An Interview With NAE's New President

Medications to Treat Opioid Use Disorder Save Lives

Landmark Report Celebrates 10 Years of Impact

A Roadmap to Cutting Child Poverty in Half

THE NATIONAL ACADEMIES

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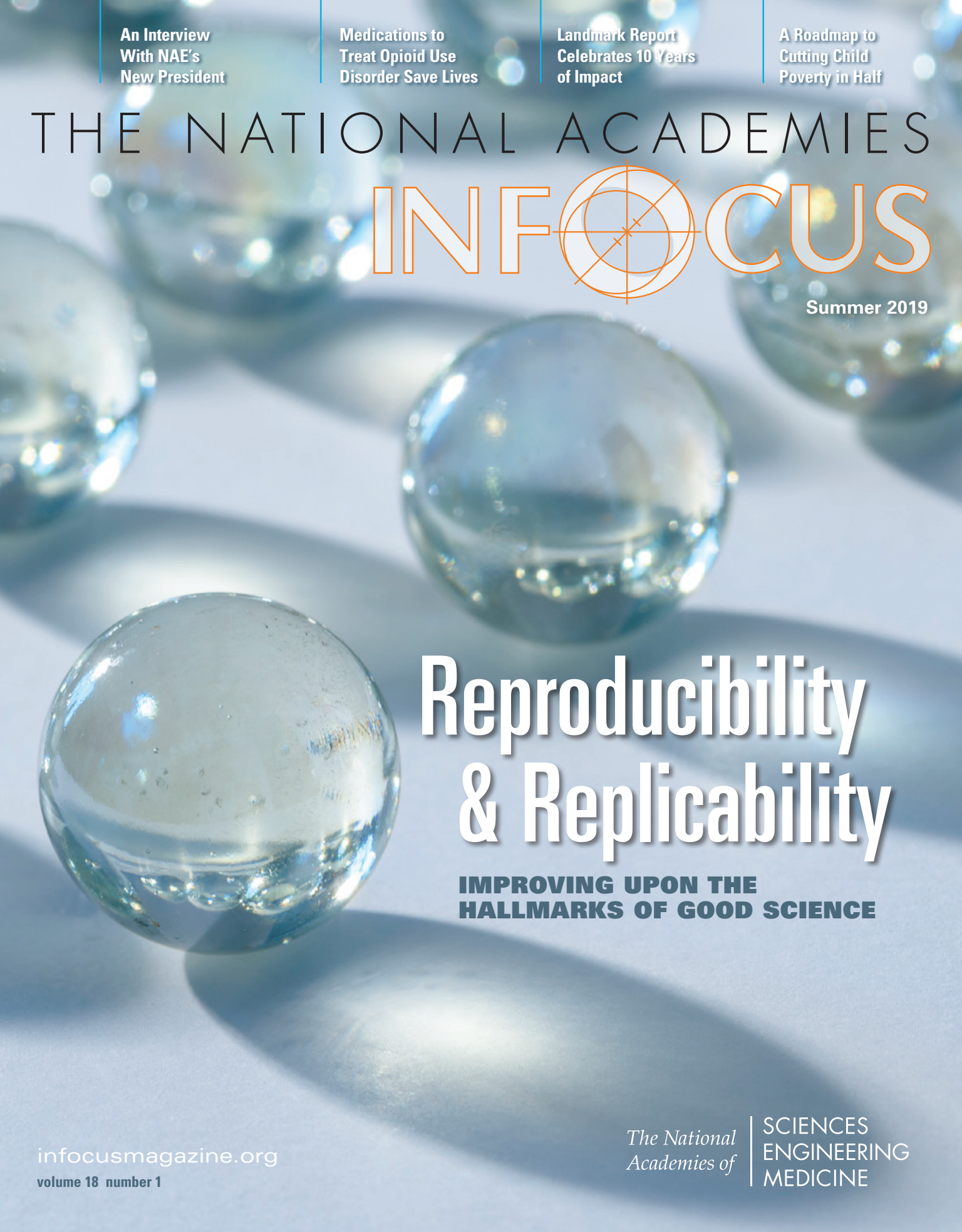
Summer 2019



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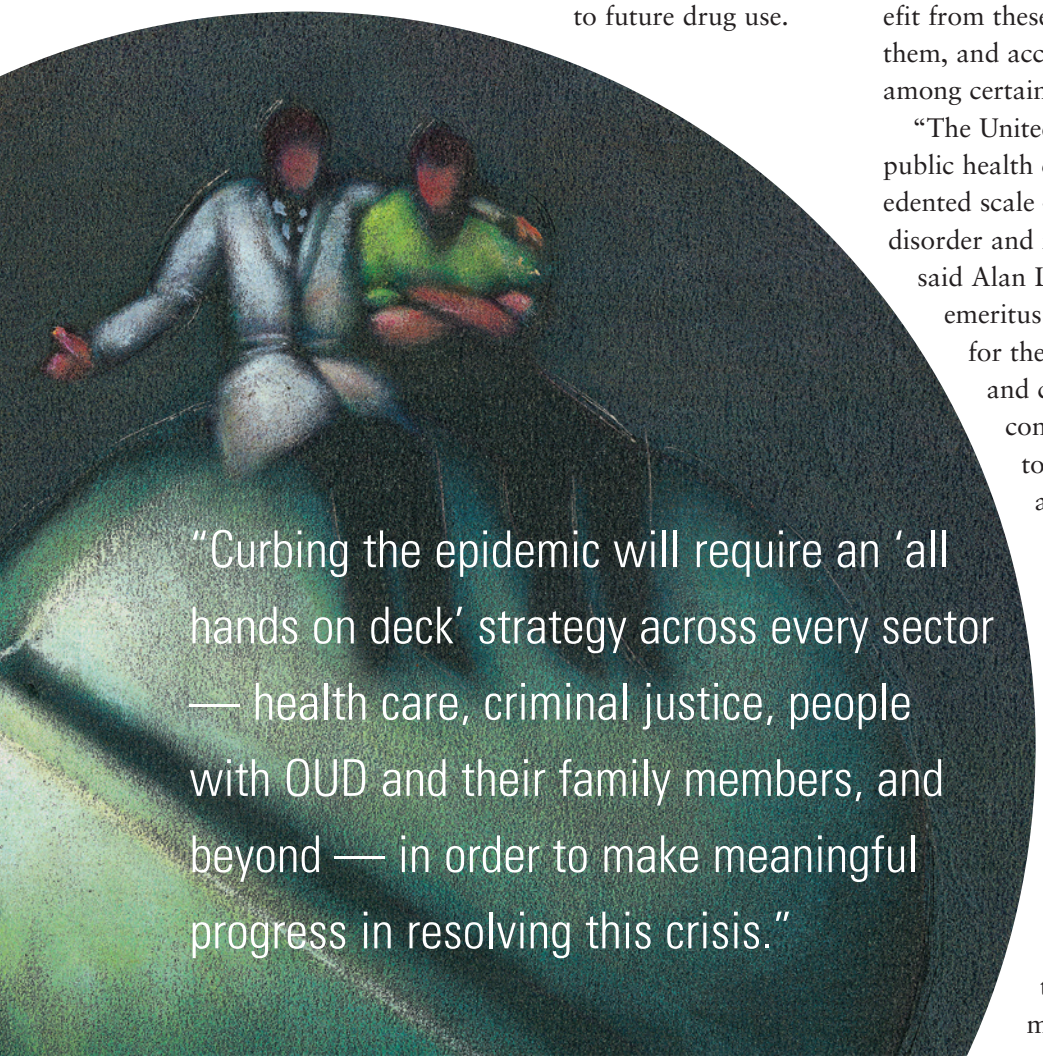
In the Struggle Against Addiction, MEDICATIONS to Treat Opioid Use Disorder SAVE LIVES

The U.S. is grappling with a devastating crisis in which opioid addiction and overdose are destroying individual lives and eroding the health and prosperity of entire families and communities. More than 2 million people in the United States are estimated to have opioid use disorder (OUD), a life-threatening condition associated with a twentyfold greater risk of death due to overdose, infectious disease, trauma, or suicide. In 2017, 47,000 people in the United States died as a result of opioid overdoses.

OUD is a chronic brain disease resulting from changes in neural structure and function that are caused over time by repeated use of prescription opioids or illicit opioids such as heroin. While stopping opioid misuse is extremely difficult, there are medications that can help normalize brain structure and function. Methadone, buprenorphine, and extended-release naltrexone — all approved by the FDA to treat OUD — work by alleviating withdrawal symptoms, reducing opioid cravings, or decreasing the response to future drug use.



"Curbing the epidemic will require an 'all hands on deck' strategy across every sector — health care, criminal justice, people with OUD and their family members, and beyond — in order to make meaningful progress in resolving this crisis."

Patients who receive medications to treat OUD are less likely to die from overdose or other causes related to their addiction, have higher treatment retention rates and better long-term outcomes, and are also less likely to inject drugs and transmit or contract infectious diseases. Risk of death is cut in half for people with OUD who are treated long term with methadone or buprenorphine.

A recent National Academies report says that although these medications are safe and effective, most people who could benefit from these treatments do not receive them, and access is inequitable, especially among certain groups of users.

"The United States is experiencing a public health crisis of almost unprecedented scale — an epidemic of opioid use disorder and related overdose deaths," said Alan Leshner, chief executive officer emeritus of the American Association for the Advancement of Science, and chair of the committee that conducted the study. "The factors impeding full use of FDA-approved medications to treat OUD must be addressed, including stigma surrounding both addiction and the medications used to treat it, as well as counterproductive ideologies that consider addiction simply a failure of will or a moral weakness as opposed to understanding that opioid use disorder is a chronic disease of the brain that requires medical treatment. Curbing the epidemic

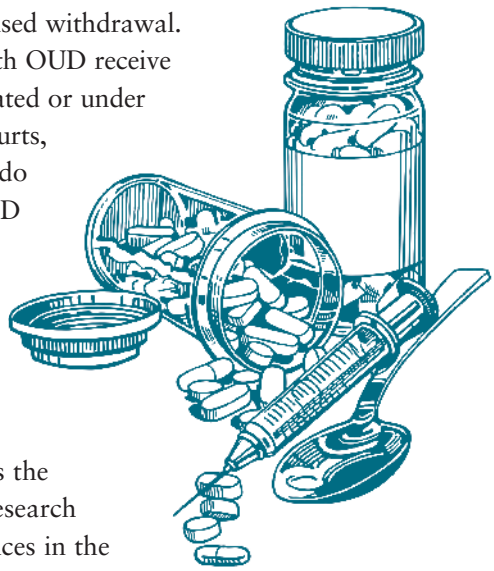
will require an 'all hands on deck' strategy across every sector — health care, criminal justice, people with OUD and their family members, and beyond — in order to make meaningful progress in resolving this crisis."

As the number of people with OUD surges, the need for treatment far exceeds the rates at which people receive it. Major barriers to the use of medications to treat opioid use disorder include inadequate education and training of the professionals responsible for working with people with OUD; a fragmented system of care; and current financing and payment policies. Moreover, regulations around methadone and buprenorphine, such as waiver policies, patient limits, restrictions on treatment settings, and other policies that are not supported by evidence or employed for other medical disorders, obstruct the use of these medications.

In addition, access to medication-based treatment is inequitable among certain subpopulations — for example, adolescents and young adults, people in rural areas, and racial and ethnic minority groups — even though evidence supports the effectiveness of treating OUD with medication in all populations, including adolescents, pregnant women, and people with comorbidities.

In terms of treatment settings, methadone can only be administered in the U.S. through federally approved opioid treatment programs, but evidence shows that delivering it through an office-based medical practice is also effective. Most residential treatment facilities do not offer medications, and if they do, they rarely offer all three medications. Pharmacies, mobile medication units, community health centers, emergency departments, and other care settings provide opportunities to engage people with OUD and connect them with effective care, the report says.

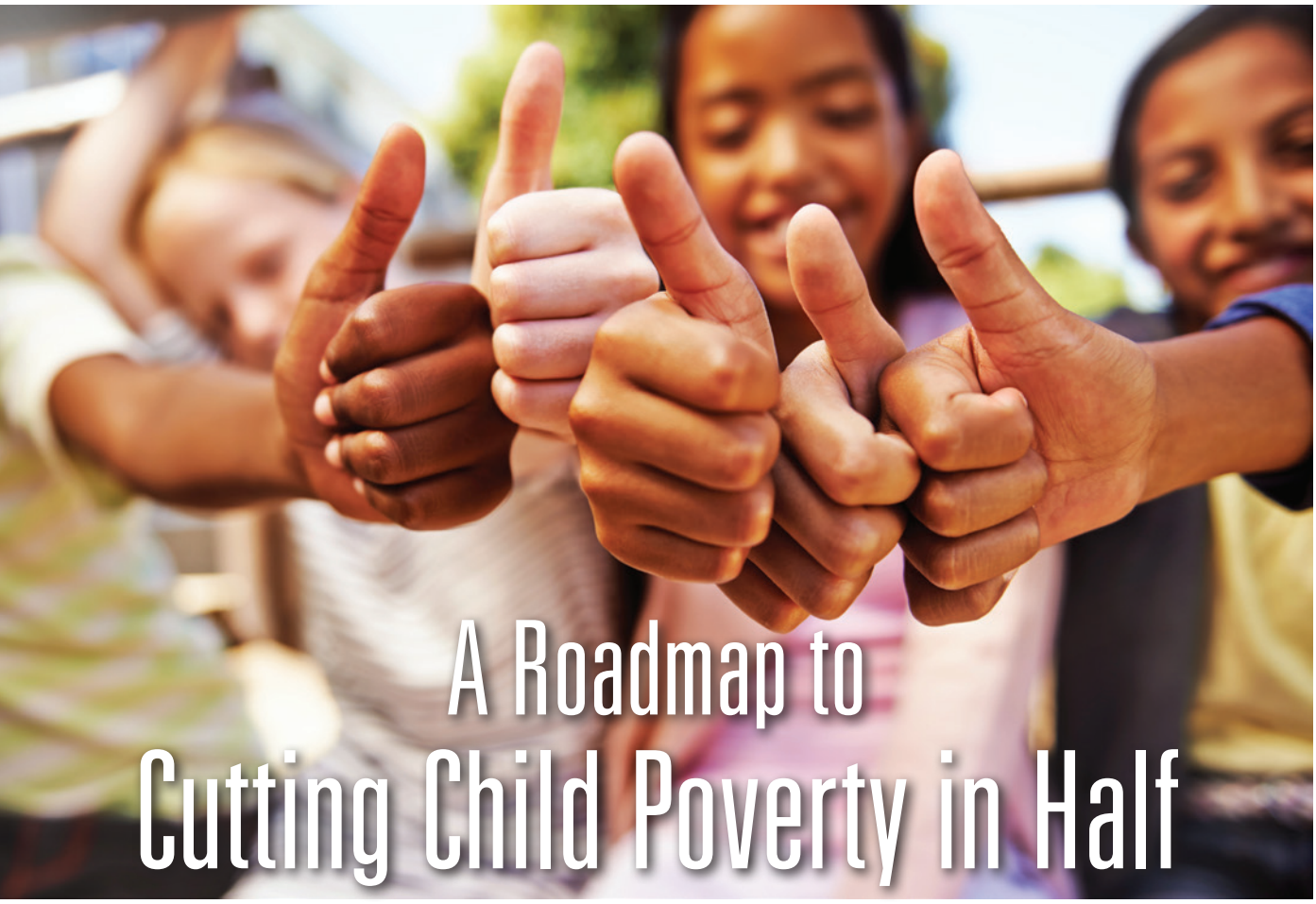
Despite the large and increasing numbers of people with OUD entering the U.S. criminal justice system, medications are often withheld or only provided on a limited basis for medically supervised withdrawal. As a result, few people with OUD receive medication while incarcerated or under the supervision of drug courts, and frequently those who do receive medication for OUD are not connected with care upon their release, leading to treatment discontinuation and the associated risks of overdose and death.



To more widely address the opioid crisis, additional research will be needed on differences in the nature of OUD in subgroups, as well as determining behavioral therapies that can help maximize positive outcomes.

— *Dana Korsen*

Medications for Opioid Use Disorder Save Lives (2019, 174 pp., ISBN 978-0-309-48648-4) is available from the National Academies Press, tel. 1-800-624-6242; $55.00 plus $7.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/25310>. The study was sponsored by the Substance Abuse and Mental Health Services Administration and the National Institute on Drug Abuse of the National Institutes of Health.



A Roadmap to Cutting Child Poverty in Half

A well-functioning and prosperous society rests on a foundation of a capable, responsible, and healthy population. Many studies suggest that a lack of adequate resources in childhood compromises these capacities in adults, which makes the widespread poverty among children in the U.S. a cause for concern. So, are there ways to cut the child poverty rate, ideally by half in the next 10 years? A new report from the National Academies offers evidence-based policy and program packages that could be the answer.

Studies estimate that child poverty costs the nation roughly between $800 billion and $1.1 trillion annually in terms of lost adult productivity, increased costs of crime, and increased health expenditures. Poor children develop weaker language, memory, and self-regulation skills than their peers. When they grow up, they have lower earnings and income, are more dependent on public assistance, have more health problems, and are more likely to commit crimes. The report identifies two packages of policies and programs that could reduce child poverty in the United States by half

within 10 years, at a price tag far lower than the estimated costs it bears currently from child poverty — a "means-tested supports and work package" and a "universal supports and work package."

The means-tested supports and work package combines expansions of the earned income tax credit (EITC) and the child dependent care tax credit (CDCTC) with expansions of two existing income support programs: the Supplemental Nutritional Assistance Program and housing voucher programs. This package of programs would cost an estimated $90.7 billion per year based on the 2015 tax law. The package is also estimated to add about 400,000 workers and generate $2.2 billion in annual earnings.

Both the U.S. historical record and the experiences of peer countries demonstrate that reducing child poverty is achievable.

The universal supports and work package is designed to enhance income security and stability while also rewarding work and promoting social inclusion. The cornerstone of this package is a child allowance, but the package also includes a new child support assurance program, an expansion of the EITC and CDCTC, an increase in

the minimum wage, and elimination of the immigrant eligibility restrictions imposed by the 1996 welfare reform. This package of programs is estimated to cost $108.8 billion per year based on the 2015 tax law. The net effect of this full package is to increase employment by more than 600,000 jobs and earnings by $13.4 billion.

Both the U.S. historical record and the experiences of peer countries demonstrate that reducing child poverty is achievable. Child poverty fell by nearly half between 1970 and 2016, and government programs such as the EITC and SNAP played important roles in achieving this drop. If further reduction of child poverty is our goal, then implementing these anti-poverty programs should be a priority objective for U.S. policy, the report says. — *Kacey Templin*

A Roadmap to Reducing Child Poverty (2019, approx. 598 pp., ISBN 978-0-309-48398-8) is available from the National Academies Press, tel. 1-800-624-6242; $85.00 plus $7.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/25246>. The study was sponsored by the Doris Duke Charitable Foundation, Foundation for Child Development, Joyce Foundation, Russell Sage Foundation, W.K. Kellogg Foundation, William T. Grant Foundation, and the U.S. Department of Health and Human Services.

BIOTECH TREES

Weighing a New Weapon Against Forest Pests

In the 19th century, about 4 billion American chestnut trees thrived in Eastern forests stretching from Maine to Mississippi. In some regions the species accounted for one out of every four trees, playing a foundational role in forest ecosystems and providing rural communities with timber, food, and livestock feed.

But in 1904, American chestnut trees at the Bronx Zoo in New York City died from infection by a fungus, which had likely arrived in the U.S. on Japanese chestnut trees imported as early as 1876. In the decades that followed, chestnut blight spread throughout the American chestnut's entire range, slipping into the trees through small wounds in the bark, damaging the tissues that enable growth, and killing the trees. Meanwhile, chestnuts in the southern part of the species' range faced an additional threat, a fungus that caused their roots to rot.

Traditional methods for fighting back against tree pathogens, such as chemical treatments and burning, proved ineffective, and eventually the diseases killed nearly all mature American chestnuts. The trees' demise was devastating to the rural communities that had depended on them, and to the forest ecosystems in which they played an integral part.

Although particularly severe, the loss of the American chestnut is only one instance of the harm that pests and pathogens can cause to native tree species. Ash trees have been decimated by the Emerald Ash Borer beetle, for example, and the most common native tree in Hawaii, the ohi`a, has been severely affected by a fungal disease first detected in 2015.

Smaller outbreaks of native insects and diseases are common and can help renew forests, but these massive, simultaneous die-offs threaten the survival of entire tree species in the landscape. And the threats are unlikely to diminish. Global trade and travel have accelerated the movement of pests and pathogens, and climate change is expanding their geographic ranges.

Researchers and forest managers are now considering a possible new way to respond: by genetically engineering trees to be resistant to the pests and pathogens that endanger them. While no genetically engineered trees have been planted in the wild, scientists are experimenting with a few species of trees, which are currently in controlled field trials. One of them is the American chestnut, which has been engineered to include a gene from wheat that would make them resistant to chestnut blight.

The National Academies were asked to examine the potential benefits and risks of using biotechnology to protect the health of forest trees. Following a two-year study, the resulting report concludes that biotechnology has the potential to help fend off threats to forest health — but it also cautions that the approach presents challenges, and more research will be needed to meet them.

The genetic changes that are needed to achieve resistance to a pest or pathogen are often not easy to identify, the report says, and they can be tricky to implement for many reasons, including trees' long life spans and large genomes. Furthermore, it's not enough to gauge whether a genetic change is effective at protecting the trees. The modified tree also needs to be tested to discern its potential impact on other species in the environment and on the benefits that forests provide to humans.

These assessments of impacts should also take into account the people likely to be affected. Surveys, town hall meetings, and other methods that can tap into diverse perspectives, values, and sources of knowledge should contribute to decision making. And an additional framework is needed to consider forests' intrinsic value — that is, the value they have for their own sake.

If a decision is made to go ahead with planting a biotech tree in the wild, a full monitoring and assessment plan should be developed so that ample learning takes place from these initial efforts, the report says. The planting of biotech trees in unmanaged environments will be accompanied by uncertainties about impacts, and so decisions should be modified as knowledge is gained through on-the-ground experience with the trees.

Global trade and travel have accelerated the movement of pests and pathogens, and climate change is expanding their geographic ranges.

The report cautions that biotechnology is only one of many ways to address pests, and it should not be pursued to the exclusion of other management practices, such as traditional breeding, thinning tree stands, using insecticides and fungicides, and undertaking efforts to prevent the arrival of pests in the first place. — *Sara Frueh*

Forest Health and Biotechnology: Possibilities and Considerations (2019, 240 pp., 978-0-309-48288-2) is available from the National Academies Press, tel. 1-800-624-6242; $90.00 plus $7.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/25221>. The study was sponsored by the Agricultural Research Service, Animal and Plant Health Inspection Service, National Institute of Food and Agriculture, and the U.S. Forest Service of the U.S. Department of Agriculture; the U.S. Endowment for Forestry and Communities; and the U.S. Environmental Protection Agency. The study committee was chaired by Susan E. Offutt, independent consultant, and former chief economist at the U.S. Government Accountability Office.

New Study Confirms Classification of Red Wolf and Mexican Gray Wolf

Scientists strive to develop clear rules for taxonomy — the naming and grouping of living organisms. It's essential for studying life on Earth and evolutionary histories, and it can influence decisions about conservation that can shape the fate of entire species.

Taxonomy is not a "one-and-done" pursuit. As more information becomes available, taxonomists try to enhance classifications to reflect species' associations, behavior, physiology, ecology, geographic patterns, and other important traits. However, it is sometimes challenging to answer taxonomic questions, because of the ever-evolving nature of species.

Wolves offer one such example. The earliest undisputed occurrence of a wolf in North America was the medium-sized *Canis edwardii,* which appeared about 3 million years ago. Wolves have captivated the public imagination, symbolizing the spirit of the wilderness, and for others, they are regarded as troublesome threats to livestock. In recent years, the wolf population size has dwindled, so much that two species of wolves — the red wolf and the Mexican gray wolf — are listed as endangered under the U.S. Endangered Species Act.

Scientists have recognized three historical North American lineages of wolves, each named after one of the species in that lineage: *Canis dirus* (dire wolf), *Canis lupus* (gray wolf), and *Canis rufus* (red wolf). Since the discovery of the dire wolf, gray wolf, and red wolf, scientists have been revising their conclusions about what makes a wolf a wolf, how many species are recognized in each lineage, and about the relationship among the various populations of wolves.

A recent National Academies report assesses whether the red wolf is a taxonomically valid species and whether the Mexican gray wolf is a taxonomically valid subspecies.

Mexican Gray Wolf

Gray wolves are highly mobile and tend to travel long distances. They can also adapt to a variety of environments, from Arctic tundra to grasslands — lending to the emergence of subspecies. Currently, the Mexican gray wolf is classified as a subspecies of the gray wolf.

Mexican gray wolves were nearly driven to extinction through intensive predator eradication programs. With no known wild populations remaining in the United States,

the Mexican gray wolf was listed as endangered in 1976. Twenty years ago, amid much controversy, specimens bred in captivity were reintroduced into a small portion of their former range in the Southwestern United States.

Their designation as a subspecies has been controversial, due to speculation that they are not physically or genetically distinct enough to justify that classification. The designation has also been questioned on the grounds that the current Mexican gray wolf population may include ancestry from dogs or coyotes.

The report concludes that the Mexican gray wolf is a valid taxonomic subspecies of the gray wolf. Since its discovery, the Mexican gray wolf's small body size, reddish coloration, narrow and arched skull, and propensity for arid climates have distinguished it from other gray wolves. In addition to its distinct physical characteristics, this subspecies has been determined to be the most genetically divergent wolf in North America.

Furthermore, there is no evidence that Mexican gray wolves are derived from a hybridization with dogs and no evidence for any recent hybridization with coyotes.

Red Wolf

Red wolves once roamed much of the Southeastern United States. But in the early 20th century, like the Mexican gray wolf, red wolf populations were nearly eradicated due to predator removal programs.

A few remaining specimens were captured from Texas and Louisiana, and used to establish a captive breeding program in North Carolina. However, those wolves were largely selected on the basis of physical characteristics — not genetics.

Current controversy questions whether there is such a thing as a historic red wolf; and whether there is continuity between the historic red wolf population and those in the captive breeding program.

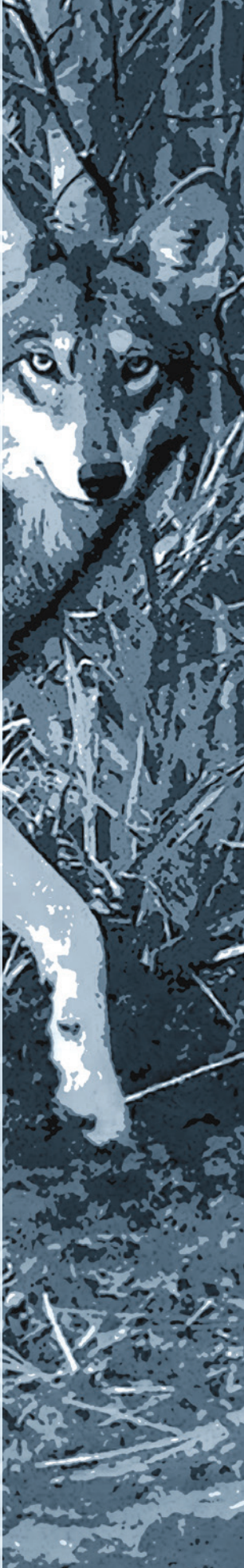
The report concludes that available evidence supports the classification of the contemporary red wolf as a distinct species, but it remains unclear whether the captive and managed populations share continuity with the same red wolves that roamed North America from the Pleistocene to the early 1900s. Genomic DNA from historic specimens could help clarify this issue.

Although the timing of the interbreeding between red wolves and other canids remains unresolved, red wolves have divergent genetic ancestry that predates European colonization, the report says.

Future Implications

The taxonomy of red wolves and Mexican gray wolves might seem like an obscure topic of debate. However, the outcomes may have implications for addressing critical conservation issues in a variety of threatened and endangered mammals. In an era marked by climate and landscape change, continued research will be critical, not only for the wolves but also their surrounding ecosystem. — *Stephanie Miceli & Sara Frueh*

Evaluating the Taxonomic Status of the Mexican Gray Wolf and the Red Wolf (2019, 104 pp., ISBN 978-0-309-48824-2) is available from the National Academies Press, tel. 1-800-624-6242; $65.00 plus $7.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/25351>. The study, sponsored by the U.S. Fish and Wildlife Service, was chaired by Joseph Travis, Robert O. Lawton Distinguished Professor of Biological Science at Florida State University.



Imagine giving one recipe to 10 different chefs and getting 10 completely different results. This inconsistency could be due to any number of factors — variables that cannot be controlled, omission of details, or shortcomings in design and execution.

The same challenges apply to scientific experiments.

Reproducibility & Replicability in RESEARCH

One of the ways that scientists confirm the validity of a new discovery is by repeating the research that produced it. When scientific results are frequently cited in textbooks and TED Talks, the stakes for validity are high. The stakes become even higher when the results inform policy, future scientific studies, or people's health decisions.

A new National Academies report defines reproducibility and replicability and examines the extent of non-reproducibility and non-replicability. The report also provides recommendations to researchers, academic institutions, journals, and funders on steps they can take to improve reproducibility and replicability in science.

"It's harder to gain recognition if your body of work is repeating what someone has already done, rather than exploring the new," said Harvey Fineberg, president of the Gordon and Betty Moore Foundation and chair of the committee that conducted the study. "Over time, our hope is that when a scientist takes on or attempts replication — because the value of the result can outweigh cost, because a great deal weighs on scientific basis — those types of papers will get recognition in a scholar's career."

Consistent Definitions

Reproducibility and replicability are commonly used terms in the scientific community. However, some fields use the terms interchangeably, or even use the terms with opposing definitions. The committee that wrote the report said it's important to distinguish these terms to unravel the complex issues associated with confirmation of previous studies.

Reproducibility is defined as obtaining consistent results using the same data and code as the original study (synonymous with computational reproducibility). Replicability means obtaining consistent results across studies aimed at answering the same scientific question using new data or other new computational methods.

One typically expects reproducibility in computational results, but expectations about replicability are more nuanced. A successful replication does not guarantee that the original scientific results of a study were correct, nor does a single failed replication conclusively refute the original claims.

Several factors can contribute to non-reproducibility or non-replicability, including previously unknown variation or effects, inadequate recordkeeping, technology limitations, potential biases, lack of training, institutional barriers, or even misconduct, in rare cases.

It is hard to quantify the extent of non-reproducibility or how much of science is reproducible. And while reproducibility and replicability are important for research, they are not the be-all and end-all, the committee emphasized.

"The goal of science is not to compare or replicate [studies], but to understand the overall effect of a group of studies and the body of knowledge that emerges from them," said Fineberg.

Responsibility Starts with Researchers

Academic institutions, journals, conference organizers, funders of research, and policymakers can all play a role in improving the reproducibility and replicability

of research. But that responsibility begins with the researchers themselves, who should operate with "the highest standards of integrity, care, and methodological excellence," Fineberg said during a May 7 webinar. That responsibility extends to the institutions where they are trained and continue to practice their craft.

Important steps researchers can take include clearly and accurately describing their methods, conveying the degree of uncertainty in their results, properly using statistical methods, and preventing overhype in press releases or media coverage about their work.

No Crisis, But No Time for Complacency

Some news articles go as far as declaring a non-reproducibility and non-replicability "crisis" in science, but the committee doesn't necessarily agree. Occasionally, non-replicability may even be helpful. For example, the discovery of new phenomena and the collection of new insights about variability both contribute to the self-correcting nature of science, and should not be interpreted as a weakness.

Nonetheless, improvements are needed — more transparency of code and data, for example, and more rigorous training and education in statistics and computational skills.

The report also recommends that journals and funders of research explicitly consider replicability and reproducibility in application and submission processes. This calls for culture shift so that it is in scientists' best interest to submit these types of papers — and that they become the norm. — *Stephanie Miceli*

Reproducibility and Replicability in Science (2019, approx. 218 pp., ISBN 978-0-309-48616-3) is available from the National Academies Press, tel. 1-800-624-6242; $60.00 plus $7.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/25303>. The study was sponsored by the National Science Foundation.

The Future of the Interstates

Investing in a Modernized Interstate Highway System

The idea of a national network of highways had existed for decades when funding for construction for the U.S. Interstate Highway System was authorized in 1956, but no one could have foreseen the significance it has had in the nation's history. For more than 60 years, the interstates have been integral to shaping the country's demographic, economic, and social development. The system is critical to transportation, both passenger and freight, within large urban spaces, and between metropolitan and rural areas. Despite the nation's reliance on this vital infrastructure, however, a growing number of structural and operational deficiencies, as well as looming issues such as autonomous vehicles, electric vehicles, and climate-related vulnerabilities, present challenges for the interstates.

A new commitment must be made to remedy the system's deficiencies, says a recent report from the National Academies of Sciences, Engineering, and Medicine. There is a real risk that the interstates will become increasingly unreliable and congested, less safe, incompatible with evolving technology, and far more costly to maintain. Despite constituting only about 1 percent of public road mileage, the interstates carry about one-quarter of the nation's vehicle miles traveled, including about half of the miles traveled by heavy trucks. Its importance cannot be overstated. The report calls for a 20-year "blueprint for action," which includes creating an "Interstate Highway System Renewal and Modernization Program" that has a dedicated source of funding and a long-term plan and vision.

"The interstates have long been the backbone of our country's transportation system, but most of them have exceeded their design lives and in many places are worn and overused," said Norman Augustine, former chairman and CEO of Lockheed Martin Corp. and chair of the committee that wrote the report. "These aging interstates are highly congested oftentimes and in need of reconstruction. Furthermore, technological advances are offering new opportunities, but they may also undermine a principal source of income for the interstates, namely the tax on fuel. Essentially, we need a reinvigoration of the federal and state partnership that produced the Interstate Highway System in the first place."

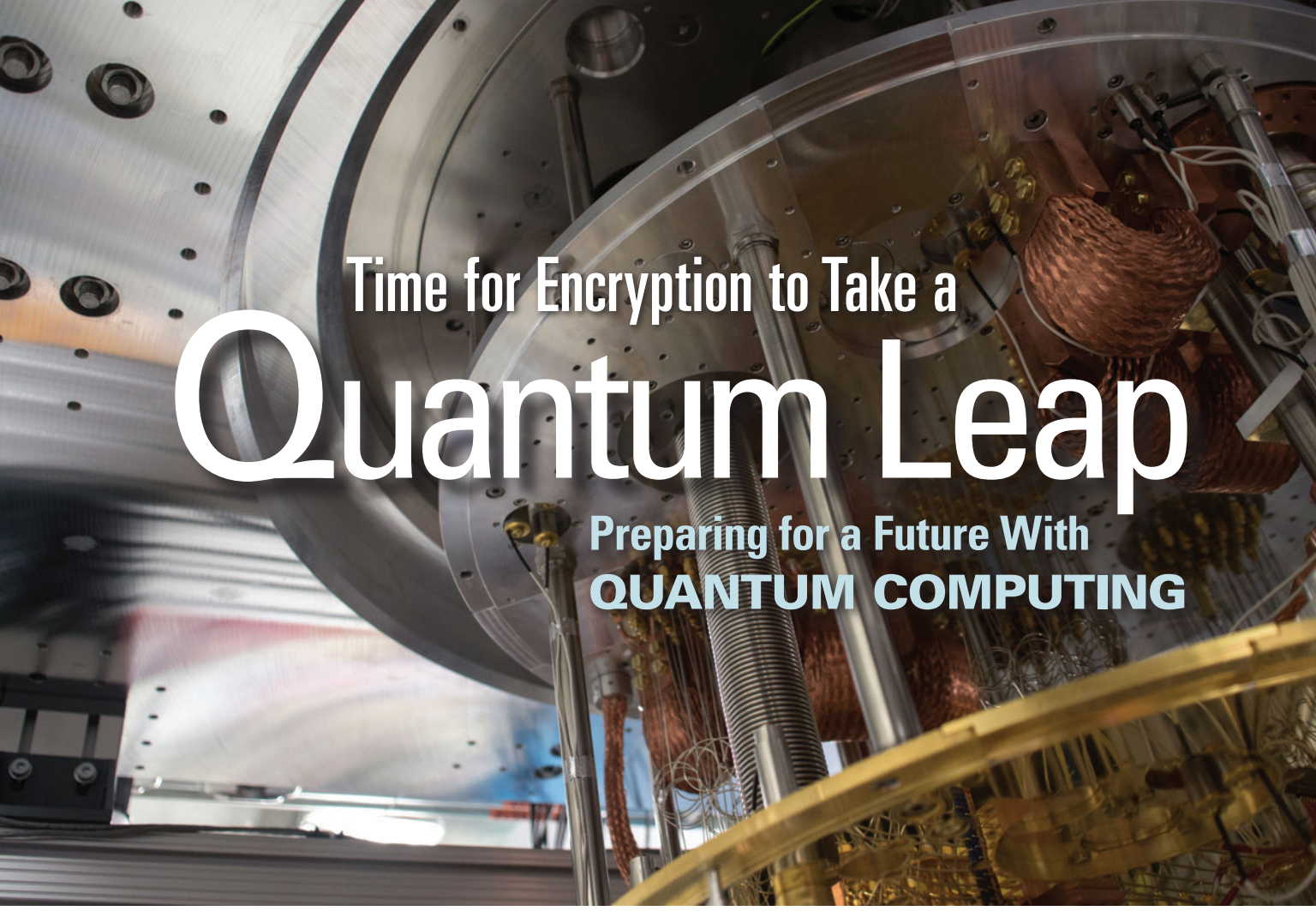
The report recommends a coordinated federal and state government effort that focuses on goals similar in motivation to the original Interstate Highway System Construction Program. The proposed

Interstate Highway System Renewal and Modernization Program would reinforce the federal and state partnership, where the federal government would provide leadership, vision, and the bulk of funding, and the states would prioritize and execute projects in their traditional role as owners, builders, and maintainers of the system.

The interstates need an increase in federal investment to between $45 billion and $70 billion annually, compared with the approximately $25 billion currently being spent annually, the report says. Raising the level of revenue needed to fix and modernize the interstates will be no small task, requiring sizable changes to the public's perspective of how to use and update the system. Among the recommendations to raise revenue is increasing the federal fuel tax, which has not raised since 1993, allowing inflation to stifle its effectiveness. Additionally, the ban on tolling the interstates should be lifted in order for the highways to raise their share of revenue and manage traffic demand in some highway segments.

The Interstate Highway System has been, and will continue to be, an essential part of the country's society and economy. The technological and environmental challenges of the future only emphasize the need to begin its renewal and modernization sooner rather than later. — *Andrew Robinson*

Renewing the National Commitment to the Interstate Highway System: A Foundation for the Future (2018, 614 pp., ISBN 978-0-309-48755-9) is available from the National Academies Press, tel. 1-800-624-6242; $64.00 plus $7.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/25334>. The study was sponsored by the U.S. Department of Transportation.

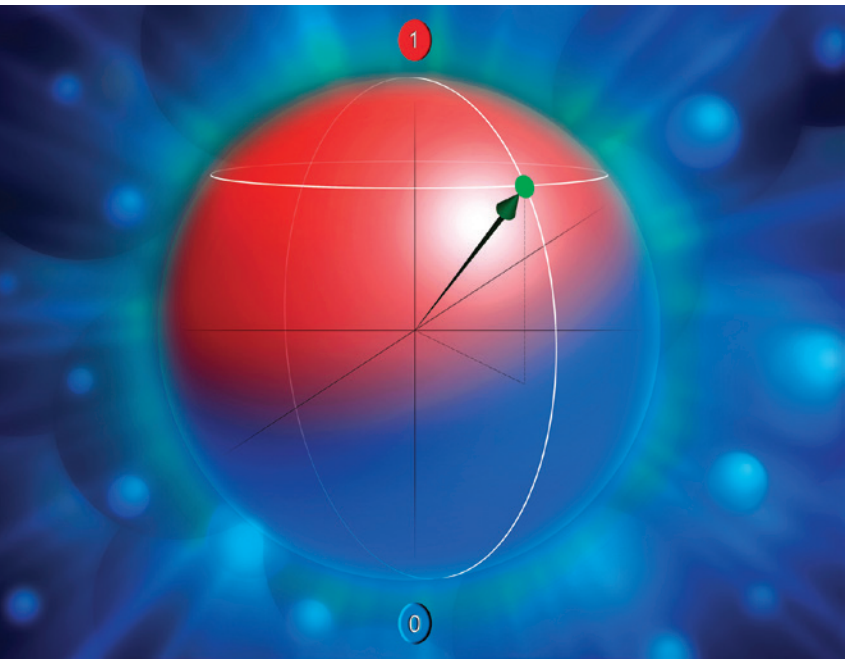


Time for Encryption to Take a Quantum Leap

Preparing for a Future With QUANTUM COMPUTING

Quantum computing, which relies on the characteristics of quantum mechanics to carry out computations, presents both the potential for faster computing as well as risks to current security paradigms. Conventional computers rely on bits with binary values of 1 or 0; quantum computers use the unique properties of quantum bits or qubits, which can be both 1 and 0 at the same time, a principle known as quantum superposition. This ability of a qubit to have two different values at the same time, when carefully harnessed, allows for certain calculations to be performed in a fraction of the time it would take a traditional computer. While the concept of a quantum computer has been around for decades, only recently have researchers demonstrated their fundamental operations in real-world systems.

One of the calculations that a large-scale quantum computer could theoretically perform would make it possible to break the public-key encryption that protects most of today's private communications and stored data. Although such a system has not yet been achieved, nor is one expected to be within the next decade, a large-scale quantum computer could theoretically break this encryption in a matter of hours. Therefore, says a recent report from the National Academies, work that is underway to develop and deploy algorithms that are resilient against an attack by a quantum computer is critical, because



replacing an established Internet protocol generally takes over a decade.

Mark Horowitz, chair of the committee that wrote the report and Yahoo! Founders Professor at Stanford University, said, "There has been remarkable progress in the field of quantum computing, and the committee doesn't see a fundamental reason why a large, functional quantum computer could not be built in principle. However, many technical challenges remain to be resolved before we reach this milestone."

The report identifies significant challenges that lie ahead for quantum computing, including correcting errors in the quantum system, itself a costly measure, and the problem of converting large amounts of conventional data into a quantum state, for which there is no known rapid method. Due to these and other obstacles, it is too early to predict a realistic time horizon for a practical quantum computer. Researching the commercial applications of near-term quantum computers — expected to be much smaller and more error-prone than those that could defeat public-key encryption — is also critical for the field, the report says.

Although the arrival of a general-purpose quantum computer could have a major detrimental impact on cryptography, there are also many potential benefits from pursuing advances in the field of quantum computing. Like few other foundational research areas, quantum computing has the potential to greatly speed computing for certain applications, which makes supporting a robust research community in the U.S. of strategic national value. Results from research in this area have already spurred progress more generally in physics and computer science.

Even though technical challenges currently prevent quantum computers from defeating today's security protocols, the committee stressed that developments in security and encryption need to happen soon in order to be fully implemented before the technical barriers are overcome. This exciting new technology may have unknown potential, but it also could make private information more vulnerable if cryptography does not keep pace.

— *Andrew Robinson*

Quantum Computing: Progress and Prospects (2018, 272 pp., ISBN 978-0-309-47969-1) is available from the National Academies Press, tel. 1-800-624-6242; $55.00 plus $7.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/25196>. The study was sponsored by the Office of Director of National Intelligence.

John L. Anderson Discusses His New Role as the National Academy of Engineering's President

When John L. Anderson, president emeritus and distinguished professor of chemical engineering at the Illinois Institute of Technology, was first elected to the National Academy of Engineering almost 30 years ago, he remembers being deeply honored and excited about how the recognition would help his career. But it wasn't until a few years later, when he got more directly involved in the work of the NAE and the National Academies, that he began to appreciate that his membership could be something much more meaningful.

"As I went along, I got opportunities to be involved in activities at the national level," says Anderson, who — in addition to serving on the NAE Council and many NAE committees — also chaired National Academies' panels on research needs for countering improvised explosive devices and on techniques to identify and respond to potential terrorist attacks that involve chemical explosives. "That is when I realized that this is much more than being a member of an honorific society. I might actually be able to do some good for the nation."

Anderson, who began his six-year term as the 12th president of the NAE on July 1, says that the NAE and the Academies' ability to convene the best available expertise in engineering, science, and medicine is "our No. 1 strength." He believes that

maintaining the Academies' reputation as nonpartisan, independent advisers to the nation is critical — especially at a time when Washington, D.C., and the nation are often bitterly divided along partisan lines.

Fortunately, says Anderson, many issues related to science and technology tend to unite, rather than divide, most Americans. "What I've seen as a member of the National Science Board, and as a university

president and educator, is that when it comes to science and engineering, there isn't very much partisanship. That is the result of an appreciation — by the country and by the taxpayers — that science and engineering education, research, and innovation are really important to society."

As NAE president, one of Anderson's top priorities will be to find ways for the institution to engage the business community in more of its work and benefit from its unique perspective on issues. In addition, Anderson says, NAE could also help bridge gaps between entrepreneurs and big companies. "Entrepreneurs produce the new [inventions and products] and big companies are the ones that make them better and more widely available," he says. "Innovation often begins with entrepreneurs, and connecting them with big companies is a challenge of the engineering profession."

The NAE will also continue to focus on helping the engineering profession bring more women and underrepresented minorities to engineering. Progress has been made in some fields, such as environmental engineering, chemical engineering, and biomedical engineering, but not in others. "We need to work on that as a profession, and NAE can help," Anderson says. He intends to build on impactful NAE programs such as the Global Grand Challenges Scholars Program, EngineerGirl, and Frontiers of Engineering.

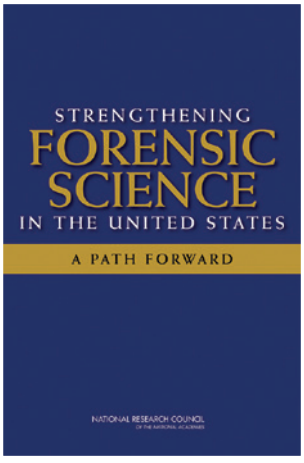
In his new role, Anderson plans to draw on his long and distinguished background as administrator and educator. He served as the president of Illinois Tech from 2007 to 2015, and is currently a distinguished professor of chemical engineering at Illinois Tech's Armour College of Engineering. His past academic leadership positions include chair of biomedical engineering, department head of chemical engineering, and dean of engineering at Carnegie Mellon University, as well as provost and executive vice president at Case Western Reserve University.

He is also the recipient of numerous awards and honors. He was a presidential appointment to the National Science Board in 2014 [his term expires next year], and is a fellow of the American Academy of Arts and Sciences and the American Association for the Advancement of Science. He was awarded the Andreas Acrivos Award for Professional Progress in Chemical Engineering (1989) and the National Engineering Award by the American Association of Engineering Societies (2012). He held a Guggenheim Fellowship at MIT in 1982-83.

"Education is the reason I'm here," says Anderson, who proudly notes that from elementary school through university, his entire education was obtained at public institutions. "I really value education and the importance of mentoring. I think that's my most trusted philosophical guideline."
— *Molly Galvin*

Landmark Report on Forensic Science

Celebrates 10 Years of Impact



This year marks the 10-year anniversary of the release of the National Academies' *Strengthening Forensic Science in the United States: A Path Forward,* a report that drew national attention to the need for stronger science in an arena where matters of vital importance — freedom and even lives — are at stake.

The report found that many common forensic science methods used in criminal investigations have not been scientifically validated. "With the exception of nuclear DNA evidence … no forensic method has been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between a piece of evidence and an individual or source." The statement stands in stark contrast to claims that forensic practitioners have often made in court, such as testifying that a bullet came from a particular gun "to the exclusion of every other firearm in the world," or that a piece of evidence — such as a hair strand or fingerprint — was a "100% match" with a particular suspect.

The report recommended sweeping reforms, including mandatory certification for forensic science practitioners and accreditation for labs, research to gauge the reliability and limits of various forensic methods, and the creation of an independent entity to promote research and foster reforms.

"The National Academies' report on Strengthening Forensic Science was the first serious and objective look at the forensic

science evidence that had for decades been routinely received by the courts — and what it revealed was that too much forensic science did not adhere to basic scientific principles and was sometimes little more than guesswork," notes Jed Rakoff, senior judge of the U.S. District Court for the Southern District of New York.

The report had immediate impact. At the American Academy of Forensic Science's annual meeting the following year more than a dozen sessions explored the report's implications across a range of areas, from certification to fingerprint and bite mark analyses.

Federal policymakers responded as well. Several months after the report's release, the White House National Science and Technology Council chartered a Subcommittee on Forensic Science to coordinate federal efforts to lead national activities to improve the science and application of forensic science. The subcommittee's working groups explored the implications of the report's recommendations and identified possible approaches for implementing them.

One forensic science discipline whose weaknesses were highlighted in the report was microscopic hair analysis. New scrutiny of this technique led the Federal Bureau of Investigation, the Innocence Project, and the National Association of Criminal Defense Lawyers to create a partnership in 2012 to re-examine cases in which microscopic hair analysis was conducted and used in testimony by the FBI. The review found that forensic scientists' testimony had outstripped what the science could support in more than 90 percent of cases. After those findings emerged, the FBI and its partners in the review worked to notify those who were defendants in the cases. The FBI also committed to stopping the erroneous testimony, and to using mitochondrial DNA hair analysis in addition to microscopic hair analysis.

In some instances the report affected states' approaches to forensic science, as well as individual cases. "Research scientists who challenged foundational aspects of forensic science before the NAS report was published were often dismissed," said Clifford Speigelman, University Distinguished Professor at Texas A&M University and statistics adviser to the Texas Forensic Science Commission. "The report not only provided a critical scientific consensus that supported our concerns, but it is advancing science to change lives. In my home state of Texas, it has led to the courts to abandon bite mark evidence and exonerate Steven Chaney who spent 28 years in prison for a crime he did not commit."

The report's impact on judicial rulings has reached as high as the U.S. Supreme Court. In the 2009 case *Melendez-Diaz v. Massachusetts,* the Supreme Court ruled that defendants had a right to cross-examine forensic scientists in court. Justice Antonin Scalia referenced the NAS report in the majority opinion, in support of the

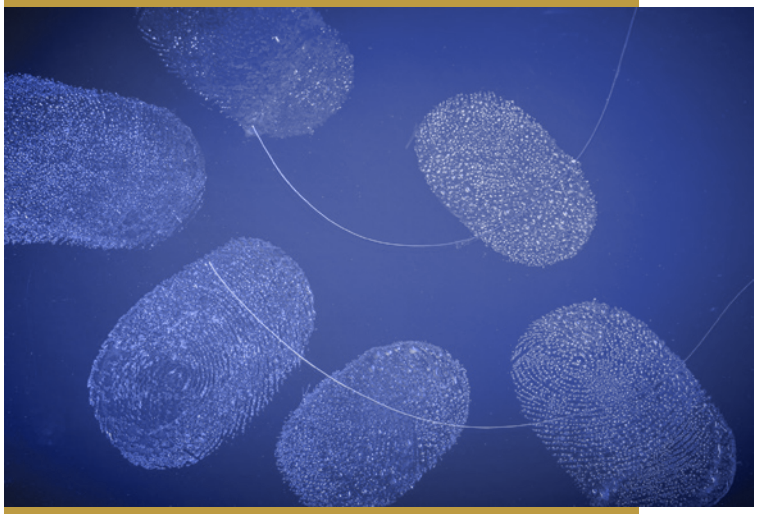
court's determination that forensic science testimony should be open to challenge as a way to identify deficiencies in training and judgment, and because the neutrality and reliability of forensic evidence could not be assured.

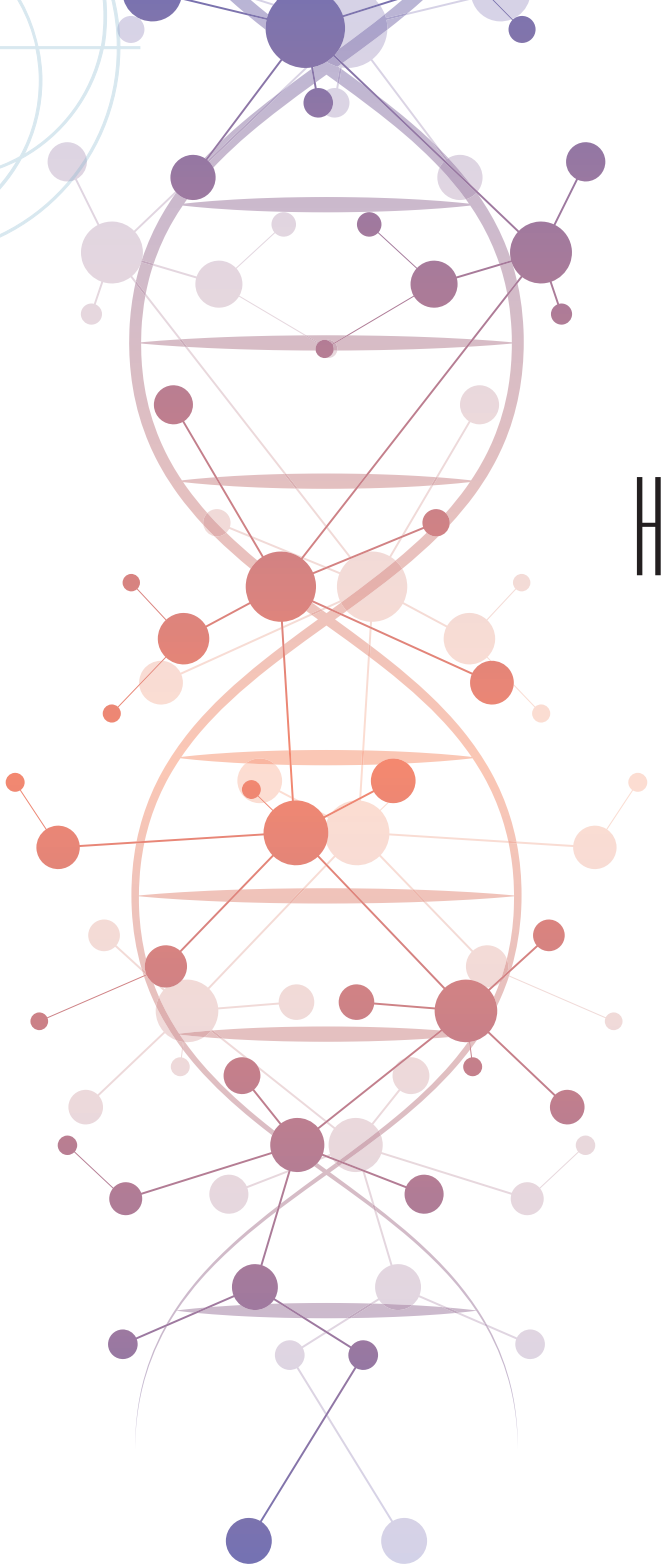
In 2013 the U.S. Department of Justice and the National Institute of Standards and Technology established the National Commission on Forensic Science, an advisory committee whose goal was to offer policy guidance for improving the practice and reliability of forensic science. Based on the commission's recommendations, DOJ adopted a new code of professional conduct for those working in its federal laboratories, and some commission recommendations were proactively adopted by some state and local crime laboratories. DOJ disbanded the commission when its charter expired in 2017.

Despite the progress that has been made, the continued lack of an independent entity to oversee forensic science — a recommendation of the report — hinders further efforts, as do remaining gaps in research, said Judge Harry T. Edwards, who co-chaired the study committee that wrote the report. "Perhaps most critically, we still do not know what we do not know," said Edwards. "We need better scientific studies and standards to shape the work of forensic practitioners and regulate the admission of forensic evidence. This means that more top scientists must engage in research on forensic methods and appear in court to explain the evidence. This will allow judges to better understand forensic evidence and to more clearly and accurately instruct jurors on the limits of the evidence."

— *Sara Frueh*

In April 2019, committee co-chairs Harry T. Edwards and Constantine Gatsonis received, on behalf of the study committee, the Champions of Justice award from the Innocence Project in recognition of the report's effect on the criminal justice system. In notifying Edwards and Gatsonis about the award, the Innocence Project thanked the committee for the report, noting that the report "has truly transformed the state of forensic science and the involvement of the research community in service of criminal justice reform."





The Urgent Need for a Global Framework to Guide Clinical Use of Heritable Genome Editing

When a researcher from China announced last November at the Second International Summit on Human Genome Editing the birth of twins whose healthy embryonic genomes had been edited, it generated headlines around the world and was widely condemned for violating long-standing scientific principles and ethical norms. The researcher's work also served as a wake-up call for the scientific and medical communities: More work is needed to establish global agreement on issues surrounding heritable genome editing.

To address these issues, an international commission has been convened by the U.S. National Academy of Medicine, the U.S. National Academy of Sciences, and the Royal Society of the U.K. — with the participation of science and medical academies around the world — to develop a framework for scientists, clinicians, and regulatory authorities to consider when assessing potential clinical applications of human germline genome editing. The framework will identify a number of requirements that should be considered, and could inform the development of a potential pathway from research to clinical use — if society concludes that heritable human genome editing applications are acceptable.

"These revelations at the summit in Hong Kong underscore the urgent need for an internationally accepted framework to help scientists, medical experts, and regulators address the complex scientific and medical issues surrounding clinical use of germline genome editing," said NAM President Victor J. Dzau and Royal Society Vice President John Skehel, co-chairs of the commission's international oversight board, in a joint statement. "We also welcome the formation of the World Health Organization's Expert Advisory Committee on Developing Global Standards for Governance and Oversight of Human Genome Editing that will operate in parallel to our commission."

The U.S. National Academies and the Royal Society will serve as secretariats of the commission, which includes representatives from 10 nations. Kay Davies, professor of genetics at the MDUK Oxford Neuromuscular Centre at the University of Oxford, England, and Richard Lifton, president of the Rockefeller University in New York City, will co-chair the commission.

The commission will:

- identify the scientific issues — as well as societal and ethical issues, where inextricably linked — that must be evaluated for any possible clinical application of germline genome editing;
- identify protocols and preclinical validation for evaluating the potential for off-target effects, mosaicism, and any potential long-term side effects that may result;
- discuss ways to assess the balance between potential benefits and harms of germline editing applications to a child and to subsequent generations;
- design appropriate protocols for obtaining patient consent and ethical approval from review committees, and for satisfying requirements of regulatory authorities;
- assess possible mechanisms for long-term monitoring of children born with edited genomes; and
- outline research and clinical characteristics that would form part of an oversight structure, including defining criteria for heritable genome editing, monitoring any clinical use, and bringing forward concerns about human experiments.

The commission will hold public meetings in Washington, D.C., and London and an international workshop, and will also issue a call for public input to inform their work. The commission's final report is expected to be issued in the spring of 2020. — *Molly Galvin*

For more information, visit <nationalacademies.org/gene-editing/international-commission/>.

THE NATIONAL ACADEMIES HOST

Family Science Day

Although Abraham Lincoln and Albert Einstein were not actually historical contemporaries, the lure of the National Academies' first-ever Family Science Day was enough to conjure them into simultaneous existence on Saturday, April 13, at the National Academy of Sciences building, where we welcomed them and about 3,000 of their best science-interested friends.

Staff from around the Academies worked together to create a set of fun, family-focused, hands-on activities designed to introduce children and their parents to the ways in which science and engineering can be used to make good decisions at home and in the community. Visitors also immersed themselves in DecisionTown, voting on important town issues and claiming citizenship at the Town Hall. It was a pretty great day for everyone, including all of our honorary citizens, who left knowing a little bit more about how science and engineering — and the National Academies — relate to their everyday lives. — *Ann Merchant*

Just a Few Stops in **DecisionTown**

DecisionTown was brought to the Academies' Family Science Day through a partnership with the Institute for Genomic Biology at the University Illinois, which is directed by NAS/NAM member Gene Robinson.

NAS Honors 10 U.S. Nobel and Kavli Prize Laureates

In science, the small, incremental advances matter just as much as the big breakthroughs — and the Nobel and Kavli prizes celebrate both on the world stage.

On April 10, the National Academy of Sciences honored 10 recent winners of the Nobel and Kavli prizes at events held on Capitol Hill and at the NAS building.

Although the honorees represent different corners of the U.S., their discoveries have rewarded people the world over. They have studied the inner workings of the ear, integrated the impact of climate change into long-term economic analysis, and unleashed the body's immune system to fight cancer.

"When you can show there are people alive because of the discovery you've made, that trumps everything," Paul Romer, winner of the 2018 Nobel Prize in economics, said of his fellow laureate James Allison, who was awarded the 2018 Nobel Prize in medicine for pioneering immunotherapy.

The importance of the basic sciences — such as physics, chemistry, and biology — was a recurring theme. After all, had Allison not been so focused on the basic biology of the T cell, he might never have made discoveries that laid the foundation for one of the most promising areas of cancer treatment.

During the event's kickoff reception in the rotunda of the U.S. Capitol, NAS President Marcia McNutt applauded the laureates' creativity, their resilience in the face of false starts and setbacks, and

their advancement of human knowledge. "Because of the vibrant research ecosystem here that supports young scientists and gives them the freedom to push the boundaries of human understanding, they were able to achieve the pinnacle of their life's work in the U.S.," she said.

Kelvin Droegemeier, director of the White House Office of Science and Technology Policy, echoed her remarks about the importance of upholding America's scientific tradition.

"You provide a beacon of leadership in the U.S. We want [science in the United States] to be an enterprise that's worthy of your accomplishments — because science anywhere is good for science everywhere," he told the laureates.

The reception was co-hosted by U.S. Senators Lamar Alexander (R-Tenn.) and Christopher Coons (D-Del.), who called for enduring, reliable support for scientific research from both sides of the aisle. Playing a role in supporting "breathtaking" science and technology innovations is "part of the joy in serving in public life," Alexander said. Coons, who credited his Republican colleague for being a "true champion of science," added that federal investment in fundamental science and human capital has created numerous jobs and has ripple effects throughout the economy.

Later that evening, Mariette DiChristina, editor-in-chief of *Scientific American*, facilitated a panel discussion with the laureates at the NAS building. The laureates addressed several topics, from open data sharing to the many ways science creates "a planet worth living on," in the words of Frances Arnold, winner of the 2018 Nobel Prize in chemistry.

"These prizes are not about you. These prizes are given to *science*. It's about bringing science to other people and the chance to share it with the whole world," Arnold said.

Many of the laureates agreed the distinction comes with the responsibility to be an ambassador for science — starting in their communities and in elementary school classrooms. For those working in areas in which they may not live to see the fruits of their labor — such as climate change — there's nothing more urgent than educating the next generation.

This event, now in its second year, recognizes trailblazing research and the role of science in our everyday lives.

— *Stephanie Miceli*

The honorees were:

- **Arthur Ashkin,** who received one-half of the 2018 Nobel Prize in Physics
- **Rainer Weiss,** who shares the 2016 Kavli Prize in Astrophysics and received one-half of the 2017 Nobel Prize in Physics
- **James Allison,** who received one-half of the 2018 Nobel Prize in Physiology or Medicine
- **Robert Fettiplace** and **James Hudspeth,** who share (with Christine Petit) the 2018 Kavli Prize in Neuroscience
- **Frances Arnold** and **George Smith,** who share the 2018 Nobel Prize in Chemistry (one-half and one-fourth, respectively)
- **Jennifer Doudna,** who shares the 2018 Kavli Prize in Nanoscience
- **William Nordhaus** and **Paul Romer,** who each received one-half of the 2018 Nobel Prize in Economic Sciences

New Action Collaborative Formed to Spur Systemic Change to Prevent Sexual Harassment

A new action collaborative launched by the National Academies and dozens of U.S. colleges, universities, and research institutions is seeking ways to spur and take action to prevent sexual harassment in higher education. The member institutions are working to move beyond basic legal compliance and to implement evidence-based policies and practices that both prevent all forms of sexual harassment and promote a culture of civility and respect.

The action collaborative builds on a foundation laid by the Academies' 2018 report *Sexual Harassment of Women: Climate, Culture, and Consequences in Academic Sciences, Engineering, and*

Medicine, which found high rates of sexual harassment across academia. After the report's release, members of the study committee traveled to colleges and universities around the U.S. to present the report's findings. During these visits, they repeatedly heard

administrators, faculty, and students wonder what novel approaches and promising practices other institutions were using to implement the report's recommendations and prevent and respond to sexual harassment.

"While there was a lot of energy and desire for action prompted by the #MeToo movement and by the report, there was no good forum where institutions could share ideas and drive the systemic changes called for in the report," said Frazier Benya, the senior program officer at the National Academies who directed the sexual harassment study, and who directs the new action collaborative.

Seeing this gap — and considering its own success in convening activities — the National Academies decided to partner with 28 schools to form an action collaborative to support efforts to move the report's recommendations and other evidence-based efforts into policy and practice. More institutions have since joined, bringing the total membership to 57 institutions.

The action collaborative is designed to be an active space where colleges, universities, and research and training institutions can research and develop effective ways to address and prevent all forms of sexual harassment. Annual meetings will be held for member institutions to learn from one another and from experts. The institutions are forming four working groups to identify promising practices and find ways to address on-the-ground barriers to implementing changes — these groups will focus efforts on prevention, response, remediation, and evaluation. In addition, public workshops will engage the broader higher education community in order to share successful practices and innovative ideas.

"We hope that going forward even more colleges, universities, and other organizations will follow our work, participate at our public events, and join us in taking action to prevent and effectively address sexual harassment," said Benya. — *Sara Frueh*

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