

Transmission

News from the College of Natural Sciences & Mathematics

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ON THE CREST OF A NEW WAVE IN ASTRONOMY

GWPAC's four faculty members, pictured left to right: **Geoffrey Lovelace, Josh Smith, Jocelyn Read, and Alfonso Agnew.**

Researchers from the College of Natural Sciences & Mathematics recently played a significant part in the first detection of gravitational waves, fulfilling the last prediction of Albert Einstein's theory of general relativity.

Einstein described gravity not as Isaac Newton proposed, as an instantaneous force between two objects, but rather as a curvature of space and time. Much like a bowling ball placed on a trampoline will cause an indentation and curve the trampoline surface, heavy astronomical objects like the sun curve the space-time around them. The stronger the curvature, the stronger the gravity.

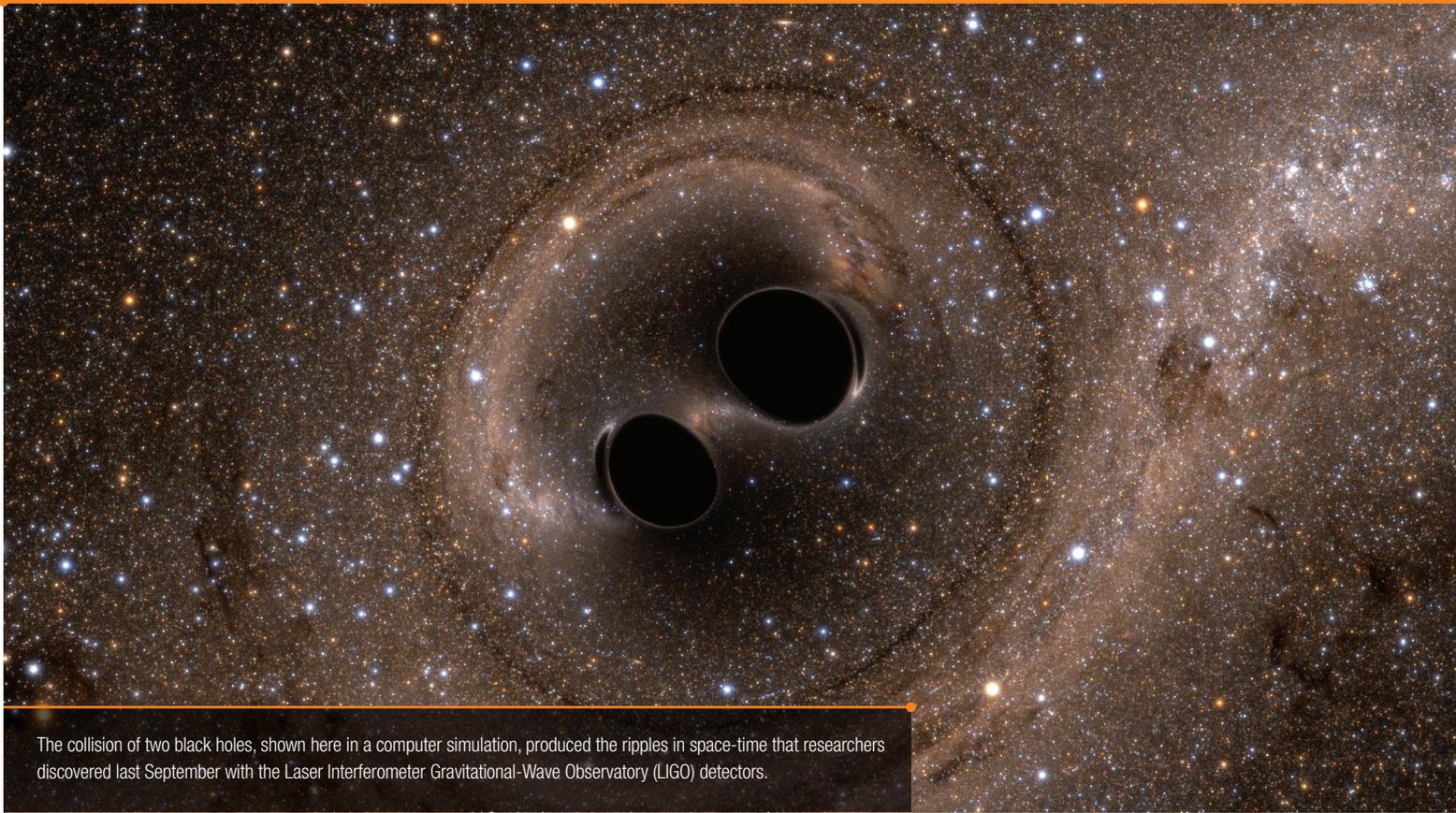
"Gravitational waves are ripples in the fabric of space-time that travel outward from their sources at the speed of light," says Josh Smith, associate

professor of physics and Dan Black director of the Gravitational-Wave Physics and Astronomy Center (GWPAC) at the college. "The collision of two black holes in a close and fast orbit produced ripples in space-time that we've detected here on Earth with the Laser Interferometer Gravitational-Wave Observatory (LIGO)."

Until recently, those gravitational waves were theoretical. Though Einstein predicted them 100 years ago, they weren't detected until Sept. 14, 2015. GWPAC's four faculty members –

Smith; assistant professors of physics Jocelyn Read and Geoffrey Lovelace; and mathematical physics professor Alfonso Agnew – and students conducting research at the center directly contributed to LIGO's discovery.

LIGO researchers estimate the black holes that caused these waves were about 29 to 36 times the mass of the sun, and that the event took place 1.3 billion years ago.



The collision of two black holes, shown here in a computer simulation, produced the ripples in space-time that researchers discovered last September with the Laser Interferometer Gravitational-Wave Observatory (LIGO) detectors.

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“This discovery builds on years of work in the gravitational wave community,” explains Smith. “We hope this is the first of many, and that we and our students will continue to explore this new frontier of astronomy.”

CONDUCTING REVOLUTIONARY RESEARCH

Twin LIGO detectors in Livingston, La., and Hanford, Wash., received the signals. These detectors, funded by the National Science Foundation (NSF), were conceived, built, and are operated by the California Institute of Technology and the Massachusetts Institute of Technology. Much of GWPAC’s work was crucial to this discovery and its interpretation.

“Dr. Lovelace and his students and colleagues in the Simulating Extreme Spacetimes collaboration are experts at simulating merging black holes with supercomputers,” explains Smith. “They were the first group to produce

realistic simulations and gravitational waveforms for the merging binary black hole system, and their work is featured in the *Physical Review Letters’* announcement paper.”

Smith led the detector characterization group that searched for and helped eliminate sources of noise in the LIGO detectors, helping to extend their reach. Since September, his group has been verifying the instrument status at the time of the discovery and checking and ruling out other potential explanations for the signal. Smith also served as one of six primary editors for the discovery announcement article.

“Dr. Read is an expert on neutron star astrophysics and is likely to lead the astrophysical interpretation of LIGO’s next big discovery, merging neutron stars, which could reveal how matter acts when it is packed extremely tightly,” he says.

Cal State Fullerton has made another significant contribution to the field by training the next generation of gravitational wave researchers.

Since 2010, more than 40 undergraduate and master’s students have conducted gravitational wave research at CSUF. With Agnew, Lovelace, Read, and Smith, the students completed projects in mathematical relativity; computationally solved Einstein’s equations for black hole mergers; calculated gravitational waveforms for systems of black holes and neutron stars; identified and removed sources of noise in the LIGO instruments; and improved the optics used by LIGO.

“This research spans mathematics, computational physics, astrophysics, and experimental optics,” says Smith. “Seven of our students have gone on to Ph.D. programs, five in gravitational wave astronomy.”

Lovelace, Read, and Smith co-authored the gravitational wave detection report, along with computational specialist Joe Areeda. Alumni Thomas Abbott (’10, BS; ’12, MS), Joshua Hacker (’15, MS), Gabriel Islas (’14, MS), Fabian Magaña-Sandoval (’12, BS),

Gabriela Serna ('15, MS), and Daniel Vander-Hyde ('15, BS), also co-authored the piece.

FINDING NEW FRONTIERS

Smith says the discovery of gravitational waves from a merging system of black holes has opened a new window on the universe.

“Most of humanity’s information about the universe comes from light – visible, radio, X-rays, gamma rays – but gravitational waves are an entirely new type of wave with a spectrum of their own,” he explains. “We’ve just received our first transmission. But we expect many, many more, and we will use these to view parts of the universe inaccessible to light, such as black holes, the interior of neutron stars, and the start of the universe.”

Confirming Einstein’s theory inaugurated a new field of astronomy and activated astronomy studies at GWPAC. Prior to detection, faculty

and students focused on improving LIGO, predicting what gravitational waveforms it would detect, and planning how to extract the most information from the first detections.

“Now we can become a rapid response team for vetting new candidates using data from the instruments and quickly perform simulations to identify exact parameters of newly detected systems,” says Smith. “Our students will also help develop technology for the next generation of improved gravitational wave detectors.”

Since 2010, scientists have been working on a major upgrade called Advanced LIGO to increase the detectors’ sensitivity tenfold, which translates to a thousandfold increase in the volume of the universe accessible to LIGO. Upgrades included an active seismic isolation system that measures the motion of the ground and pushes LIGO optics the opposite way to

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LONGTIME DONOR SUPPORTS GWPAC SCIENTISTS

Physics alumnus and frequent donor Dan Black’s ('67) latest \$225,000 gift will expand faculty and student research supporting LIGO and other physics and astronomy endeavors.

As the first Dan Black Director of the Gravitational-Wave Physics and Astronomy Center, Josh Smith says Black’s gift will help involve more undergraduates in research activities, hire a postdoctoral scholar to mentor students, and contribute to faculty research on gravitational wave discoveries to come.



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Josh Smith, associate professor of physics and Dan Black director of the Gravitational-Wave Physics and Astronomy Center



“I hope students will feel pride knowing their peers and faculty helped make these discoveries.”

Josh Smith

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reduce their true motion; development and installation of the most stable laser system in the world; and the installation of 40kg mirrors (one of which GWPAC studied at CSUF) with advanced material and optical properties. This upgrade “unlocked” a new part of the gravitational wave spectrum.

“We knew a discovery was possible, but we were surprised to get such a strong, clean signal so soon,” explains Smith. “We saw two black holes, each about 30 times the mass of the sun, orbiting around each other at a quarter the speed of light and one billion light years away, finally merging to form one final black hole.”

A third detector, called Advanced Virgo, will soon operate in Cascina, Italy, and a fourth LIGO detector has been approved by the Indian government. Researchers hope this new equipment will allow them to regularly observe gravitational waves and rapidly provide locations and timing to other scientists so they can follow up with telescope observations.

GWPAC researchers can now probe and simulate distant wave-producing sources in the universe and they are grateful for the opportunity to conduct gravitational wave research right on campus.

“This will rewrite parts of our astronomy textbooks and give us a great way to illustrate the discovery-driven nature of science to our classes,” says Smith. “We’ll cover this in many of our courses, including the Astronomy 101 course Dr. Read and I teach, gravitational physics with Dr. Lovelace, and general relativity mathematics with Dr. Agnew. I hope students will feel pride knowing their peers and faculty helped make these discoveries. Our work would not have been possible without the support of our colleagues, the culture of scientific excellence at the college, and the collegiality across campus.”

MAKING SCIENTIFIC STRIDES

The leadership role GWPAC faculty and students played in such a significant discovery thrills college and university leaders.

“There is no doubt that this opens the door for incredible future opportunities for students and faculty,” says David Bowman, interim dean of the College of Natural Sciences & Mathematics. “And our undergraduate and master’s students’ participation once again demonstrates that CSUF students don’t just come here to learn about science, they do science.”

The CSU system recognized the GWPAC’s accomplishments when Chancellor Timothy White visited the campus less than a week after the announcement.

“We’re very proud that Chancellor White paid a special visit to the faculty and students of GWPAC,” says Bowman. “We have always believed that engaging students in research is critical to their education, and the Chancellor’s visit underscores this fact. As universities around the country try to increase research opportunities for undergraduates, Chancellor White’s visit shows that NSM is leading the way.” •

“[Becoming dean seems] a natural continuation of a desire to effect positive change on a widening scale.”



COLLEGE OF NATURAL SCIENCES & MATHEMATICS WELCOMES NEW DEAN

For 21 years, Marie Johnson has taught geology at the country’s oldest and most famous service academy – the United States Military Academy at West Point. In 2008, she became Environmental Program Director at the prestigious institution. On July 1, she’ll make a big move – across the country and to the helm of a brand-new, non-military college – when she becomes dean of the College of Natural Sciences & Mathematics.

“I’m 90 percent excited and 10 percent anxious about the move,” says Johnson. “I have very much enjoyed my time at West Point and learning about the Army, but I’m energized at the prospect of being back with a full-time academic institution and living on the West Coast for the first time.”

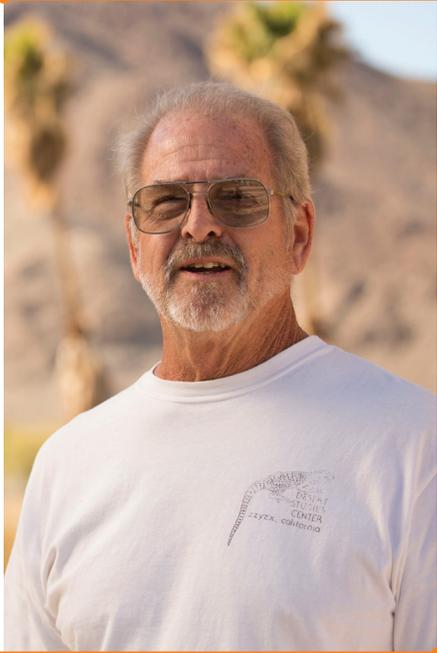
Johnson has wanted to work in science since she was 8 years old, so the college is a perfect fit. The diverse student body, genuine collegiality of its faculty, staff, and students, and opportunities to lead environmental programs and partnerships underpinned by sound math and science were a powerful draw. She feels becoming dean seems “a natural continuation of a desire to effect positive change on a widening scale,” which she developed as a program director.

Prior to West Point, Johnson earned her undergraduate degree at Harvard College and her Ph.D. from Brown University, both in geology. She was then a researcher at Lamont Doherty Earth Observatory of Columbia University.

Johnson’s goal as dean is to be as effective as possible as quickly as possible. She plans to be “cheerleader-in-chief” within the university system and the community, building strong relationships for the institution.

“My first priority is to listen and get a sense of where the college is right now before we can responsibly discuss new directions and initiatives,” says Johnson. “My experiences at West Point have shaped my thoughts on leadership, as well as allowed me to build teams, write a self-study for a national accreditation review, and mentor and develop students and faculty members through a myriad of opportunities and challenges. I’m eager to bring those experiences to the college, and I’m thrilled to be a Titan!” •

“My first priority is to listen and get a sense of where the college is right now before we can responsibly discuss new directions and initiatives.” — Marie Johnson



“We’ve had really exciting projects here over the years, including early Mars rover tests because the desert surface is similar to Mars.”

William Presch, Professor of Biological Sciences and Director of the Desert Studies Center

CELEBRATING FOUR DECADES OF DESERT STUDIES

On the western shore of Soda Dry Lake, in the northwest corner of the Mojave National Preserve, sits a unique field station that operates through a collaborative management agreement between California State University (CSU) and the National Park Service.

This “off-the-grid” Desert Studies Center (DSC) encompasses 1,200 acres, complete with 18 buildings that can accommodate up to 70 researchers, visitors, and staff members. It generates its own power, pumps and purifies water, and runs its own sewage system.

In 2015, 2,366 visitors came to the DSC from 12 CSU campuses, the University of California, 20 other colleges across the United States and Europe, and 24 agencies. These included NASA, U.S. Fish and Wildlife, the U.S. Geological Survey, the Federation of Mineralogical Societies, the Desert Research Institute, and the National Park Service.

“We have 32 active projects on site,” says William Presch, professor of biological sciences and director of the Desert Studies Center. “These include

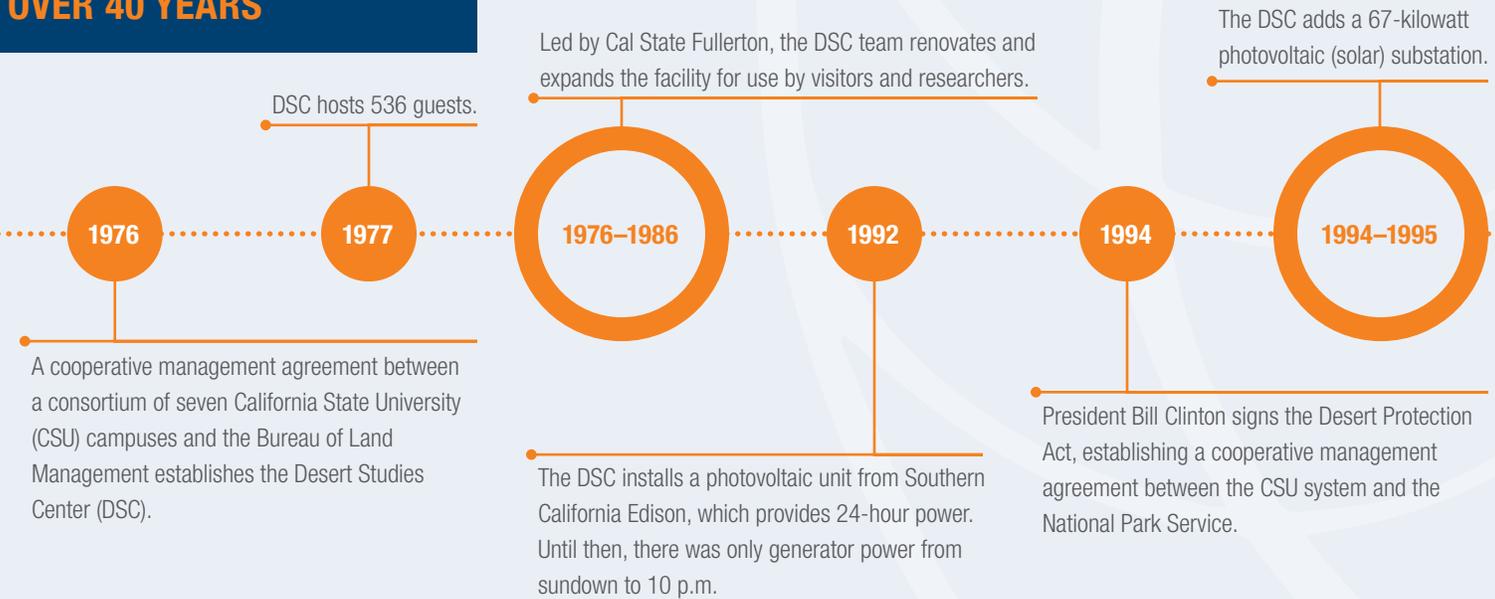
research into endangered species, desert plant distribution, the effects of wind events, tortoise distribution, earthquake monitoring, and more. We’ve had really exciting projects here over the years, including early Mars rover tests because the desert surface is similar to Mars.”

The DSC is celebrating 40 years since its establishment as a cooperative agreement between the Bureau of Land Management and CSU. CSU and the National Park Service have cooperatively managed it since 1994.

FORGING AHEAD INTO THE FUTURE OF DESERT STUDIES

In August, Presch will retire after 15 years as director. Darren Sandquist, chair of the board

DESERT STUDIES CENTER OVER 40 YEARS



of governors for the California Desert Studies Consortium, will take the helm.

“The DSC functions very well in support of academic courses related to desert systems,” says Sandquist. “The past 10 years have seen significant infrastructure improvements and growth. In the next 10 years, we wish to increase the center’s use by members of the Consortium and other CSU campuses, promote more research that addresses important themes in desert systems, especially those of value to the Mojave National Preserve, and develop interdisciplinary programs that provide unique curricular and co-curricular opportunities for CSU students.”

Some of those programs are already in development, including Cal State Fullerton’s new GeoBio Field Investigations course. This cross-disciplinary intersession course’s first classes were in January, and it uses the DSC as a home base for its field research component.

“The students loved it, but more importantly, it’s the kind of course that incorporates virtually all elements of academic high-impact practices,” says Sandquist.

EMBRACING AN ENLIGHTENING EXPERIENCE

Justine Perez, a senior majoring in biological sciences, was one of the first GeoBio students. With the class, she traveled to the Death Valley and Mojave Preserve regions to study their geological history and organisms.

“We visited the Racetrack Playa, Trona Pinnacles, Ubehebe Crater, Salt Creek, Ash Meadows, Badwater Basin, Kelso Dunes, Ballarat Ghost Town, and Lake Manly. At each stop, we learned that it is difficult to understand biological features without understanding geological features of the area,” says Perez.

After five days camping in the desert, the students worked in interdisciplinary groups at the DSC to analyze the geology and vegetation of an alluvial fan.

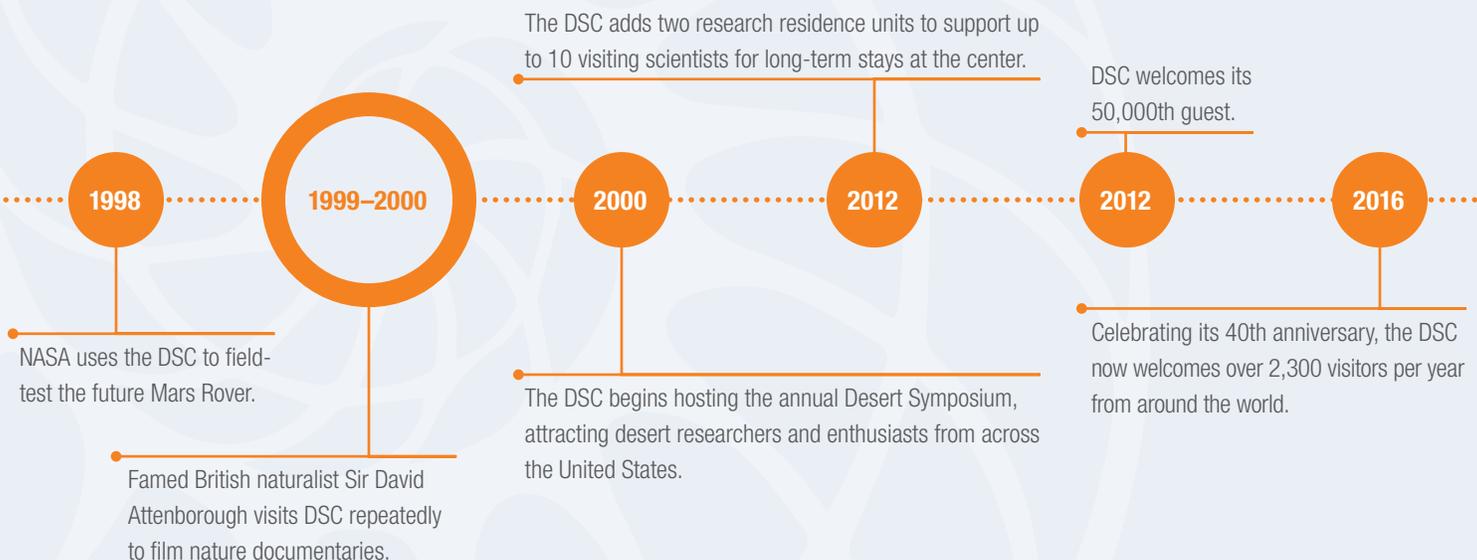
Perez learned the importance of cross-disciplinary research during her time in the field and at the DSC, and says the DSC’s opportunities for hands-on fieldwork are unique.

“The world becomes your classroom, and the phenomena you learn in class finally come to life,” she says. ●



“The world becomes your classroom, and the phenomena you learn in class finally come to life.”

Justine Perez





MESSAGE FROM THE INTERIM DEAN

It has been my honor to serve as interim dean of the College of Natural Sciences & Mathematics for the past two and a half years. NSM is a truly amazing group of students, staff, and scholars, and it has been enormous fun for me to discover so many new areas in which our students and faculty excel. Of course, as friends of our college, you know this because you lived it!

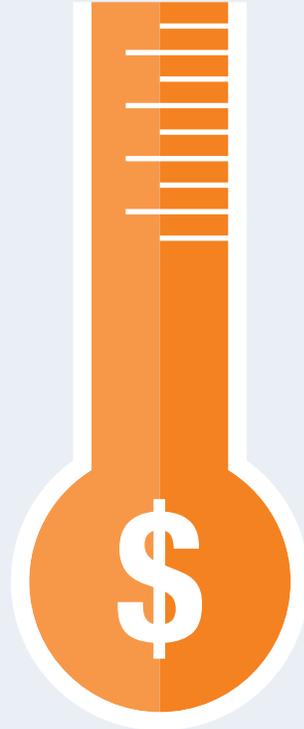
I'm particularly proud of the way the college has expanded high-impact scholarly opportunities for our students during my tenure. We've greatly expanded off-campus research opportunities for faculty and students, from Argentina to Uzbekistan. We've also deepened research opportunities in our own backyard, including the amazing work being done in the Gravitational-Wave Physics and Astronomy Center, the John D. Cooper Center for Archaeology and Paleontology, and the Center for Computational and Applied Mathematics, to name a few.

I'm thrilled to have served the college during this time of transition and welcome Marie Johnson as the new dean starting in July. This is an exciting time for NSM, and I know that we'll rise to even greater heights under her leadership. Go Titans!

David Bowman, Ph.D.

Interim Dean, College of Natural Sciences & Mathematics

\$50,000



WE HAVE MET OUR GOAL!

Thank you to **Kathy and Dan Black ('67)** for issuing a challenge to raise \$50,000 this fiscal year for undergraduate research. The NSM community came together to help us reach our goal three months ahead of schedule! We've received more than 80 gifts and pledges to the challenge, including 21 leadership-level gifts of more than \$1,000.

This support will directly fund student undergraduate research experiences in all five departments in the college. The challenge might be over, but you can still give to undergraduate research and provide additional opportunities to our students. **Donate today at fullerton.edu/nsmgiftchallenge.** •

SCHOLARSHIP SPOTLIGHT

Jerry Gannon, Ph.D., came to Cal State Fullerton in the mid-1970s and worked as a professor of mathematics until his retirement several years ago. During his time, Gannon was the driving force behind the development and growth of the master's program in mathematics – teaching option. As a result of his efforts, graduates of this program are teaching mathematics in virtually every high school and community college in the Greater Orange County area.

In February 2015, a small group of Gannon's friends and colleagues gathered to begin a conversation about establishing a permanent endowed scholarship to honor Gannon's impact on numerous students and colleagues. To date, they have raised approximately \$18,000 in gifts and pledges toward their goal of \$25,000 to establish the endowment.

To make a gift to support the establishment of the Dr. Gannon Endowed Scholarship, please visit giving.fullerton.edu/gannonscholarship or mail your donation to CSUF, Attn: Mike Karg, P.O. Box 6850, Fullerton, CA 92834. Please make your check out to CSFPF.

SUPPORTING THE FOUNDATION OF HER SUCCESS



“I became the first in my family to earn a college degree, but my initial challenges were monumental.”

Cher Carrera

As a 16-year-old Cal State Fullerton freshman, Cher Carrera ('93, BS; '02, MS) faced tremendous hurdles. Diagnosed with Hodgkin's lymphoma, she underwent radiation treatments in the morning and attended class in the afternoon.

“I became the first in my family to earn a college degree, but my initial challenges were monumental,” says Carrera. “I wasn’t the best student because I didn’t have help and didn’t know where to find it.”

After beating her disease, she earned bachelor’s and master’s degrees in mathematics from CSUF. She went on to earn a second master’s degree, this time in education, from Claremont Graduate School, as well as an Ed.D. in education from Argosy University. When she became a math professor at Santa Ana College (SAC), she did one more amazing thing: She created a scholarship to help other CSUF students who face detours on their way to a mathematics degree.

“It is possible to succeed regardless of the challenges you face. The GPA requirement is lower than other scholarships to encourage the student who, like me, has the potential, but not the support, to excel,” explains Carrera.

Carrera says she received the highest caliber mathematics education at CSUF and feels fortunate for the doors the university opened. She tries to pay it forward and has made gift commitments of more than \$75,000 to her alma mater.

“The work students, faculty, and administration do is remarkable,” she says. “No matter how you support the college, you become part of the team, with every research advancement or student success partly yours.”

Carrera is vice president of membership and marketing for the CSUF Alumni Association, holds season tickets to CSUF baseball, and participates in Women of Distinction events.

Completing her fourth year as dean of science, mathematics, and health sciences at SAC, she initiated the Southern California Community Colleges Regional Science Deans’ meetings, supported SAC and CSUF collaborations, and helped develop partnerships and programs to qualify people for entry-level technical jobs without two- or four-year degrees.

In August, she’ll return to teaching mathematics – this time at SAC’s sister college, Santiago Canyon College.

Teaching, family, and numerous hobbies keep her busy, but never too busy for CSUF.

“There’s a lot to be said for having a connection to the school and cultivating Titan Pride.” •

“The work students, faculty, and administration do is remarkable. No matter how you support the college, you become part of the team, with every research advancement or student success partly yours.”

Cher Carrera



DETERMINING DINOSAURS' BODY TEMPERATURE

Sean Loyd, assistant professor of geological sciences, used a new technique to determine dinosaurs' body temperatures based on their eggshells. His work, along with the research of several collaborators published in the journal *Nature Communications*, indicates that some dinosaurs could regulate their internal body temperatures, rather than rely on heat sources like the sun.

FACULTY FOCUS



Maria Linder, professor of chemistry and biochemistry, was named an American Association for the Advancement of Science Fellow for her research into how iron stores in the body are tapped when needed and how copper is absorbed from the diet and excreted.

Sean Walker, professor of biological science, is the new chair of the Department of Biological Sciences. Part of the NSM faculty since 2003, his research includes evolutionary and behavioral ecology, evolution of sexual dimorphism, statistical analysis of biological data, and more.



Paul Stapp, professor of biological science, co-authored "Ecological Traits Driving the Outbreaks and Emergence of Zoonotic Pathogens" in *BioScience*, which details a decade of research into the ecology of plague in Colorado's black-tailed prairie dogs.



Amybeth Cohen, professor of biological science, received the 2016 Andreoli Faculty Service Award from the CSU Program for Education and Research in Biotechnology for her outstanding contributions as director of CSUF's Maximizing Access to Research Careers program and as a research mentor.

Peter de Lijser, professor of organic chemistry, is the new chair of the Department of Chemistry & Biochemistry. A member of the NSM faculty since 1999, his research includes mechanistic and kinetic studies of reactions involving radical and radical ion intermediates, rational drug design and synthesis, and structure/reactivity studies of drug candidates.

Adam Glesser, assistant professor of algebra, **Bogdan Suceava**, professor of differential geometry, and undergraduate **James Shade** co-authored the paper "On the Inverse Curvature Problem," which appeared in the May 2015 issue of *The College Mathematics Journal*.



Kathryn Dickson, professor of biological science, received the 2015 Distinguished Service Award from the American Institute of Fishery Research Biologists for her service as secretary and member of the board from 2009 to 2014.

Nilay Patel, associate professor of biological science, received a \$3 million grant from the California Institute for Regenerative Medicine to continue CSUF's Bridges to Stem Cell Research scholars program.



STUDENT SPOTLIGHT

THREE SCERP SCHOLARS WIN OUTSTANDING RESEARCH AWARDS

Southern California Ecosystems Research Program (SCERP) scholars **Velvet Park**, **Evelyn Ruelas**, and **Nathan Vega** were each recognized for their research. Park was honored for investigating the effects of wastewater outflow on the reproductive physiology of Pacific sanddabs (flatfish). Ruelas was honored for her work examining the reproductive morphology and physiology of black perch. Vega was recognized for investigating water uptake by leaves in coastal sage scrub plants.

GRADUATE STUDENT SHEDS LIGHT ON EXTINCT SPECIES

Geological sciences graduate student **Gabriel-Philip Santos** is the lead author of a study published in the *Journal of Vertebrate Paleontology* on desmostylians, an extinct group of herbivorous marine mammals that resemble hippos. For three years, Santos studied the partial jaw fossil of a desmostylian at the Cooper Center to determine the creature's age and growth. The fossil was found in Orange County in 1996.

MCNAIR SCHOLAR RECOGNIZED FOR PLANT PHYTOLITH RESEARCH

Ronald E. McNair scholar and psychology major **Jessica Sanchez**, who minors in biological science and chemistry, received a research presentation award for her investigation into the nature of organic carbon in plant phytoliths.

DUAL SCHOLAR ACKNOWLEDGED FOR MOLECULAR BIOLOGY STUDY

Molecular biology and biotechnology student **Carina Sandoval**, a Howard Hughes Medical Institute undergraduate research scholar and a Ronald E. McNair scholar, was honored for her research into how the tomato plant immune system works to detect and fight off infection from the tomato mosaic virus.

BIOLOGY GRADUATE STUDENT WINS TEACHING AWARD

For his hands-on and creative approaches to teaching general microbiology to undergraduates, **Kevin Chiem**, a biology graduate student, received the Crellin Pauling Student Teaching Award from the California State University Program for Biotechnology (CSUPERB). •



FORMER “MYTHBUSTERS” INSPIRE STUDENTS TO BE FEARLESS SCIENTISTS

Two Discovery Channel stars encouraged students attending the College of Natural Sciences & Mathematics’ “Realizing Reality: Shattering Expectations” symposium to embrace failure in order to learn – a philosophy they’ve followed in their quest to prove or disprove popular myths, misconceptions, and legends.

Jamie Hyneman and Adam Savage, who just wrapped up their 14-year run as hosts of the science entertainment show “MythBusters,” delivered the keynote address before a large audience of students, faculty, staff, and community members on March 17.

Answering questions from the audience and offering advice, the former TV hosts encouraged students to inquire, interact, and get involved in scientific pursuits whenever possible.

“Science is just another genre of storytelling,” Savage told the crowd, “just with more rigor.”

The symposium was presented by the NSM Interclub Council student organization, with support from the college, Cox Communications and LINN Energy. •



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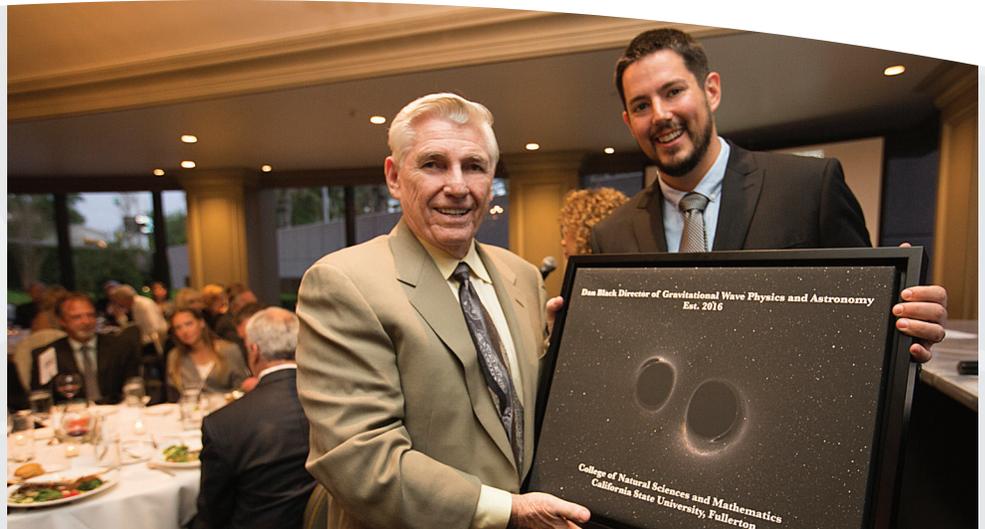
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Donor **Dan Black** (left) and **Josh Smith** (right) celebrate the establishment of a new GWPAC directorship.

NAMED DIRECTORSHIP ANNOUNCED AT GWPAC EVENT

Longtime Cal State Fullerton supporter and physics alumnus **Dan Black** ('67) established the first named directorship in the college with a three-year, \$225,000 gift presented at the “Gravitational Waves: Examining the Universe in a Whole New Way” event on April 7.

Josh Smith, associate professor of physics, will serve as the inaugural Dan Black director of the Gravitational-Wave Physics and Astronomy Center. Black's support will help advance the center's research, teaching, and outreach. •