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AMERICAN Scientist

July–August 2018

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only to vanish?

SIGMA XI

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Sigma Xi Today

A NEWSLETTER OF SIGMA XI, THE SCIENTIFIC RESEARCH HONOR SOCIETY

Barry University Chapter Celebrates 20th Anniversary

Two decades ago, founding members of the Barry University Sigma Xi Chapter in Miami, Florida, signed their charter. It was the same year that Google was incorporated and assembly began for the International Space Station.

The chapter marked their 20th anniversary in the spring with a dinner, induction ceremony of two new members, recognition of nine of their 30 founding members who are still involved in the chapter, and a presentation by Andres Pena, a graduate student at Florida International University, who discussed bioethics and his neurotechnology research.

In a video message, Sigma Xi Executive Director and CEO Jamie Vernon congratulated the chapter on inducting nearly 200 members over 20 years.

“You’ve strengthened the research community at your university by sponsoring symposia, and judging at science fairs, as well as celebrating a number of significant science holidays, including Darwin Day and DNA Day,” Vernon said.

Chapter president Stephanie Bingham plans to encourage more collaborations among members.

“It is my hope that we will build a collaborative science culture within our chapter by increasing opportunities for dialogue and sharing of ideas,” she said.

See more chapter achievements on page on 255.

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

From the President

I am excited to serve as president of Sigma Xi. Our highest priorities are promoting the value of research, science education and outreach, and the importance of fact-based decision making. Education in science and technology at all levels needs to be improved to produce the next generation of knowledgeable citizens as well as future scientists and engineers.

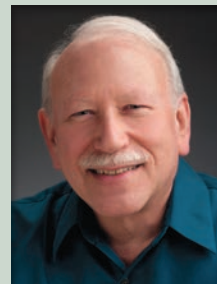
I want Sigma Xi to pursue two new initiatives, which I have been developing as president-elect with help from Sigma Xi Chief Executive Officer Jamie Vernon and others. Both initiatives will require new funding sources, and both could involve collaborations with like-minded organizations such as the American Association for the Advancement of Science (AAAS).

First, we propose to host dialogues about important policy questions for which scientific information is crucial. Each dialogue will start by identifying the key areas of agreement and disagreement—and for each disagreement the participants will be challenged to explain why they disagree. This may be not only because the underlying science is partly uncertain, but also because the participants have different assumptions about nonscientific aspects of the policy issue. By making this transparent, these dialogues can model how to inform policy decisions despite scientific uncertainty and other disagreements. We aim to make these dialogues educational and attractive to a large audience by sometimes using celebrity scientists and engineers as participants or by inviting celebrities as moderators. An ideal example might be a dialogue between Elon Musk and Neil deGrasse Tyson on the priority of sending many people to Mars, moderated by Matt Damon (star of *The Martian* movie). Other possible topics include human germline modifications, biosafety, robotics vs. jobs, universal preschool, coastal responses to sea-level rise, and the future of nuclear power.

Secondly, we propose to expand the Distinguished Lectureships Program to include younger and more diverse scientists, who are chosen for being especially effective at reaching broad public audiences. Sigma Xi could create a speakers bureau to help find audiences and media opportunities for these lecturers and curate high-quality science videos for a broad audience.

We welcome volunteers to help design both programs and assist with developing sustainable business models. We would also like to see a robust and active network of local chapters facilitate these initiatives, and we will continue our efforts to rejuvenate those chapters that have become inactive.

The **2018 Sigma Xi Annual Meeting** near San Francisco on October 25–28 will bring together researchers from many fields to collaborate, provide mentorship, share best practices, and discuss the societal benefits of their work. This year’s theme is Big Data and the Future of Research, featuring outstanding keynote speakers and Sigma Xi award winners. I encourage you to submit an abstract and attend this informative event.



Joel Primack

Joel Primack
Joel Primack

EXOPLANETS * CITIZEN SCIENCE * SUPERNOVAS
DARK MATTER * GALAXIES * DIAMOND WORLDS

SPECIAL ISSUE

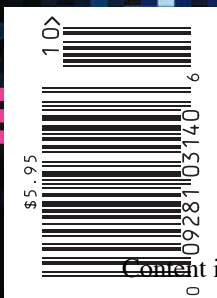
AMERICAN Scientist

September–October 2018

www.americanscientist.org

BIG DATA takes on THE UNIVERSE

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Sigma Xi Today

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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:

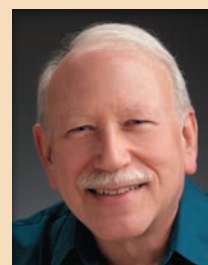
- **President-elect**
- **Directors (three-year term)**
North Central Region (NC); Southwest Region (SW); Comprehensive Colleges/Universities Constituency (CM); Area Groups, Industries, State, and Federal Laboratories Constituency (MI)
- **Associate Directors (three-year term unless noted otherwise)** 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)

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

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.



Joel Primack

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 casual 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

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

Aquariums misrepresent
OCEAN POLLUTION

Will rising sea levels put the
INTERNET UNDER WATER?

The complicated history of
COLLECTING SPECIES

AMERICAN Scientist

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rural legends from
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Award Nominations Deadline

The public may submit nominations by December 1 for Sigma Xi's 2019–2020 prizes and awards program, which recognizes major achievements in science, engineering, and science communication. Most awards include an honorarium and an invitation to present a lecture at the Sigma Xi Annual Meeting. To submit a nomination for the following honors, see www.sigmaxi.org/awards.

- The **William Procter Prize for Scientific Achievement** is presented to a scientist who made an outstanding contribution to scientific research and demonstrated an ability to communicate this research to scientists in other disciplines.
- The **John P. McGovern Science and Society Award** is for an individual who has made an outstanding contribution to science and society.
- The **Walston Chubb Award for Innovation** honors and promotes creativity among scientists and engineers.
- The **Young Investigator Award** recognizes excellence in research by an active member of Sigma Xi within 10 years of his or her highest earned degree.
- The **Evan Ferguson Award for Service to the Society** recognizes outstanding service to the Society and its mission.
- **Honorary Membership** is given to distinguished individuals not otherwise eligible for membership in Sigma Xi and who have served science, or the Society, in a manner that deserves recognition.

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From the President

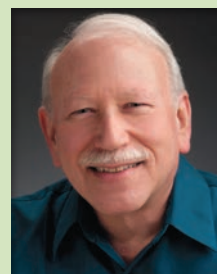
Defending the Scientific Process

Will key theories of modern science, including Darwinian evolution in biology and Einsteinian relativity in physics, survive future discoveries? Some people think such survival is impossible, because they believe that new scientific theories always overthrow the previous theories. This misunderstanding has been fostered in part by a famous book first published in 1962—Thomas Kuhn's *The Structure of Scientific Revolutions*, which argued that scientific research proceeds for long periods of time within a certain manner of thinking (a "paradigm"), until too many pieces of evidence have turned up that are unexplainable or even paradoxical. Then suddenly there is a great leap (a "paradigm shift"): The old theory is abandoned for a new theory that explains much more, and the old paradoxes disappear. The concepts of the new theory are so different from the concepts of the old one that they are "incommensurable," because the implicit assumptions have changed. For example, after the Copernican Revolution, when scientists abandoned the idea that the Earth was the immovable center of the universe, the Earth became a planet and the status of the Sun and Moon changed. The old theory was overthrown and never again taught as science.

Kuhn, whose first book was on the Copernican Revolution, appears to have assumed that all scientific revolutions are like that one. His argument implies that no scientific theory can ever be considered true, because it will eventually be overthrown by a bigger and better theory. Because the new theory will eventually be overthrown in its turn, it is ultimately no truer than the old one (even though it is temporarily more useful), so it is questionable whether science actually progresses; perhaps it just keeps changing.

But revolutionary scientific theories do not have to overthrow their predecessors except in the earliest stage of a science, when a scientific theory is replacing earlier ideas that were not well supported by evidence. Once a field of science undergoes the revolution that creates for it a solid intellectual foundation—like the ones that Newtonian mechanics gave physics and Darwinian evolution gave biology—that foundational theory can stand forever. Science then progresses by encompassing the foundational theory in a new and larger theory that explains things beyond the ken of the older theory. An encompassing theory does not overthrow the older theory—instead, it defines the limits within which the older theory is reliably true. Science does not simply toss one theory out for another: it makes real progress toward ever-larger truths. But there is a built-in enforcer of humility in science: We cannot regard something as true until we know about something bigger.

Have you encountered science skeptics who say that scientific research can't be trusted because its theories are constantly changing? If so, what has been your response? Let me know at executiveoffice@sigmaxi.org.



Joel Primack

Joel Primack

Rethinking how we
MANAGE WILDLIFE

The long, twisted path to
DATA SECURITY

Chemical reactions from
WIGGLING MOLECULES

AMERICAN Scientist

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Abstracts Accepted for the Student Research Showcase

Students can submit an abstract by February 22 for the 2019 Student Research Showcase, Sigma Xi's online science communication competition. The seventh annual online competition will challenge high school through graduate school students to create a website containing a slideshow, video, and abstract about their research.

The showcase accepts students with research projects in the following categories: agriculture, soil, and natural resources; anthropology; cell biology and biochemistry; chemistry; ecology and evolutionary biology; engineering; environmental sciences; geosciences; human behavioral and social sciences; math and computer science; microbiology and molecular biology; physics and astronomy; and physiology and immunology.

Students whose abstracts are accepted must submit presentation websites and register by March 22, and judging will occur April 15–29. Judges will select the top presenters in the high school, undergraduate, and graduate divisions; each winner will receive awards up to \$500. Judges will also select top presenters in each research category. A public vote will select one presentation for a \$250 People's Choice Award. All participants receive a certificate of participation. Sigma Xi members are invited to serve as judges. Participating students receive feedback from professional researchers. They also develop science communication skills by crafting pieces of their presentation for different audiences, from the technical to the nontechnical.

Learn more at www.sigmaxi.org/srs.

From the President

Developing Scientific Intuition

Experienced scientists can often quickly guess the likely answers to scientific questions. They may even have good judgment regarding the promise of new avenues of research. Such intuition, together with broad knowledge, can make their scientific careers more successful and allow them to provide helpful guidance to junior researchers.

How can such intuitive understanding be nurtured? I was fortunate to have had a wonderful professor in honors freshman physics, John Archibald Wheeler, who taught not only physics but also how to develop one's scientific intuition. Wheeler's rule was that when confronted with any scientific question, even just a homework problem, first make a guess about the answer before working it out in detail or learning the answer in some other way. Then keep track of how well the guess agreed with the correct answer. After many years of doing this, a scientist can become quite good at prediction in his or her field.

In his book *Thinking, Fast and Slow*, the eminent psychologist Daniel Kahneman warns about overreliance on intuition. Such fast thinking can easily go astray, leading to incorrect assertions based on too little information. Associative memory can generate compelling intuitions that are false, so subjective confidence is not a good diagnostic of accuracy. People are particularly bad at statistical thinking, which requires careful weighing of evidence by the slower analytic mind.

Kahneman describes an "adversarial collaboration"—in which experts who disagree on the science agree to do research and write a jointly authored paper—he had with Gary Klein, whose book *Sources of Power* analyzed how experienced professionals develop intuitive skills. Klein had studied decision making by people such as firefighters who can acquire reliable skill at what they do, whereas Kahneman had studied people such as financial stock pickers who try to make decisions about nearly random phenomena. Although Kahneman and Klein had developed different attitudes, emotions, and tastes that changed little over the years of their collaboration, they ultimately agreed on the criteria that determine whether intuition can be trusted. The ability depends on whether the subject under study is sufficiently regular to be predictable and whether a person has had an opportunity to learn these regularities through prolonged practice.

For a field to be considered scientific, its predictions must generally be confirmed. It is precisely in such scientific fields that experience can lead to reliable expert intuition. But this process doesn't happen by accident; just as Wheeler taught, developing reliable scientific intuition requires people to pay careful attention and keep track of the success of their initial guesses. Thus combinations of fast and slow thinking about many examples can help scientists develop intuitive understanding of their fields.



Joel Primack

Joel Primack

Stretchy mechanics of
KNITTING PHYSICS

How industrialization led to
CROOKED TEETH

Why we might need less
TRUST IN ROBOTS

AMERICAN Scientist

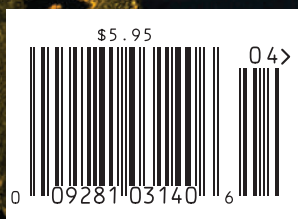
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marshlands

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Students Are Invited to Apply for Research Grants

The Sigma Xi Grants in Aid of Research (GIAR) program has been funding students' research for nearly 100 years. The grants may be used for travel to a research site or to purchase nonstandard equipment for a specific project. Undergraduate and graduate students who would like to apply may do so at www.sigmaxi.org/giar. Two review periods take place each year, with application deadlines of March 15 and October 1.

The Committee on Grants in Aid of Research, chaired by Peter J. Harries of North Carolina State University, selected 97 students for funding in the fall 2018 review period. This represented 12 percent of the applications received. The awardees were 17 undergraduate students, 24 master's degree students, and 56 doctoral candidates from six countries. Collectively, they received \$87,696. A list of the recipients is available at www.sigmaxi.org/2018grantsfall. Sigma Xi thanks the 27 volunteers who reviewed the 810 applications in this cycle.

Designated funds from the National Academy of Sciences (NAS) and donations allow the program to provide grants in a range of research categories. Some NAS funds are designated for up to \$5,000 for astronomy research or up to \$2,500 for vision-related research. The program is seeking more applications related to meteorites or space.

Donations to GIAR may be made at www.sigmaxi.org/support-giar.

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

From the President

Sigma Xi Members Can Fight Climate Change

Sigma Xi members have a special role to play in staving off the worst effects of climate change. The Society has adopted a statement on climate change, which opens with a description of its effects:

Scientific evidence continues to confirm that human activities are contributing to the warming of our planet. . . . Left unresolved, the impact on ecosystems and human quality of life may be devastating.

The statement concludes with a call for action:

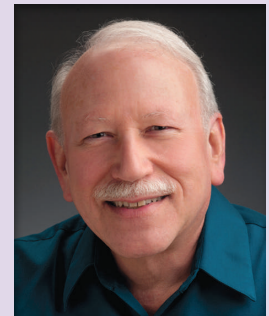
Sigma Xi's commitment to improving the human condition through science and engineering necessitates that we call on national and international leaders to pursue aggressive actions to reduce carbon emissions and to develop adaptive measures. . . .

Making decisions based on evidence is increasingly important as humanity faces urgent interconnected global problems, including accelerating species extinction. But we are seeing more and more the difference between scientific and political approaches to veracity. As the physicist Leo Szilard wrote in his 1961 story, "The Voice of the Dolphins,"

When a scientist says something, his colleagues must ask themselves only whether it is true. When a politician says something, his colleagues must first of all ask, "Why does he say it?"; later on they may or may not get around to asking whether it happens to be true.

Unlike most politicians, many scientists and engineers are themselves technical experts on important public issues. And all scientists learn how to read and evaluate the scientific literature, in order to judge which claims should be taken seriously. As a consequence, we scientists have a special responsibility to improve the use of reliable information in making crucial public decisions.

With newly elected members of the U.S. House of Representatives and Senate, scientists will have new opportunities to educate Congress and the general public about public issues that have significant scientific components. This is a challenge that Sigma Xi is well positioned to meet, with our many thousands of members and hundreds of chapters in colleges, universities, and laboratories across the nation. Now is a good time to get to know your local members of Congress and discuss issues with them. Invite them to visit your campus or laboratory. It is also a good time to educate your neighbors—by giving talks, writing letters to the editor and op-ed essays, and posting information on social media. It is crucial that citizens understand the urgent need to take action to address humanity's global challenges.



Joel R. Primack

Joel R. Primack

Read Sigma Xi's full climate change statement at www.sigmaxi.org/climatechange.

Olive oil source of natural
ANTI-INFLAMMATORIES

The daring programmers of the
APOLLO COMPUTERS

The complicated truth of
INSECT POPULATIONS

AMERICAN Scientist

May–June 2019

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Bridging Habitats

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fragments can save
species threatened
by extinction



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Sigma Xi Today

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Sigma Xi Members to Elect Leaders

Sigma Xi seeks qualified candidates for three-year positions to represent the following regions and constituencies, or to run for president.

President: for a three-year term of president-elect (July 1, 2020–June 30, 2021), president (July 1, 2021–June 30, 2022), and immediate past president (July 1, 2022–June 30, 2023).

Board of Directors (serving July 1, 2020–June 30, 2023)

- Research and Doctoral Universities Constituency
- Membership-at-Large Constituency
- Mid-Atlantic Region
- Northeast Region

Associate Directors (serving July 1, 2020–June 30, 2023)

- Area Groups, Industries, State, and Federal Laboratories Constituency
- Comprehensive Colleges and Universities Constituency
- Northwest Region
- Southeast Region

Representatives on the Committee on Nominations (serving November 2019–November 2022)

- Baccalaureate Colleges Constituency
- Canadian/International Constituency
- North Central Region
- Southwest Region

Visit www.sigmaxi.org/2019-elections for nomination requirements. Send nomination packages as a PDF or text file to elections@sigmaxi.org by May 1. All active members are eligible to vote in the online election, which will begin on November 18.

Sigma Xi Today is managed by Heather Thorstensen and designed by Dena Verdesca.

From the President

Creating a Favorable Future

In my last president's letter for Sigma Xi, I want to think long term. After all, I'm a cosmologist.

We owe our children and grandchildren a livable world. Since 1800, humanity's growth in resource use has had a doubling time of about 30 years. We humans are now changing the climate and other properties of the Earth in ways that will have consequences far into the future.

We must control this exponential growth on the timescale of the next doubling, about 30 years—the timescale of a generation. I believe that Sigma Xi researchers can help to do this as well as help an increasing fraction of the population to understand the necessity of addressing this issue. I have proposed an expanded Sigma Xi speaker program for researchers to deliver talks that might help more people understand what science is and why scientific knowledge is essential to creating a desirable future.

We need to think differently about the future. The following is a thought experiment from *A God That Could Be Real: Spirituality, Science, and the Future of Our Planet* by my wife, Nancy Ellen Abrams (Beacon Press, 2016), in the chapter on how to become a revered ancestor:

Economics tells us to discount the present value of any good that won't appear or any event that won't occur for a long time. Misapplying this formula to human beings, we discount the value of their lives, treating people of the future like some kind of low-probability event, barely worth worrying about. To see how crazy that is, imagine if we knew that the present generation would have a normal life but shortly after we die the entire human race would go extinct. Life would lose its meaning! What would be the point of everything we do or create, from raising a child to making a scientific discovery or starting a company? We need those future people *now*. To them we owe a spiritual debt for making our lives worthwhile.

One way to help create a favorable future world is to support organizations such as Sigma Xi. Nominate promising young researchers for associate membership, reinvigorate chapters, and attend the next Annual Meeting. Developing a theme for our Annual Meeting—in 2018 it was Big Data and the Future of Research—was a big success, with more member and sponsor participation than in recent history. The theme for the 2019 Annual Meeting, which will be held November 14–17, in Madison, Wisconsin, will be Our Changing Global Environment: Scientists and Engineers Designing Solutions for the Future. Join us, and help make a difference for the future.



Joel R. Primack

Joel R. Primack