

Sigma Xi Today

A NEWSLETTER OF SIGMA XI, THE SCIENTIFIC RESEARCH HONOR SOCIETY

Vote in the Sigma Xi Elections

Sigma Xi encourages active members to vote in the 2018 elections, beginning at 8:00 a.m. ET, on October 29. Active members will receive an email from elections@vote-now.com that day with instructions to vote online. The polls close at 11:59 p.m. ET, November 27.

Active members may vote for president-elect and other open positions in the region and constituency assigned to their chapter. Members-at-large vote for open positions in the Membership-at-Large Constituency.

Results will be posted on November 28 at www.sigmaxi.org. Contact the executive office with questions at elections@sigmaxi.org or (800) 243-6534.

The following positions are open:

- **President-elect**
- **Directors (three-year term)**
North Central Region (NC); Southwest Region (SW); Comprehensive Colleges/Universities Constituency (CM); Area Groups, Industries, State, and Federal Laboratories Constituency (MI)
- **Associate Directors (three-year term unless noted otherwise)**
Mid-Atlantic Region (MA); Northeast Region (NE); Baccalaureate Colleges Constituency (BA); Canadian/International Constituency (CI); Area Groups, Industries, State, and Federal Laboratories Constituency (two-year term) (MI)
- **Representatives for the Committee on Nominations (three-year term unless noted otherwise)**
Northwest Region (NW); Southeast Region (SE); Research and Doctoral Constituency (RD); Membership-at-Large Constituency (MAL); Baccalaureate Colleges Constituency (one-year term) (BA)

From the President

You're Invited to the Annual Meeting's Big Data Symposia

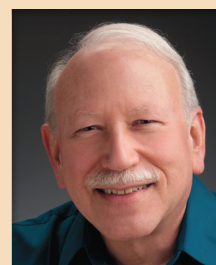
"Big Data and the Future of Research" is the topic of the 2018 Sigma Xi Annual Meeting and Student Research Conference this October in Silicon Valley, the global center for technology, venture capital, innovation, and social media. Big data has enabled major advances in science, as illustrated by many of the articles in this special issue of *American Scientist*. On October 26, symposia will start with a keynote talk by Steve Ritz, who is building the 3.2 gigapixel camera for the Large Synoptic Survey Telescope. Jeff Dean, head of Artificial Intelligence (AI) at Google, will deliver the other keynote talk about using big data to solve many of humanity's most challenging problems.

Big data is changing the nature of scientific research. Digital representations of large scientific data sets permit the identification of subtle patterns. Finding correlations that predict customer selections can be economically valuable even if the underlying causes are obscure. But such correlations are not enough for science; correlations do not prove causation. Understanding causal connections is essential—although the use of umbrellas correlates with rain, it does not follow that banning umbrellas will reduce the amount of rain. Some claim that correlations are scientifically valuable in themselves, but the choices of what data to collect and how to analyze it inevitably affect the implications that can be drawn. Sources of incompleteness and bias always need to be identified and avoided in order to draw robust conclusions.

Big data, and the use of AI to analyze it, raise new opportunities and new challenges. I've been impressed with how rapidly new tools such as convolutional neural networks can lead to new scientific achievements. The availability of new computing technology such as powerful graphic processing units has made non-linear and non-parametric analysis of big data not only possible but also relatively inexpensive. However, unequal access to big data can exacerbate inequality, because well-funded organizations are better able to collect and analyze large data sets. Data on human subjects inevitably involve privacy and ethics issues. New modes of analysis and visualization are needed—and are being developed.

At a conference at Asilomar in Pacific Grove, California, in 2017 many AI leaders adopted principles, including one that states, "Superintelligence should only be developed in the service of widely shared ethical ideals, and for the benefit of humanity rather than one state or organization." In June 2018, the California Assembly passed a resolution expressing the support of the Legislature for these principles as guiding values for AI development. The Annual Meeting is the next opportunity to discuss how researchers can respond to changes occurring due to big data.

Joel Primack



President Joel Primack

Learn more about the Big Data Symposia at www.sigmaxi.org/amsrc and on page 318.

Annual Meeting to Feature Symposium on Big Data in Physics and Astronomy



STEVE RITZ

Steve Ritz, on left, will be a plenary speaker at the Sigma Xi Annual Meeting. He is a professor of physics at University of California, Santa Cruz. Fred Adams, the Ta-You Wu Collegiate Professor of Physics from University of Michigan, will be a symposium speaker.

Thanks to advances in technology, researchers today have access to extremely large data sets that can be analyzed computationally to find patterns, trends, and associations. Sigma Xi will bring together the research community October 25–28 for its Annual Meeting and Student Research Conference to discuss how scientists and engineers can adapt to the big data era. The meeting, featuring Big Data and the Future of Research Symposia, will be at the Hyatt Regency San Francisco Airport in California.



FRED ADAMS



FRANK SUMMERS

Symposium speakers include Frank Summers, on left, an outreach astrophysicist with the Space Telescope Science Institute, and Risa Wechsler, a cosmologist and associate professor of physics at Stanford University.

One of the three symposia will focus on big data in physics and astronomy. Plenary speaker Steve Ritz is a subsystem scientist for the camera on the Large Synoptic Survey Telescope, which is expected to observe 20 billion galaxies in its first decade of operation. Other symposia will focus on big data in biology and medicine and big data in climate, energy, and the environment.



RISA WECHSLER

To learn more, visit www.sigmaxi.org/amsrc.

Procter Prize Winner Unlocked Viruses' Secrets



Anna Marie Skalka will speak at the Sigma Xi Annual Meeting about her research on retroviruses.

Viruses are villains in the biology world, and a class called retroviruses is particularly sinister. Retroviruses

use their RNA to create DNA and then uniquely integrate their DNA into the DNA of a host cell, infecting the cell for the rest of its life. The human immunodeficiency virus (HIV) is a retrovirus, for example, and retroviruses can cause cancer.

A biologist who dedicated much of her career to studying retroviruses will receive Sigma Xi's 2018 William Procter Prize for Scientific Achievement. Anna Marie (Ann) Skalka is professor emerita at Fox Chase Cancer Center; she served as the senior vice president for basic science at the center from 1987 to 2008. She will accept her prize and share stories from her research October 27 at the Annual Meeting and Student Research Conference near San Francisco, California.

Skalka and her collaborators, first at the Roche Institute of Molecular Biology and later at Fox Chase,

provided a basic understanding of the structures and functions of retroviral proteins, revealing how they insert genetic material into the host genome and replicate. The proteins include reverse transcriptase, which makes DNA from RNA; integrase, which splices DNA into the host genome; and protease, a critical player in viral reproduction. Skalka's team delineated the basic properties of protease and integrase, paving the way for pharmacologists to develop antiviral protein inhibitors.

Skalka is also a science communicator who served on advisory boards such as the U.S. Defense Science Board, and she is chair emerita of the New Jersey Commission on Cancer Research. She is one of the authors of the textbook *Principles of Virology*, and she wrote *Discovering Retroviruses: Beacons in the Biosphere*, which will be released to the public in September.

Young Investigator is Enhancing Materials Science

Why look at a picture if you can watch a video? Until just more than a decade ago, materials scientists had only snapshots. They had diffraction to send electrons through a material and watch what happens to its structure, like ripples scattering off pebbles in a pond. They could use transmission electron microscopes to take images of atoms. Now, ultrafast electron microscopy (UEM) allows scientists to take hundreds, or even thousands, of images that show extraordinarily fast nanoscale processes essentially happening in real time, such as how energy moves through solids.

Dave Flannigan, an associate professor and director of Undergraduate Studies for Materials Science and Engineering at University of Minnesota (U of M), is the recipient of Sigma Xi's 2018 Young Investigator Award for his contributions to UEM. He will



Dave Flannigan uses ultrafast electron microscopy to study processes occurring essentially in real time at the nanoscale level.

He will speak about his research October 27 at the Society's Annual Meeting.

Flannigan spent his postdoctoral days under the guidance of Nobel laureate and UEM pioneer Ahmed Zewail at California Institute of

Technology. Flannigan was the first to use UEM to image the dynamics of materials that had molecules as their constituents. He also co-developed a new imaging technique called photon-induced near-field electron microscopy that couples photons with electrons to record transient electric fields around nanoscale materials, and he was the first to extend this method to organic and biological materials. He later helped establish the first commercially available ultrafast electron microscope at U of M.

Flannigan is now using UEM to fill in fundamental gaps in our understanding of materials science. All materials have defects and impurities, and he hopes that one day UEM will help scientists use them as an advantage, such as to better control heat dissipation on a computer chip to improve computing speed.

Innovation Award Winner Wrote Popular Research Algorithms



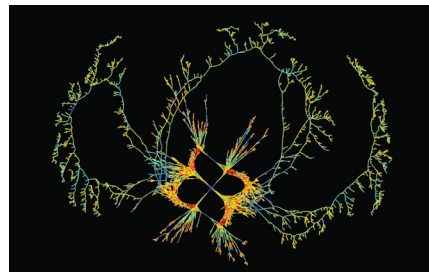
Tim Davis's algorithms are incorporated into MATLAB and Linux.

Scientists and engineers need math—a lot of it—to solve much of the work done in research. And with data sets growing in size, researchers need more efficient algorithms to support their work. Luckily, they have Tim Davis, a professor of computer science and engineering at Texas A&M University, whose algorithms are incorporated into MATLAB and Linux and widely

used in laboratories. Davis, who will receive Sigma Xi's 2018 Walston Chubb Award for Innovation for the algorithms he created, will speak October 26 at the Society's Annual Meeting and Student Research Conference.

One of Davis's specialties is sparse matrix algorithms, which crop up in many research areas. These matrices represent systems of equations with many more zeros than nonzeros. Davis writes tens of thousands of lines of code for algorithms that solve equations on a scale of millions of rows at a time. A hallmark of his code is its reliability, speed, and efficiency for solving sparse matrix problems.

His solvers are installed on a half billion smartphones, and are used to place images in Google Street View and map Mars faster than possible before. In 2015, his code helped the FBI rescue six girls from human trafficking. He recently developed the code behind GraphBLAS, an open-source library from a collaboration that aims to support big data analytics



Tim Davis writes algorithms that visualize the structure of music into art. This is his interpretation of *Fantasia Apocalyptic* by Donald Knuth.

by standardizing the building blocks for creating graph algorithms.

When he's not writing research software, Davis creates algorithms that visualize the structure of music as a song is played.

"With my algorithmic translation of music into artwork, I can give everyone a glimpse into the beauty of mathematical software," Davis said.

Sigma Xi Today is
written by Heather Thorstensen
and designed by Justin Storms.

Student Research Grant Applications Due October 1

Sigma Xi invites undergraduate and graduate students to apply for a research grant by October 1. The Grants-in-Aid of Research (GIAR) program application is available at www.sigmaxi.org/programs/grants-in-aid. Awards in this cycle will be dispersed in January 2019.

GIAR application deadlines are March 15 and October 1 each year.

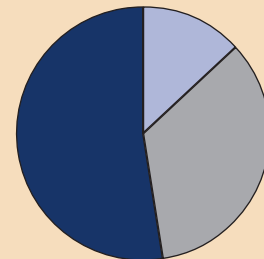
In the spring 2018 cycle, GIAR awarded approximately \$191,000 to nearly 200 students. These undergraduate students, master's degree students, and doctoral candidates from nine countries are using their

grants to tackle a diverse set of projects, from understanding stardust to investigating the effects of larvicides.

Funds from the National Academy of Sciences and from gifts make the grants possible. GIAR funded 20 percent of the grant applications received in the previous cycle, but it could award more grants in future cycles if the program receives more donations. Sigma Xi is committed to strengthening the GIAR program, which has awarded student research grants since 1922. To make a gift to GIAR, go to www.sigmaxi.org/support-giar.

Grants Awarded by Education Level

Spring 2018



■ 26 undergraduates
■ 68 master's students
■ 103 doctoral candidates

Citizen Science Champion To Receive McGovern Award

Behavioral ecologist and Sigma Xi member Dan Rubenstein is changing the game of animal conservation with the power of citizen science and big data. Rubenstein, who will receive Sigma Xi's 2018 John P. McGovern Science and Society Award, will speak about his research October 27 at the Society's Annual Meeting and Student Research Conference.

Rubenstein, of Princeton University, studies the Grevy's zebra in Kenya, an endangered species with a population of approximately 2,800 in that country. They were overhunted and outcompeted for water and vegetation over the last 50 years because livestock producers wanted the natural resources only for their animals.

To gain citizen support, Rubenstein and his collaborators hired local people as scouts to observe zebras. Scouting provided good income, which convinced communities to share their landscape with the equids.

In 2016, 150 people participated in the first Great Grevy's Rally. They drove the zebras' range and took photos of all the Grevy's zebras they saw, producing 40,000 images. In January 2018, 250 people participated in the second rally and captured 60,000 images.

"By working with people and making them partners in the process of gathering data, they actually believe the numbers," Rubenstein said. This makes a difference when developing conservation policy.

A computer program reads the photos to find an animal. Then software that Rubenstein helped develop with computer scientists, Wildbook, analyzes the data, determines if the animal is known or unknown, and records a zebra's sightings by using its stripes as a natural barcode.

"You get a much fuller picture of the dynamics of the population, and a better understanding of what might be causing problems in relation with people," Rubenstein said, "but also in terms of what is going to benefit them."



Dan Rubenstein, third from left, is director of the Program for Environmental Studies and professor of zoology at Princeton University. (Photo courtesy of Victor Kasii, @mpalalive.)