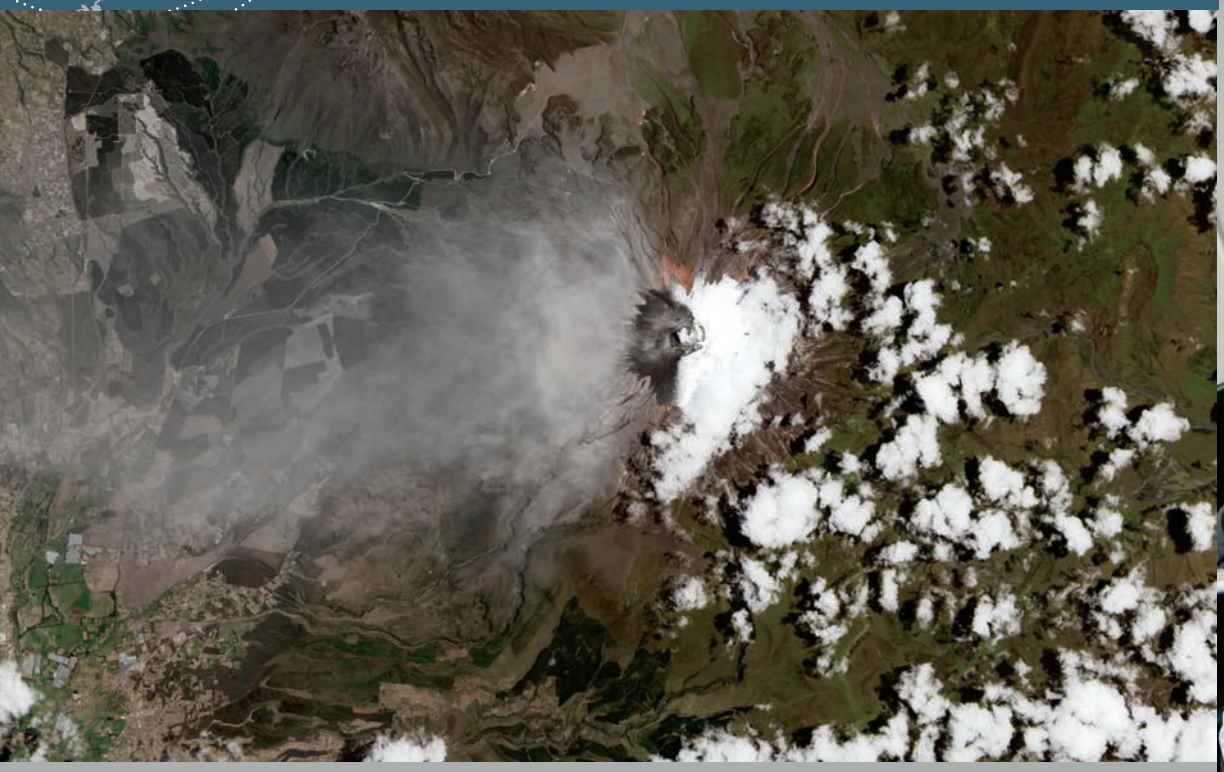


PHOTO BY VINCENT WALTER

## SOUTH AMERICA | ECUADOR

**DEEP LEARNING FOR DISASTER ASSESSMENTS** | Destruction and tragedy hit Ecuador in April 2016, when an earthquake of 7.8 on the moment magnitude scale hit the country, killing some 700 and injuring nearly 17,000. That followed an 8.8 magnitude earthquake in Chile that took more than 500 lives and triggered a tsunami. Besides rescue workers, civil engineers rushed in to both disaster areas to identify building damage and learn how to improve construction techniques.

Currently, reconnaissance teams capture damage in photographs — as many as 10,000 a day — then spend hours describing the images and planning the next day's data collection.

"That takes a tremendous amount of time," says **Shirley Dyke**, professor of mechanical engineering and civil engineering.

Could computers help, asked her postdoctoral researcher **Chul Min Yeum**, who now leads their National Science Foundation-funded work. He is creating deep-learning algorithms, inspired by the structure and function of the human brain, and developing computer vision technology to take on the task. And it's likely results will be even "more complete than human evaluations," Dyke says. "We're developing that expertise."

The work includes more than 100,000 images from about 15 earthquakes, hurricanes, floods and tornados. "What's most exciting is that we will use the actual data collected holistically, and we won't have to restrict our examination to five or 10 examples," Dyke says. "That's what makes it powerful."

Their next step: "We will take what we have learned to the field, see how it works, retrain and modify."

Besides the image analysis project, Dyke's research includes hybrid simulation — "a mix of modeling and testing" — done in her Intelligent Infrastructure Systems Lab in Bowen Laboratory. The learning and research lab includes a cyber-physical instrument for real-time structural testing, a cement wall reaction frame, hydraulic actuator, bridge model and three- and six-story building simulators.

What her team learns, she hopes, will identify better construction methods, curb building destruction and save lives.

"We will take what we have learned to the field, see how it works, retrain and modify." Shirley Dyke

# AUSTRALIA

**SLEEP TIGHT** | Until recently, Australia ranked as the area experiencing the largest outbreak of bedbugs — the wingless, reddish-brown insects reminiscent of a flat apple seed. Now, the United States and Europe share the top spot with the Land Down Under, and infestations all around the world are sucking the blood of humans.

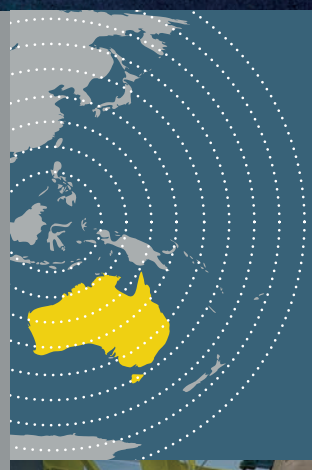
Thanks to the work of **Ameya Gondhalekar** and **Michael Scharf**, who served on an 81-collaborator international team, bedbug numbers, which had increased because of international travel, furniture reuse and insecticide resistance, could soon decline.

The team sequenced the genome of Cimex lectularius and published their findings in Nature Communications in February 2016. Purdue's role was to annotate the bugs' antioxidant genes, which detoxify the blood they ingest and likely play a role in disarming certain pesticides. That work may offer targets for genetic control measures.

"We are right at the cutting edge of what human science is able to do, applying the genome sequence to a real-world solution," says Scharf, the O. Wayne Rollings/Orkin Chair in Molecular Physiology and Entomology.

"My students are among many who are using the genome database to develop projects," says Gondhalekar, assistant professor of entomology and product research manager in the Center for Urban and Industrial Pest Management.

That multi-roomed center, filled with walk-in environmental chambers, white plastic tubs and glass jars, does have an extensive bedbug population, but it's controlled. Their roommates include cockroaches, ants and other insects, all under study.



"We are right at the cutting edge of what human science is able to do." Michael Scharf

above | This stunning image of the northwest corner of Australia was snapped by a student on Earth in 2015 after remotely controlling the Sally Ride EarthKAM aboard the International Space Station.

Photo courtesy of NASA/EarthKAM.org.

below | Michael Scharf | Ameya Gondhalekar

PHOTO BY VINCENT WALTER

# NORTH AMERICA | JAMAICA

**HARASSMENT IN PARADISE** | Palm trees, blue water and a cool breeze from the ocean? Yes. Being nagged by street vendors, crafters and cab drivers? No. Tourists want to take in the local culture on vacation without feeling harassed by retailers, and yet in some areas across the world merchants may feel compelled to act aggressively simply to make ends meet.

That's the conclusion of Jamaican-born **Annmarie Nicely**, an associate professor of hospitality and tourism management, who has studied visitor harassment in her home country and around the world. "One of the things I do when I travel anywhere, whether it's for a vacation to relax, or not, is to make observations," says Nicely.

Using her expertise in learning and performance, with an emphasis on the hotel industry, Nicely is investigating ways to help merchants in Jamaica and other countries learn more positive ways of selling.

What a vendor may perceive as good marketing a tourist might perceive as badgering, and so Nicely and other researchers in the School of Hospitality and Tourism Management have studied visitors to identify specific behaviors that they consider to be harassment. They have also discovered correlations between negative vending behaviors and both local socioeconomic and climatic conditions.

One conclusion Nicely has drawn: instead of simply enforcing zero-tolerance policies on aggressive behavior, government officials should place greater emphasis on desired nonaggressive selling behaviors in order to reinforce positive tourist-merchant interactions.

PHOTO BY VINCENT WALTER

This MODIS true-color image from 2001 shows Cuba (center) and Jamaica (lower right). The bright blue green color around the islands is likely due to the brighter solar reflection over the more shallow waters that surround the islands.

Photo courtesy of NASA.

PHOTO BY FRANK OLIVER

# NORTH AMERICA | UNITED STATES

**GOOD DOG** | Cute, cuddly and playful may be the initial qualities that attract someone to a particular puppy, but they don't necessarily show if the dog has been well-bred and cared for. Now, a certification program spearheaded by **Dr. Candace Croney**, a professor of animal behavior and well-being in the Department of Comparative Pathobiology and Animal Sciences, adds a new measure of assurance to prospective pet owners.

Canine Care Certified, a national, voluntary program that sets rigorous standards for professional breeders, was developed after three years of research at Purdue and peer reviews by experts from other major academic institutions.

"USDA licensed commercial breeders, unlike true puppy mills, have to follow certain key regulations — and there are a lot of regulations," says Croney, director of Purdue's Center for Animal Welfare Science. But some breeders — like the members of Indiana's Amish community who approached Croney a few years ago — want further guidance on caring for their animals.

The certification program, whose standards were refined after pilot-testing, addresses physical health (only veterinarians may perform necessary surgeries, for example), environment (such as enriched, high-quality spaces with outdoor access), behavioral health (including psychological enrichment and socialization), breeding life (such as mandatory spaying and neutering at retirement) and caretaker expectations (including continuing education and third-party audits).

A debate continues in the United States on whether all dogs should come from animal rescues, but statistics show that the demand for pure-bred dogs is large and growing. "If people are going to be buying dogs, we ought to figure out a way to protect those dogs as much as possible, while also not sending the message that there's something wrong with getting shelter dogs," Croney says.

Back home again in Indiana. An aerial view of farmland.

"This adds a new measure of assurance to prospective pet owners." Dr. Candace Croney

PHOTO BY VINCENT WALTER

# AMELIA EARHART

**UNSOLVED MYSTERY** | A plane disappearance attracts attention — especially when it involves one of the most famous women in America, pilot Amelia Earhart, and becomes one of the greatest unsolved mysteries of the 20th century.

Born in Atchison, Kansas, in 1897, Earhart began flying after her move to California in 1920. After taking lessons from aviation pioneer Neta Snook in a Curtiss Jenny, Earhart set out to surpass aviators before her, breaking the women's altitude record in 1922.

In 1928, Earhart became a household name as the first woman passenger to fly across the Atlantic Ocean. Her popularity soared with her solo transatlantic flight in 1932. She wrote and lectured around the country, highlighting her travels along with gender equality and women's opportunities in aviation.

When Purdue University President Edward C. Elliott heard her speak in New York, he hired Earhart to mentor and counsel students on careers for women and serve as chief consultant in aeronautical engineering. She came to campus in fall 1935, staying until her final flight in July 1937.

During her tenure, Earhart sought students' opinions and shared her views on gender stereotypes. Few women studied engineering then, and she set out to change that. Her push for women's independence included teaching women a "handyman's course."

While at Purdue, Earhart made plans to fly around the world. The Purdue Research Foundation established the Amelia Earhart Fund for Aeronautical Research and, with donations, purchased her Lockheed Electra airplane. She called it her "flying laboratory" because of her experiments on speed and fuel consumption, radio communication, navigation methods and more.

Earhart lost contact on her world-flight attempt on July 2, 1937, presumably crashing in the Pacific Ocean. Details, however, remain a mystery.

Purdue houses the world's largest Earhart collection; it includes papers, memorabilia, artifacts and her flight jacket, among other items. Her presence at Purdue lives on in other ways: Outside the residence hall named after her is a life-sized statue, dedicated in 2009.

MARK SIMONS


left | A photo of Amelia Earhart sitting on her plane, circa 1935, which appeared in a 1937 article in the New York Post.

Photo courtesy of Purdue University Archives

above | The Amelia Earhart statue in front of Earhart Residence Hall, 2010.

Photo courtesy of Purdue Marketing and Media

Michele Buzon

Mikhail Atallah

Jean Chmielewski

## BUZON PRESENTED WITH LU ANN ADAY AWARD

Using paleopathology, biological relatedness and strontium isotope analysis, **Michele Buzon** is learning that the biologically and ethnically mixed Nubians and immigrant Egyptians coexisted peacefully and enjoyed good health in the Nile Valley more than 3,500 years ago.

On trips to Tombos, Sudan, the professor of anthropology in Purdue's College of Liberal Arts has been studying human remains to increase understanding of how sociopolitical transitions affected people.

For her groundbreaking bioarchaeological work over the last 17 years, Purdue honored Buzon in 2017 with the inaugural Lu Ann Aday Award. It is the university's highest honor in humanities and social sciences.

"Her field research and scholarship have advanced multiple disciplines, and she is answering significant questions about ancient societies," says Suresh Garimella, executive vice president for research and partnerships and the Goodson Distinguished Professor of Mechanical Engineering.

Buzon's honor was approved by Purdue President Mitch Daniels following committee review of colleague nominations. The award includes a financial prize and scholarly activity funding.

A Purdue Faculty Scholar, Buzon presented the Lu Ann Aday Distinguished Lecture as part of the award celebration.

## ATALLAH RECEIVES ARDEN L. BEMENT JR. AWARD

With global computer security at the forefront of today's challenges, **Mikhail Atallah's** contributions to efficient processing and data protections make him an exemplary choice for the 2017 Arden L. Bement Jr. Award, Purdue's highest honor in pure and applied science and engineering.

Among the achievements of this distinguished professor of computer science and professor of electrical and computer engineering: settling longstanding data structure problems, solving complex geometric and combinatorial issues through optimal algorithms, and commercializing security software by co-founding Arxan Technologies Inc.

"Atallah's work in algorithms, access hierarchies and information security is world-renowned," says Suresh Garimella, executive vice president for research and partnerships and the Goodson Distinguished Professor of Mechanical Engineering.

The Bement Award, which includes a monetary prize and scholarly activity grant, was established in 2015 by Professor Emeritus Arden Bement and his wife, Louise Bement. The winner is approved by Purdue's president following committee review of colleague nominations.

A fellow of the Association for Computing Machinery and Institute of Electrical and Electronics Engineers, Atallah presented a distinguished lecture as part of the Bement salute.

## CHMIELEWSKI EARNS HERBERT NEWBY MCCOY AWARD

Citing her significant breakthroughs in chemical biology and drug discovery addressing human health and disease, Purdue University named **Jean Chmielewski** recipient of the 2017 Herbert Newby McCoy Award, Purdue's most prestigious recognition in the natural sciences.

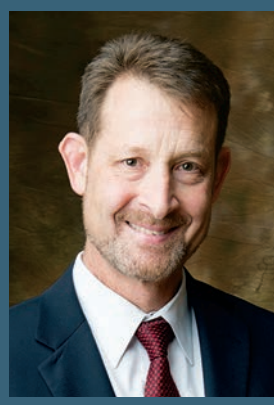
As the Alice Watson Kramer Distinguished Professor of Chemistry and professor of biomedical engineering, Chmielewski develops small molecules, peptides and peptidomimetics for drug discovery, bio-nanotechnology and cellular delivery of therapeutic agents.

"Her groundbreaking work in enabling effective antibiotics to more efficiently penetrate infected cells will facilitate better treatment of infections caused by pathogenic bacteria," says Suresh Garimella, executive vice president for research and partnerships and the Goodson Distinguished Professor of Mechanical Engineering.

First bestowed in 1965, the award was established to honor alumnus Herbert McCoy. The recipient is approved by the Purdue president each year, following committee review of colleague nominations. It includes a monetary prize and scholarly activity grant.

A fellow of the American Association for the Advancement of Science with numerous awards and publications, Chmielewski presented a distinguished lecture as part of the McCoy recognition.

Kathleen Howell



Andrew Weiner

Akinwumi Ayodeji Adesina

Eugene Spafford

## HOWELL SECURES TWO ACADEMY SPOTS

Both the National Academy of Engineering and the American Academy of Arts and Sciences have welcomed **Kathleen Howell**, the Hsu Lo Distinguished Professor of Aeronautics and Astronautics and associate dean for engineering, to their ranks.

Her research achievements include breakthroughs in orbit mechanics, trajectory optimization and spacecraft dynamics and control.

The National Academy of Engineering noted Howell's contributions in dynamical systems theory and invariant manifolds culminating in optimal interplanetary trajectories and the Interplanetary Superhighway. Founded in 1964, the organization chose 84 new members in 2017; election is considered among the highest honors for an engineer.

The American Academy of Arts and Sciences, founded in 1780, addresses current societal, scientific and intellectual issues. Howell was one of 188 fellows named in 2017 and among 11 Purdue colleagues previously recognized.

## WEINER ELECTED FELLOW, NATIONAL ACADEMY OF INVENTORS

Notable research on ultrafast optics prompted the National Academy of Inventors to name **Andrew Weiner** a fellow.

The Scifres Family Distinguished Professor of Electrical and Computer Engineering holds 18 U.S. patents and has achieved breakthroughs in processing high-speed lightwave signals and ultra-broadband radio-frequency signals.

He has also distinguished himself in the programmable generation of arbitrary ultrashort pulse waveforms, with applications in fiber optic networks and ultrafast optical science laboratories worldwide.

Founded in 2010, the National Academy of Inventors recognizes university and nonprofit institute researchers whose inventions benefit society. Weiner is the ninth Purdue researcher to be named a fellow.

His many recognitions also include membership in the National Academy of Engineering and selection by the Department of Defense for a National Security Science and Engineering Faculty Fellowship.

## ALUMNUS LANDS 2017 WORLD FOOD PRIZE

After earning two Purdue University degrees in agricultural economics — a master's in 1985 and doctorate in 1988 — **Akinwumi Ayodeji Adesina** took his knowledge home to Africa. There, he pursued an international career in agricultural development.

His significant achievements since then were recognized in 2017 when he was named the World Food Prize Laureate.

Since 2015, Adesina has served as president of the African Development Bank Group, whose mission is to reduce poverty by spurring sustainable economic development and social progress in its member countries. Among his earlier posts, he was minister of agriculture and rural development in Nigeria.

Considered equivalent to a Nobel Prize, the World Food Prize is the highest international honor given to those who have advanced human development by improving the quality, quantity and availability of food.

Adesina received an honorary doctorate from Purdue in 2015.

## SPAFFORD RECOGNIZED WITH INTERNATIONAL AWARD

**Eugene Spafford's** significant achievements in education, research, leadership, mentoring and information security, particularly in international endeavors, were highlighted at the 32nd International Conference on ICT (Information and Communication Technology) Systems Security and Privacy Protection in Rome.

There, he accepted the 2017 Kristian Beckman Award from the International Federation of Information Processing Societies (IFIP) and gave an invited lecture.

The Beckman Award has been given annually since 1992 by IFIP, an organization Spafford has been active in for 25 years. He is a member of its technical committee and has served as academic editor and editor-in-chief of its journal, Computers & Security. The organization's membership tops a half-million from 56 countries and regions in five continents.

A computer science professor who founded Purdue's Center for Education and Research in Information Assurance and Security (CERIAS) in 1998, Spafford has now received every major cybersecurity award.

## EIGHT DESIGNATED AS AAAS FELLOWS

With accolades for their science achievements, eight Purdue professors were named fellows in the American Association for the Advancement of Science.

Among the 391 elected worldwide in 2016 by the nonprofit dedicated to advancing science for the benefit of all people are:

**Elisa Bertino**, professor of computer science and research director of Purdue's Center for Education and Research in Information Assurance and Security (CERIAS), for advancements in information and computer security;

**William A. Cramer**, the Henry Koffler Distinguished Professor of Biological Sciences, for studies on the structure and function of membrane proteins involved in photosynthetic energy transduction, and the membrane translocation pathway of the colicin protein cytotoxin through the network of bacterial membrane protein receptors. Cramer is a fellow of the Biophysical Society;

**James Andrew DeWoody**, professor of genetics in the College of Agriculture, for work on wildlife and fisheries genetics and extending the theory and practice of parentage analysis in molecular ecology and conservation genetics;

**Barbara Lynn Golden**, professor of biochemistry in the College of Agriculture, for advancements in the field of RNA structural biology and biochemistry;

**Hilkka Inkeri Kenttämaa**, the Frank Brown Distinguished Professor of Analytical Chemistry and Organic Chemistry, for research in organic mass spectrometry, particularly on distonic radical cations and new ionization and structural characterization methods;

**Matthew W. Ohland**, professor of engineering education, for studies in how engineering students are educated through classroom teaching, research impact, development of educational technology and society leadership;

**Craig K. Svensson**, dean emeritus and professor of medicinal chemistry and molecular pharmacology, whose contributions include findings in pharmacokinetics, drug metabolism and disposition, and administratively as division head and dean; and

**Wallace E. Tyner**, the James and Lois Ackerman Professor of Agricultural Economics, for achievements in agricultural and energy economics and research at the interface of the two areas, especially biofuels economics and policy.

## ZWIER RECEIVES HUMBOLDT RESEARCH AWARD

The Alexander von Humboldt Foundation chose **Timothy Zwier** as one its 2017 Humboldt Research Award recipients. The honor recognizes Zwier's discoveries, theories and insights that are significantly impacting science and the likelihood that his cutting-edge achievements will continue.

An interdisciplinary organization for German foreign cultural and educational policy, the foundation promotes international cultural dialogue and academic exchange. Its award comes with a financial stipend and opportunity to spend up to a year at the University of Göttingen in Germany, collaborating with colleagues.

At Purdue since 1988, Zwier is the M.G. Mellon Distinguished Professor of Chemistry. His wide-ranging research in physical chemistry includes the study of the structures of peptides, the photochemistry occurring in the outer planets and moons, and the highly reactive intermediates present in combustion.

Zwier is a fellow of the American Chemical Society, the American Physical Society and AAAS.

## ROSSMANN COLLECTS MICROBIOLOGY SOCIETY PRIZE MEDAL

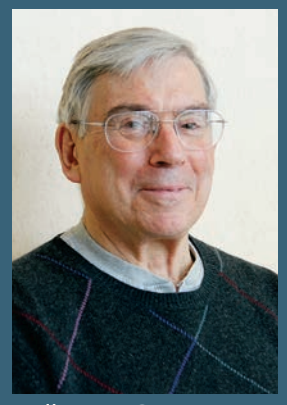
**Michael Rossmann**, whose Purdue tenure spans more than 50 years, added the British Microbiology Society Prize Medal to his long list of top recognitions in 2016. The annual award goes to a global leader for work of far-reaching impact.

The Hanley Distinguished Professor of Biological Sciences was recognized for "outstanding contributions to the development of protein crystallography and understanding of virus structures" at the society's 2017 conference in the United Kingdom, where he presented the prize lecture on the history of structural virology.

Rossmann's achievements include developing the molecular replace method, defining the nucleotide binding fold often called the Rossmann fold, leading the team that mapped the cold virus to an atomic level, and co-leading the team that identified the Zika virus code, among others.

Work in the Rossmann laboratory focuses on the way viruses interact with their


Elisa Bertino


William A. Cramer


James Andrew DeWoody


Barbara Lynn Golden

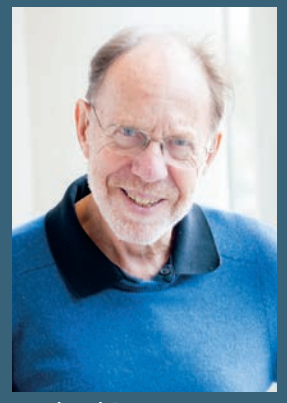

Hilkka Inkeri Kenttämaa


Matthew W. Ohland


Craig K. Svensson

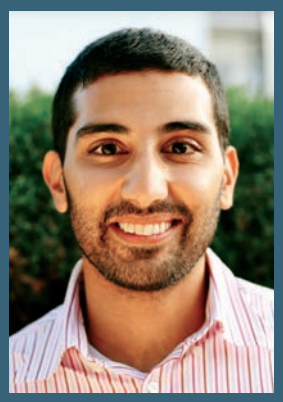

Wallace E. Tyner


Timothy Zwier


Michael Rossmann


Peter Hirst


Karthik Kannan


Sonak Pastakia


Chi Li


Takashi Hibiki


Thomas Hertel

environment, with studies that include polioviruses, coxsackieviruses, dengue virus, alphaviruses, parvoviruses and others.

Rossmann is a fellow in the American Academy of Microbiology and member of the National Academy of Science and the Royal Society in London.

## HIRST, KANNAN, PASTAKIA: JEFFERSON SCIENCE FELLOWS

**Peter Hirst**, professor of horticulture; **Karthik Kannan**, professor of management; and **Sonak Pastakia**, associate professor of pharmacy practice, have each been named 2017/2018 Jefferson Science Fellows.

Established in 2003 to further build capacity for science, technology and engineering expertise within the U.S. Department of State and U.S. Agency for International Development, the program is an initiative of the Office of Science and Technology Adviser to the U.S. Secretary of State. Administered by the National Academies of Science, Engineering and Medicine, Jefferson fellows help formulate U.S. foreign policy.

Hirst brings to the table his experience in robotics, sensing technologies and predictive computer models used in fruit orchards.

Kannan studies how information technology exploits human instincts and biases to nudge or manipulate behavior. He has applied related ideas in pricing using auctions of information goods, pricing of data networks and information security economics.

Pastakia spends much of his time in Kenya, where his research work includes diabetes care, chronic disease management, a rheumatic heart disease program and pharmacy distribution for HIV and other treatments.

With nine other faculty chosen previously, Purdue has more Jefferson fellows than any other institution.

## LI NAMED SLOAN RESEARCH FELLOW

Citing **Chi Li** and 125 other U.S. and Canadian researchers as "rising stars of the academic community," Paul Joskow, president of the Alfred P. Sloan Foundation, announced the 2017 Sloan Research Fellowships.

Li, a professor of mathematics, is researching the Kähler-Einstein metric. Using a variety of techniques, he has studied manifolds with three compatible structures — complex, symplectic and Riemannian — classified as Kähler manifolds. He also teaches graduate classes in differential geometry and linear algebra.

Awarded since 1934, the Sloan Fellowships include a monetary award to support original research in science, technology, mathematics and economics. The Sloan Foundation recognizes recipients as the next generation of scientific leaders and "for transforming their fields and opening up entirely new research horizons."

## HIBIKI HONORED BY ATOMIC ENERGY SOCIETY OF JAPAN

The Atomic Energy Society of Japan bestowed its 2017 Award for Eminent Achievements in Nuclear Science and Technology, its most prestigious honor, to **Takashi Hibiki**, professor of nuclear engineering.

The award recognizes Hibiki's superior achievements in peaceful uses of atomic energy, specifically citing his contributions to nuclear thermal-hydraulics, instrumentation methods and modeling of two-phase flow.

Hibiki's current research includes interfacial area transport equation formulation, modeling of heat transfer in mini- and micro-channels, non-drag force model development, drift-flux model development, flow-induced vibration analysis and research reactor utilization for industrial purposes. One of his papers is ranked No. 1 in paper citations among all papers published in the International Journal of Multiphase Flow since 1974 based on the Web of Science.

Founded in 1959, the Atomic Energy Society of Japan first awarded the annual Academic Achievement Award in 1968.

## HERTEL ACCEPTS ECOLOGICAL AWARD

A team of 11 authors, including **Thomas Hertel**, Distinguished Professor of Agricultural Economics, earned the Ecological Society of America's 2017 Sustainability Science Award for the research review, "Systems Integration for Global Sustainability," published in Science in February 2015.

The award recognizes scholarly work that makes the greatest contribution to the emerging science of ecosystem and regional sustainability through the integration of ecological and social sciences.

Calling the effort to meet current needs of Earth's human population while securing natural resources for future generations "a massive global task," the society honored the team's report covering ecosystem

services, environmental footprints, planetary boundaries, human-nature nexus and telecoupling.

Known for his research on the global impact of trade, climate and environmental policies, Hertel is a fellow and past president of the Agricultural and Applied Economics Association.

## YOUNG INVESTIGATOR AWARD GOES TO SEN

Demonstrating exceptional ability and promise for conducting basic research within five years of receiving his doctorate degree earned **Shreyas Sen** a Young Investigator Research Award and three-year monetary stipend from the U.S. Air Force Office of Scientific Research. His proposal was one of 58 selected from a field of 230.

An assistant professor of electrical and computer engineering, Sen earned his doctorate in 2011 and joined Purdue in 2016. He has achieved distinction for work in communication circuits and systems, and intelligent sensor nodes for the Internet of Things (IoT), among other areas.

Sen will use the funding to work on Human Body Communication — using the human body as a secure conducting medium to interconnect wearable and implantable devices and sensors. This basic research could impact neuroscience, electroceuticals, augmented and virtual reality, secure authentication, and personal entertainment around the human body.

The Young Investigator Program was initiated to foster creative basic research, enhance early career development and increase opportunities for recipients to recognize the Air Force mission and related challenges in science and engineering.

## GALLON RECEIVES FELLOWSHIP FROM THE AMERICAN COUNCIL OF LEARNED SOCIETIES

**Kim Gallon**, assistant professor of history in Purdue's College of Liberal Arts, received a Digital Innovation Fellowship from the American Council of Learned Societies. Founded in 1919, the council focuses on advancing the humanities.

Funded by the Andrew W. Mellon Foundation, Gallon's fellowship supports her digital scholarship work, "The Black Press Born-Digital Project." She is researching, archiving and producing knowledge on discourses and representations of gender and sexuality in the early 20th century black press.

An ongoing visiting scholar at the Center for Africana Studies at Johns Hopkins University, Gallon founded and directs the Black Press Research Collective, an interdisciplinary group of scholars generating digital scholarship about the historical and contemporary role of black newspapers in Africa and the African Diasporas. The collective is a repository for storage, analysis, digitization and distribution of material on the global black press.

## OLIVER CHOSEN FOR AAAS

**Haley Oliver**, associate professor of food science in the College of Agriculture, is one of 15 researchers spending the 2017/2018 year as a Public Engagement Fellow of the Alan I. Leshner Leadership Institute for Public Engagement with Science through the American Association for the Advancement of Science.

Now in its second year, the institute chooses researchers specializing in infectious diseases who have demonstrated leadership and excellence. Participation provides opportunities to enhance leadership and promote meaningful dialogue between scientists and society. Her activities include a week in Washington D.C. learning to train trainers and develop an engagement plan.

Oliver's work focuses on foodborne disease, including transmission of L. monocytogenes and salmonella at restaurants, groceries and other food retailers. She also works to increase public awareness of exposure risks.

## BOEHLJE SELECTED FOR MORRILL AWARD

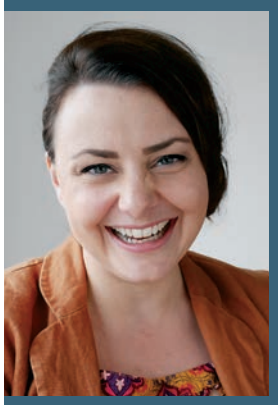
**Michael Boehlje**, a distinguished professor in agricultural economics and the Center for Food and Agricultural Business, received Purdue's sixth annual Morrill Award. Named to honor the 1862 Morrill Act establishing land-grant universities and colleges, it recognizes excellence in teaching, research and engagement.

In keeping with the Morrill Act's objective of educational access, Boehlje shares his expertise with business leaders and policymakers on agricultural finance, farm and business strategy, management and the industry's changing structures. He emphasizes the importance of planning and positioning businesses for long-term success and covers topics such as systems analysis, process control, transaction costs and supply-and-value chain management.

Boehlje is a fellow of the American Agricultural Economics Association and the International Food and Agribusiness Management Association.


Shreyas Sen


Kim Gallon


Haley Oliver

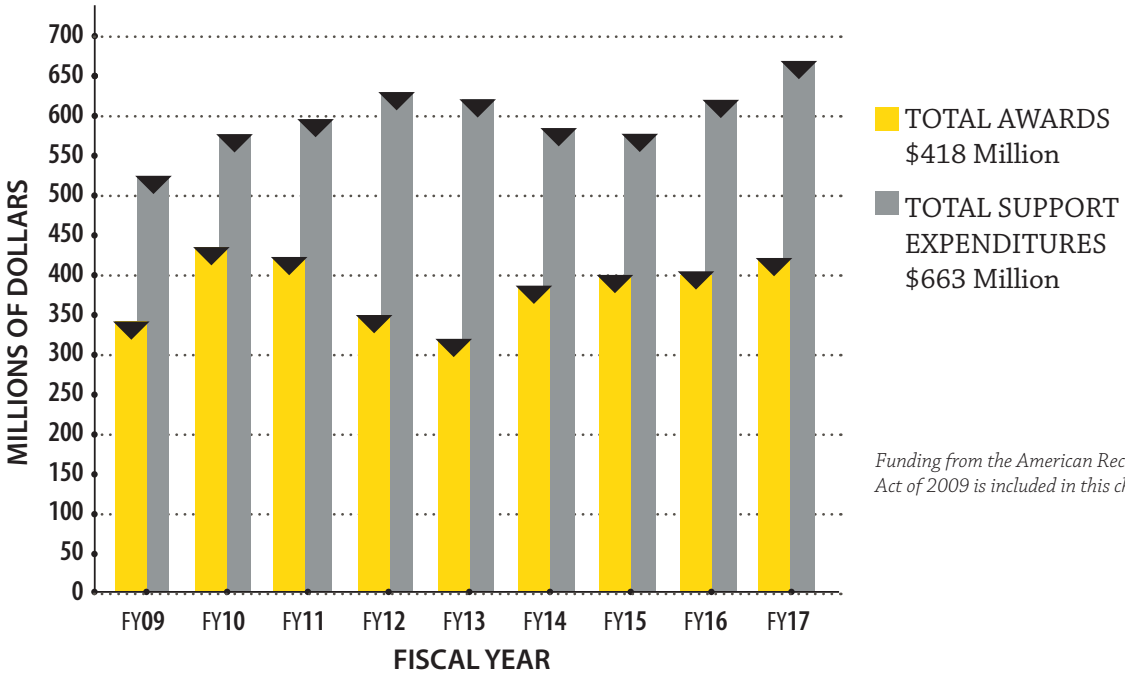

Michael Boehlje

# SYSTEM-WIDE SPONSORED PROGRAM AWARDS AND EXPENDITURES

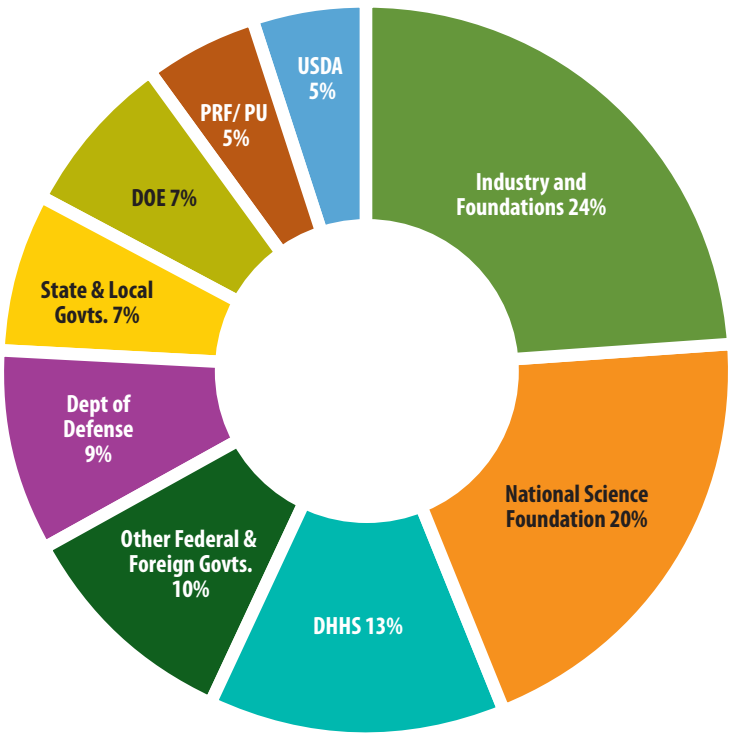
Purdue University continues to land significant funding in sponsored programs system-wide.

As a leading research university in the state of Indiana with a global reputation of excellence, Purdue is dedicated to maximizing our resources to build a research enterprise that supports impactful research. During FY 2017, Purdue received more than $418 million in sponsored program awards system-wide.

With these awards, faculty will continue to push the boundaries of discovery and raise the profile of both the research and student experiences at Purdue University.




*Funding from the American Recovery and Reinvestment Act of 2009 is included in this chart.*




Committed sponsors partner with Purdue, enabling faculty and staff researchers to respond to 21st century grand challenges.

| | |
|---|---|
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| DOE | U.S. Department of Energy |
| PRF | Purdue Research Foundation |
| PU | Purdue University |
| USDA | U.S. Department of Agriculture |

*Sponsored Awards come from multiple sources.*

## FROM THE PRESIDENT

Here at Purdue University — a vast laboratory for discovery — imagination, ingenuity and innovation are never in short supply. Our researchers in West Lafayette and system-wide campuses continue to make breakthrough discoveries, launch startup companies and move innovations into the marketplace in order to improve lives and drive long-term economic growth for Indiana, the nation and the world.

Mitchell E. Daniels
President

## FROM THE EXECUTIVE VICE PRESIDENT FOR RESEARCH AND PARTNERSHIPS

A record year of $663 million in research expenditures is proof of the tremendous research activity happening at Purdue, thanks to the quality, creativity and tenacity of Purdue faculty, students and staff. New grants and corporate agreements are only possible because of the tremendous talent of Purdue people and the availability of advanced facilities and infrastructure for high-level, innovative research.

Suresh V. Garimella
Executive Vice President for Research
and Partnerships

## FROM THE PROVOST AND EXECUTIVE VICE PRESIDENT FOR ACADEMIC AFFAIRS AND DIVERSITY

As a 21st century land-grant institution, Purdue University is dedicated to helping solve the world's most pressing problems and creating a better future for generations to come. The challenges may be daunting, but Purdue faculty, staff and students continue to deliver innovative solutions to enhance lives and livelihoods on every continent around the globe.

Jay T. Akridge
Provost and Executive Vice President for Academic Affairs and Diversity

back cover | An active region of the sun just rotating into the view of NASA's Solar Dynamics Observatory gives a profile view of coronal loops over about a two-day period, from Feb. 8-10, 2014.

Photo courtesy of NASA.

# 2016 | 2017

**Office of the Executive Vice President for Research and Partnerships**
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