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Protecting the Crescent City

Learning Science in Nontraditional Settings

The Future of Oceanography

Guidelines for Pregnancy Weight Gain

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THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

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Cover: (clockwise from upper right) ©BananaStock/SuperStock; ©Blend Images/Fotosearch; courtesy Office of Ocean and Atmospheric Research/National Undersea Research Program/NOAA; helicopter loads sandbags into area where levee broke as a result of Hurricane Katrina, photo by Jocelyn Augustino/FEMA

Page 1: (col. 1, from top) ©moodboard/Corbis, blackside hawkfish in the Northwestern Hawaiian Islands Marine National Monument, photo by Claire Fackler/NOAA National Marine Sanctuaries; (col. 2, from top) ©Gallo Images ROOTS RF/PunchStock, geneticist harvests switchgrass seed as part of program to develop cultivars with improved biomass conversion to bioenergy, broad adaptation, and high biomass yields, photo by Wolfgang Hoffmann/USDA Agricultural Research Service

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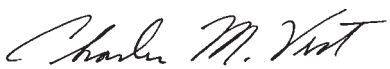
Facing New and Not-So-New Issues

Medicine, science, and engineering increasingly intersect and blend as we approach new challenges that are at once broad and deep. This certainly is apparent in this issue of *In Focus*, which covers a range of important questions addressed in recent months by the National Academies, from the lessons that can be learned from Hurricane Katrina for security, mitigation, and preparedness to how we can learn about the sciences in non-classroom settings, as well as looks at the transportation fuels we could choose to foster a low-carbon economy and the strategies America might choose to respond to climate change.

This issue of the magazine also reminds us that despite our scientific and technological progress, fundamental human and social issues such as conflicts of interest and inequality remain at the fore in our society and even in our own professions. Consider the fact that many women still experience their academic careers in science, engineering, and mathematics differently than most of their male colleagues do. This often results in professional inequities, both subtle and sometimes not so subtle. Considerable progress has been made at our universities; more female administrators are in positions of leadership than was the case even a decade ago, and undergraduate enrollments in most fields of science and engineering are moving toward a better gender balance. However, there continue to be stresses and strains at each step along the way to a successful and satisfying career in these fields.

A recent National Research Council report, *Gender Differences at Critical Transitions in the Careers of Science, Engineering, and Mathematics Faculty,* which is summarized on page 4, looked at individual and institutional experiences in this regard, with some revealing and useful findings. I believe it is essential that as a community we resolve these issues and the even more complex challenges regarding the overall racial and cultural diversity of our institutions if we are to truly serve our nation and world now and in the future.

Finally, it bodes well for our institution that we are able to report on President Obama's speech to the National Academy of Sciences' annual meeting. His appearance, soon after his inauguration, is a historically significant moment for us all and one that is emblematic of the growing importance of the work of the Academies to our nation's future.



CHARLES M. VEST
President, National Academy of Engineering

IS THE **GENDER GAP** NARROWING?

New Data on Female Faculty in Science and Engineering

Among faculty in science and engineering at research universities, women have historically been outnumbered by men — an imbalance that's persisted even as women in many other academic fields and business made more progress.

In the past decade, many universities have publicly pledged to use their resources to correct this disparity, but concerns about the status of women remain. Spurred by such questions, Congress asked the National Research Council to examine how female academics are faring in science and engineering compared with men — a massive task for which existing data was inadequate. So the study committee fielded two national surveys of departments in six scientific disciplines at major research universities in the U.S. The surveys examined gender differences at key junctures in academic careers — being hired for tenure-track jobs, for example, and receiving tenure.

The surveys turned up some encouraging findings — chief among them that

female applicants for tenure-track jobs have a higher chance of being hired than male applicants do. For instance, women made up 20 percent of applicants for positions in mathematics but accounted for 28 percent of those interviewed, and received 32 percent of the job offers. The trend also held true for decisions in favor of tenure, which tapped women as often as men, or more so.

But the news was not all positive: The survey also found that women aren't applying for jobs at research universities at the same rates that they are earning Ph.D.s. While women received 45 percent of Ph.D.s in biology awarded by research universities from 1999 to 2003, for instance, they made up only 26 percent of applicants to tenure-track positions at those schools. Why the gap happens — whether women are being pulled away by family responsibilities, for example, or subtly pushed away by chilly departmental climates — is a question that future research should explore. As for schools' efforts to recruit women to apply for these jobs, they have been neither aggressive nor particularly effective, the committee observed. One strategy did seem to make a difference: having a higher number of women on the search committee, including a female chair.

So how are women treated once they've been hired? Women who were surveyed reported having similar access to many types of institutional resources — travel funds, for example, and research assistants to supervise. At first glance men seemed to have more lab space, but the difference disappeared when other factors, such as faculty rank and discipline, were accounted for. However, men did have greater access to equipment needed for research and to clerical support. And among full professors, men were paid about 8 percent more than women — a gap that didn't exist among assistant and associate professors.

While women were as likely to chair committees and be part of research teams as men, they were less apt to engage in conversation on research, salary, and benefits — a gap that may make them feel more marginalized in their professional lives, the report notes.

Overall, the findings signal that positive changes are occurring at research universities, said the committee, which expressed hope that the data reflecting equity in hiring practices would encourage more women to apply for faculty positions. But it also cautioned against complacency, warning that the data should not be mistakenly interpreted as indicating that men and women faculty have reached full equality and representation. — *Sara Frueh*

Gender Differences at Critical Transitions in the Careers of Science, Engineering, and Mathematics Faculty. Committee on Gender Differences in Careers of Science, Engineering, and Mathematics Faculty; Committee on Women in Science, Engineering, and Medicine, Division on Policy and Global Affairs, and Committee on National Statistics, Division of Behavioral and Social Sciences and Education (2009, approx. 500 pp.; ISBN 0-309-11463-2; available from the National Academies Press, tel. 1-800-624-6242; $48.95 plus $4.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/12062.html>).

The committee was co-chaired by **Claude Canizares,** vice president for research and Bruno Rossi Professor of Experimental Physics, Massachusetts Institute of Technology, Cambridge; and **Sally Shaywitz,** Audrey G. Ratner Professor in Learning Development and co-director of the Yale Center for Dyslexia and Creativity, Yale University School of Medicine, New Haven, Conn. The study was funded by the National Science Foundation.

SCIENCE LEARNING
BEYOND THE CLASSROOM

Every year a virtual virus sweeps through the online world of Whyville, a social networking site for kids and teens. A child chatting online may suddenly find her sentences punctuated by the word "Achoo!" — a sign that she has caught the Whypox virus. Over the course of weeks, the virus spreads from user to user, eventually infecting thousands. Kids can watch how quickly the disease is spreading on charts — posted by the Whyville branch of the CDC — and speculate about how the virus is transmitted.

The Whypox epidemic, created by researchers at UCLA, is just one example of an informal effort to teach people about science. Every year millions of children and adults experience such learning opportunities by visiting museums and aquariums, attending after-school programs or lectures, or watching TV documentaries.

There is plenty of evidence that these activities — even something as simple as a walk in the park — can contribute to one's knowledge of and interest in science, says a report from the National Research Council. And these settings can significantly improve learning outcomes for people from groups historically underrepresented in science.

The research base varies from setting to setting, however, and there are few generally agreed-upon ways to evaluate how much people learn in informal environments. Should evaluators use the same measures commonly used in school settings, or should they let the learners themselves define what they've learned? Neither blindly adopting academic goals nor embracing purely subjective standards is the answer, the report says. Instead, it offers six "strands" of science learning that take place in informal settings, and can inform evaluations of how well people are learning. For example, visitors can experience motivation to learn about phenomena in the natural and physical world, and learn how scientists conduct their work using specialized tools and equipment.

The report also offers advice to those on the front lines of informal education, such as museum staff. In discussing new science concepts, they should draw on learner's existing knowledge and use everyday language. And those who design exhibits and other settings should partner with their communities to develop local science learning opportunities. A companion guide to the report is slated for release this fall and will offer in-depth guidance for those who design these environments. — *Sara Frueh*

Learning Science in Informal Environments: People, Places, and Pursuits. Committee on Learning Science in Informal Environments, Board on Science Education, Center for Education, Division of Behavioral and Social Sciences and Education (2009, 352 pp.; ISBN 0-309-11955-3; available from the National Academies Press, tel. 1-800-624-6242; $49.95 plus $4.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/12190.html>).

The study committee was co-chaired by **Philip Bell,** associate professor of learning sciences and educational psychology, College of Education, University of Washington, Seattle; and **Bruce Lewenstein,** professor of science communication, departments of communications and science and technology studies, Cornell University, Ithaca, N.Y. The study was funded by the National Science Foundation.

A HARBOR IN THE TEMPEST

Protecting the Crescent City

Hurricane Katrina. The words alone stir up powerful images of devastation — entire neighborhoods submerged underwater, people stranded on rooftops and in the city, and levees blasted by floodwaters. But more than anything, the words are connected with pain and suffering for the citizens who are still trying to rebuild their lives and communities.

In Katrina's aftermath, Americans wondered how the system of levees and floodwalls designed to protect New Orleans could have failed. To help answer this question, the U.S. Army Corps of Engineers created the Interagency Performance Evaluation Task Force (IPET) to carry out a large-scale investigation into the failure of the New Orleans hurricane-protection system and to provide advice on strengthening the system. Subsequently, the National Research Council and National Academy of Engineering were asked by the U.S. Department of the Army to evaluate IPET's progress and reports.

For more than three-and-a-half years, the study committee examined IPET's work, as well as held meetings in New Orleans to listen to concerned citizens. From examining IPET's reports and other evidence, the study committee determined that levees and floodwalls surrounding New Orleans cannot provide absolute protection against overtopping or failure in future extreme events such as a hurricane — no matter how large or sturdy the structures are. They should

be viewed as ways to reduce risks from hurricanes and storms, not as complete protection. As with many structures built to protect against flooding, the New Orleans hurricane-protection system promoted a false sense of security that regions behind the structures were absolutely safe for habitation and development.

Settlement in areas most susceptible to flooding should be discouraged, the report says. Moreover, voluntary relocation of people and neighborhoods from vulnerable areas should be considered as a viable public policy option. If relocation is not feasible, an alternative would be to elevate the first floor of buildings to at least the 100-year flood level.

Although some of the report's recommendations to enhance hurricane preparedness have been widely acknowledged for years by experts in fields such as natural hazards mitigation and urban planning, many have not been adequately implemented. Rebuilding the New Orleans area and the levees and floodwalls to their pre-Katrina state would leave the city and its inhabitants vulnerable to similar disasters, the report notes.

The committee also recommended that officials establish a comprehensive evacuation program that is well-designed and tested; includes improved local and regional shelters that would make evacuation less imposing; and enhances the efficiency of evacuations by locating facilities for the ill and elderly away from hazardous areas.

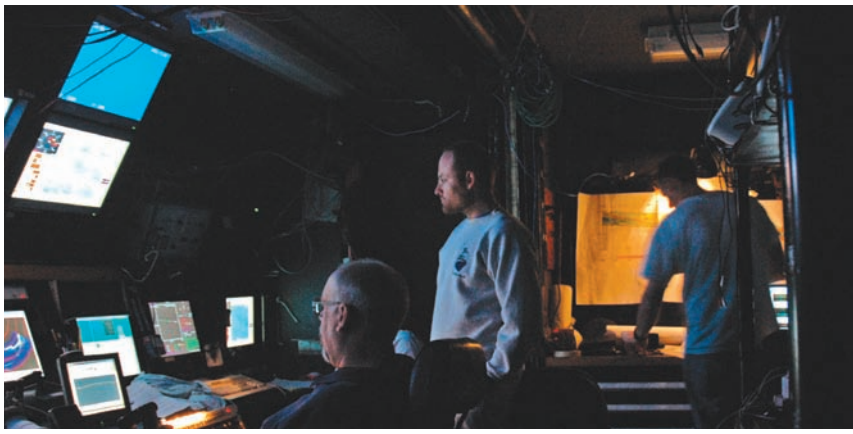
As further assistance to helping protect the city, a separate National Research Council report released in January found that replacing Federal Emergency Management Agency flood maps with ones that contain high-accuracy and high-resolution land surface elevation data could help avoid significant loss of life, destroyed property and businesses, and repairs to infrastructure, not just in New Orleans but throughout the whole country.

Better flood maps would provide more reliable measures of flood hazards, enabling structures to be insured at appropriate levels and more targeted land-use regulations, the report says. Moreover, coastal region flood maps, like those used near New Orleans, could also be improved by updating current models and using two-dimensional storm surge and wave models.
— *Jennifer Walsh*

The New Orleans Hurricane Protection System: Assessing Pre-Katrina Vulnerability and Improving Mitigation and Preparedness. Committee on New Orleans Regional Hurricane Protection Projects; Water Science and Technology Board, Division of Earth and Life Studies; Board on Infrastructure and the Constructed Environment, Division on Engineering and Physical Sciences; and National Academy of Engineering (2009, 58 pp.; ISBN 0-309-13833-7; available from the National Academies Press, tel. 1-800-624-6242; $21.00 plus $4.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/12647.html>). The committee was chaired by **G. Wayne Clough,** secretary of the Smithsonian Institution. The study was funded by the U.S. Department of the Army.

Mapping the Zone: Improving Flood Map Accuracy. Committee on FEMA Flood Maps: Accuracy Assessment and Cost-Effective Improvements, Board on Earth Sciences and Resources and Water Science and Technology Board, Division of Earth and Life Studies (2009, 136 pp.; ISBN 0-309-13057-3; available from the National Academies Press, tel. 1-800-624-6242; $32.00 plus $4.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/12573.html>). The committee was chaired by **David R. Maidment,** professor of civil engineering and director of the Center for Research in Water Resources, University of Texas, Austin. The study was funded by the Federal Emergency Management Agency and National Oceanic and Atmospheric Administration.

On the Horizon of **OCEANOGRAPHY**



Jules Verne's 1870 literary classic *Twenty Thousand Leagues Under the Sea* captured the inquisitiveness and enthusiasm for ocean exploration, decades before much of the technology in the book would become reality. In a similar spirit, earlier this year the National Research Council convened a workshop with an eye toward the future to discuss the needs and directions for oceanography and what the field would look like in 2025. Approximately 50 scientists from academia, federal agencies, and industry attended.

Ocean exploration is following the model of NASA's Mars rovers, sending home digital data and limiting the dependence on physical samples, commented attendee Justin Manley from Battelle Applied Coastal and Environmental Services. And technical advances and remote sensing promise to dramatically improve the study of our oceans, according to Jim Bellingham from the Monterey Bay Aquarium Research Institute. For instance, techniques for precise identification of species in the laboratory and detection of organisms in the field will be developed. In addition, more robotic platforms will conduct observations and simple tasks with little or no human supervision, which will enable a continuous, interactive presence in remote ocean locations.

Besides ship-based measurements, a wide array of samples could be collected by sensors on floats, gliders, and moorings, and by computer-controlled autonomous underwater vehicles that follow pre-programmed or adaptive trajectories.

Moreover, sensors will become smaller and use less energy, with some high-powered sensors drawing energy from waves and solar panels, noted Meghan F. Cronin, a scientist from Seattle.

Ocean mapping will change in the future, too. According to Larry Mayer from the Center for Coastal and Ocean Mapping at the University of New Hampshire, the "new generation of systems will allow information to be collected from the entire water column, not just the seafloor, resulting in the evolving real time high-resolution 3D image of the seafloor and targets in the water column," such as fish.

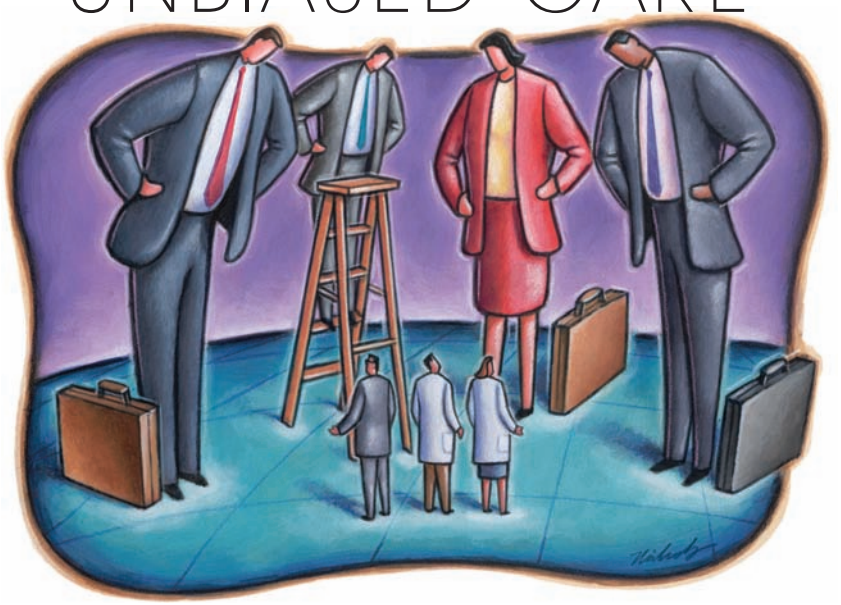
Others at the workshop also forecast that the field of oceanography will become more integrated with other scientific disciplines. Shuyi S. Chen of the Rosenstiel School of Marine and Atmospheric Sciences at the University of Miami said that the ocean and atmosphere will be viewed as a fully coupled system — at the air-sea interface and at the level of biological and chemical processes.

— *Jennifer Walsh*

Oceanography in 2025: Proceedings of a Workshop. Panel on Public Participation in Environmental Assessment Committee on Oceanography in 2025: A Workshop, Ocean Studies Board, Division on Earth and Life Studies (2009, 198 pp.; ISBN 0-309-13745-4; available from the National Academies Press, tel. 1-800-624-6242; $44.25 plus $4.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/12627.html>).

The steering committee was chaired by **Daniel L. Rudnick,** deputy director of education at Scripps Institution of Oceanography in La Jolla, Calif. The study was funded by the Office of Naval Research.

UNBIASED CARE



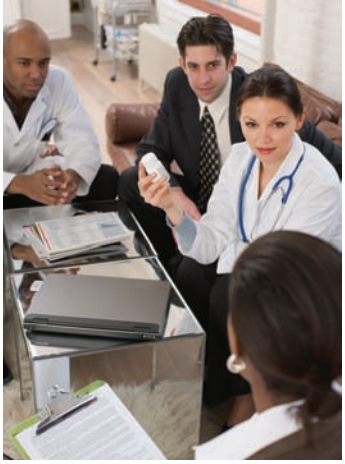
Report Lays Out Path **To End Medical Conflicts of Interest**

Does it make a difference in a patient's care if his doctor writes a prescription with a pen featuring a pharmaceutical company's logo? What if the physician accepts lunch from a company sales representative? Or gives a presentation noting the virtues of a medical-device maker's product?

These scenarios illustrate the uncertainties about when and how relationships with the medical industry affect practitioners' habits. Some contend that documented harms to patients as a result of health care providers' or researchers' industry ties are few and that such cases are aberrations. Others argue that any ties to industry are inherently fraught with potential for creating biases and point to a number of conflict-of-interest cases that have come to light in just the past year.

Revelations of undisclosed financial relationships between the medical community and companies could have a corrosive effect on people's trust in medicine, says a new report from the Institute of Medicine. And some relationships pose risks for bias while offering little or no societal benefits.

Americans have traditionally placed great trust in physicians and clinical researchers, granting them considerable leeway to regulate themselves. And collaborations with companies have advanced medical knowledge and yielded new diagnostic tests, more options for therapy, and better approaches



to care. But in light of growing concerns among policymakers, medical leaders, and the public about medical conflicts, the report lays out a blueprint for voluntary and regulatory measures that can strengthen protections against inappropriate relationships without hindering patient care or the advancement of medical knowledge.

"Responsible and reasonable conflict-of-interest policies and procedures will reduce the risk of bias and the loss of public trust while avoiding undue burdens or harms," said Bernard Lo, chair of the committee that wrote the report and professor of medicine and director of the program in medical ethics at the University of California, San Francisco.

Most medical institutions have conflict-of-interest policies of some kind, but they vary considerably. Compliance also varies widely as does institutional oversight and management, the committee found.

The report encourages enhanced requirements for all physicians, scientists, and medical institutions to disclose their links to companies. The format for disclosure and categories of relationships that must be revealed should be standardized to make it easier to judge the nature of relationships and to ease the burden for individuals who must report to multiple organizations. In addition, Congress should require pharmaceutical, biotechnology, and medical device firms to report through a public Web site the payments they make to doctors, researchers, academic health centers, professional societies, patient advocacy groups, and others involved in medicine.

Disclosure is only one part of the solution, however. The report also calls for individuals and institutions to simply refuse to accept industry gifts, sign their names to industry-written articles or materials, and engage in other inappropriate relationships.

Industry involvement in continuing medical education (CME) stirs significant debate. Company sponsorship has helped make CME more widely accessible, but has increasingly led to concerns about the objectivity of the information being presented. To remove even the appearance of slanted information, CME should be free from industry influence, the committee said. It did not rule out the possibility of industry support, however, noting that it may be possible for financial assistance from firms to be channeled through a mechanism that allocates it in a neutral fashion.

The report emphasizes the role of voluntary efforts as more likely to reinforce professional values and foster policies that minimize unintended consequences and administrative burdens. However, if the industry and the medical community fail to strengthen their conflict-of-interest policies, practices, and enforcement, policymakers may turn to legislative solutions. — *Christine Stencel*

Conflict of Interest in Medical Research, Education, and Practice. Committee on Conflict of Interest in Medical Research, Education, and Practice, Board on Health Science Policy, Institute of Medicine (2009, approx. 392 pp.; ISBN 0-309-13188-X; available from the National Academies Press, tel. 1-800-624-6242; $54.95 plus $4.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/12598.html>).

The committee was chaired by **Bernard Lo,** professor of medicine and director of the program in medical ethics, University of California, San Francisco. The study was funded by the National Institutes of Health, Robert Wood Johnson Foundation, Greenwall Foundation, ABIM Foundation, Burroughs Wellcome Fund, and Josiah Macy Jr. Foundation.

PREGNANCY WEIGHT GAIN

New Guidelines Balance Benefits and Risks

How much weight should women gain during pregnancy? During the nearly 20 years since the Institute of Medicine last answered this question, research has added to our understanding of the effects of gestational weight gain on mothers and their children. Moreover, the percentage of American women who are overweight or obese has increased dramatically.

Nonetheless, the new guidelines issued by the IOM and National Research Council are similar to the 1990 set, though they are based on updated body mass index (BMI) categories and include a new recommended range of gain for women who start pregnancy obese.

Women at a normal BMI (18.5 to 24.9) should gain 25 to 35 pounds during pregnancy, the new guidelines state. Underweight women (BMI less than 18.5) should gain more, 28 to 40 pounds, and overweight women (BMI of 25 to 29.9) should gain less, 15 to 25 pounds. Where the 1990 report simply stated that obese women should gain at least 15 pounds, the new report says they should gain 11 to 20 pounds.

The latest review of the evidence focused not only on health outcomes for infants but also on the potential impact of weight gain on mothers. Evidence is consistent that some weight gain during gestation is necessary for fetal growth as well as breast, uterine, and placental growth. However, research also underscores women's anecdotal experiences that it can be easy to gain weight during pregnancy and difficult to lose the extra weight after birth. The committee strove to balance the health needs of both infants and mothers in setting the new guidelines.

"That we came to such similar recommendations with a completely different approach should give women and their health care providers confidence that these recommendations are appropriate and useful," noted Kathleen Rasmussen, a professor of nutrition at Cornell and chair of the committee that wrote the report.

The principal message: Women should start pregnancy at or as close to a normal BMI as possible and stay within the guidelines during pregnancy. Recognizing that this is easier said than done, the committee recommended support for programs and efforts to provide women counseling on nutrition and physical activity and opportunities to engage in healthy eating and exercise. Meeting all of the committee's recommendations, however, will require major improvements in the health care offered to women before, during, and after pregnancy.
— *Christine Stencel*

Weight Gain During Pregnancy: Re-examining the Guidelines. Committee to Re-examine IOM Pregnancy Weight Guidelines; Food and Nutrition Board, Institute of Medicine, and Board on Children, Youth, and Families, Institute of Medicine and National Research Council (2009, approx. 336 pp.; ISBN 0-309-13113-8; available from the National Academies Press, tel. 1-800-624-6242; $47.95 plus $4.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/12584.html>).

The committee was chaired by **Kathleen Rasmussen**, professor, division of nutritional sciences, Cornell University, Ithaca, N.Y. The study was funded by the U.S. Department of Health and Human Services' Health Resources Services Administration, Centers for Disease Control and Prevention, National Institutes of Health (National Institute of Child Health and Development, National Institute of Diabetes and Digestive and Kidney Diseases, and Division of Nutrition Research Coordination), HHS Office of Women's Health, and the HHS Office of Disease Prevention and Health Promotion; and the March of Dimes. Additional support was provided by the HHS Office of Minority Health (National Minority AIDS Council).

Fuel of the Future

Driving the U.S. **Toward Alternative Fuels**

Transportation plays a key role in the U.S. economy and, as in most industrialized societies, it runs largely on petroleum-based fuels. The effects of this reliance on petroleum are broad, ranging from energy security to climate change. To reduce this state of dependence, alternatives are being developed. A new report from the National Research Council reviewed two: liquid fuels from coal and biomass.

Although corn-based ethanol is likely the most familiar form of biomass fuel, the report focused on biofuels from grass, waste, or forest debris, which can avoid the potential conflicts between food and fuel. Cellulosic ethanol, plant material converted into ethanol via bacteria or yeast, has become a center of attention in the U.S. transition to alternative fuels. In 2007, the U.S. Department of Energy offered up to $385 million in funding for projects that would bring cellulosic ethanol to market. The renewable fuel standards recently proposed by the U.S. Environmental Protection Agency require that transportation fuel in the U.S. contain 10.5 billion gallons of cellulosic biofuel by 2020.

Cellulosic ethanol is in the early stages of commercialization. Verenium, a biofuel company in the U.S., has a 1.4 million gallons per year demonstration plant running in Jennings, La., and recently announced plans to partner with oil giant BP to develop the first U.S. commercial-scale cellulosic ethanol plant. Plants such as these are a critical step

in the transition to alternative fuel, according to the report. The know-how required to produce cellulosic biofuel, or any alternative fuel for that matter, will really only come from doing it.

Although cellulosic ethanol is moving forward, there are drawbacks to this form of fuel. Ethanol fuels are too corrosive to be distributed through gasoline pipelines; currently most ethanol here is distributed via railway or truck. This system works fine, as long as the ethanol market remains relatively small, but substantial investments in infrastructure would be needed to ramp up ethanol fuel use in the United States. The next generation of biofuels, such as biobutanol or other longer-chain alcohols, have chemical properties that would allow distribution in existing gasoline pipelines.

The report also looked at the possibility of producing transportation fuels from coal. One of the main benefits of coal is its abundance; it is estimated that U.S. coal reserves are sufficient to last at least 100 years, assuming that we maintain current rates of consumption. At the moment, the primary use for coal in the U.S. is power. If coal also became a source of transportation fuel, consumption rates could soar.

The environmental impact of coal-based fuel would be its most serious disadvantage. Coal mining would have to increase significantly in order to meet the demand for fuel, and carbon emissions from producing and using coal fuel would be nearly double that of petroleum. Geologic carbon storage would be necessary if coal-based fuels were to become a part of the U.S. transportation fuel portfolio.

One way to get both the environmental benefits of biofuel and the abundance and low cost of coal fuels, is to literally combine the two. A handful of pilot plants in Europe have begun mixing biomass with coal to produce fuel. Computer models suggest that the carbon emissions of combined coal and biomass would be similar to petroleum fuel and could be brought close to zero with geologic carbon storage.

Clearly, there is no magic solution to our petroleum addiction, but these approaches could reduce U.S. oil use by 15 percent to 25 percent and significantly reduce our dependency on foreign oil. All alternative fuels currently being discussed have both pluses and minuses; a future with alternative fuels will likely mean coming up with a number of approaches to expand the range of options for the U.S., and moving forward from there. — *Rebecca Alvania*

Liquid Transportation Fuels from Coal and Biomass: Technological Status, Costs, and Environmental Impacts. Panel on Alternative Liquid Transportation Fuels, Committee on America's Energy Future, Phase 1, National Academy of Engineering and National Research Council (2009, approx. 300 pp.; ISBN 0-309-13712-8; available from the National Academies Press, tel. 1-800-624-6242; $49.95 plus $4.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/12620.html>).

The study was chaired by **Mike Ramage,** retired executive vice president of ExxonMobil Research and Engineering Co. The study was funded by the U.S. Department of Energy, BP America, Dow Chemical Company Foundation, Fred Kavli and the Kavli Foundation, GE Energy, General Motors Corp., Intel Corp., and the W.M. Keck Foundation.

PLUTONIUM, Part 2

The Return of a Long-Defunct ISOTOPE PROGRAM

On May 25, the U.S. Department of Energy announced it would start making plutonium-238, a radioactive isotope created as a byproduct of the nuclear weapons industry that has not been produced in the U.S. since the end of the Cold War. Hours before DOE's announcement, the National Research Council released a new report stating that if the U.S. did not start producing plutonium-238 again, the nation's space programs could be in jeopardy.

These isotopes are needed in space to generate electrical power. As radioactive elements like plutonium decay, they give off heat, which can be converted to electricity. Radioactive power systems are particularly important on space missions where solar energy may be too weak to generate useful power, such as deep-space missions. Maintaining electrical power is primarily dependent upon having sufficient radioactive isotopes for the mission.

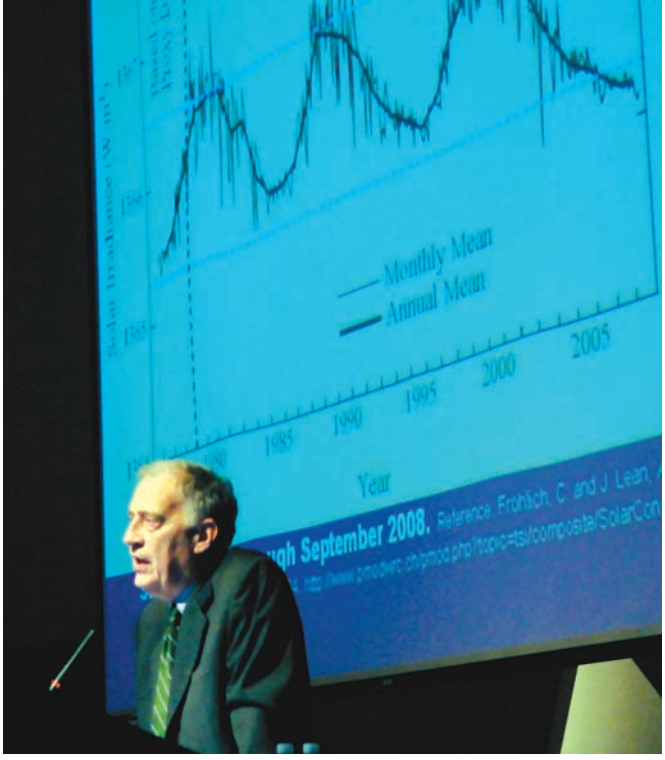
The best isotope for use in radioactive power systems is plutonium-238 (Pu238), which historically came from U.S. government facilities supporting the nuclear weapons industry. But once the Cold War ended, DOE shut down these facilities. Since then, the U.S. space program has been running on leftovers. Ironically, Russia, a chief rival in the Cold War race to stockpile nuclear weapons, has been one of the United States' principal suppliers of Pu238. The stocks of both the U.S. and Russia are now nearly depleted, however, and no other nations are actively producing Pu238. DOE will soon accept its final shipment of Russian Pu238.

A worldwide shortage of Pu238 could be devastating for space research. NASA is already making mission decisions based upon declining availability of Pu238. The Mars Science Lab and an outer-planet mission tentatively scheduled for 2020 will likely use the last of the existing stores.

The National Research Council estimated that Pu238 production could be restarted at nuclear reactors in Idaho and Tennessee, and recommended that DOE produce 5 kilograms annually. DOE's 2010 budget request included $30 million for Pu238 production. While these funds may be enough to restart the program, they are likely not adequate to achieve the goal of 5 kilograms per year, leaving the long-term future of Pu238 in space uncertain. — *Rebecca Alvania*

Radioisotope Power Systems: An Imperative for Maintaining U.S. Leadership in Space Exploration. Radioisotope Power Systems Committee, Space Studies Board and Aeronautics and Space Engineering Board, Division on Engineering and Physical Sciences (2009, 68 pp.; ISBN 0-309-13857-4; available from the National Academies Press, tel. 1-800-624-6242; $21.00 plus $4.50 shipping for single copies; also on the Internet at <www.nap.edu/catalog/12653.html>).

The committee was co-chaired by **William Hoover,** U.S Air Force (retired), and **Ralph McNutt,** senior space physicist, Johns Hopkins University, Baltimore. The study was funded by NASA.



A National Response to Climate Change

SUMMIT KICKS OFF NEW STUDY

The "green movement" has penetrated the American consciousness, and its growing popularity has been turning people on to becoming more environmentally responsible. Across the country people are trying to help by swapping plastic bags for reusable bags at the grocery store, reducing their carbon footprint, or making more energy-efficient choices. This wave of "green" enthusiasm mainly focuses on how individuals or business can help lessen their environmental impact, but actions such as reducing the use of plastic bags won't really influence the overarching issue of global warming. To combat climate change, a more far-reaching course of action is needed, not only for individuals, but the entire nation.

Looking for such a path, Congress asked the National Research Council to study the steps and strategies policy leaders should take. The resulting project, America's Climate Choices, lays the groundwork for how the nation can respond through a series of reports that will be issued next year.

A summit last spring brought together members of Congress, administration officials, top scientists, business leaders, state government officials, and representatives of nongovernmental organizations to hear the expert views on what the study should cover and include.

"This study is not about what the individuals should do … recycle aluminum cans



or not," said Albert Carnesale, chair of the Committee on America's Climate Choices while addressing the audience. "This is about … what the nation is going to do."

"This report will inform a thousand different policy decisions layered throughout our federal, state, and local government — in fact, our entire economy," said U.S. Rep. Alan Mollohan, D-W.Va. "If sea levels are projected to rise X feet over the next 30 years, for example, how does that affect wetlands restoration activities in Louisiana? How do we provide water to California if the snowpack in the Sierra Nevada is substantially reduced? At what point will depleted aquifers in America's bread basket force us to make fundamental changes in our agriculture policy?"

Rep. Mollohan added that he expected the study to define these uncertainties, evaluate this meaningfulness for policymakers, and map out a way to narrow the remaining questions about climate change.

Examining the Challenges

Some of the most difficult obstacles to combating climate change that speakers identified deal with improving technology to create more efficient use of fuel and electricity, promoting more climate-friendly behaviors, and incorporating information about climate change into decision being made at all levels. Currently, the United States puts out 6 billion tons of carbon dioxide of the world's total output of 30 billion tons per year. In order to substantially reduce these emissions, massive changes are needed in the ways we produce and use energy, said Robert Socolow, a professor at Princeton University and member of the America's Climate Choices committee.

Moreover, the study needs to consider how U.S. climate solutions will integrate into a global framework. How much would they cost to implement, and how does that mesh with the current gloomy state of the economy? "Without a blueprint for domestic action, it will be difficult to agree to an international plan with firm targets for the United States and other nations," noted Eileen Claussen, president of the Pew Center on Global Climate Change.

Looking Back and Forward

Although the summit was a launch pad for the America's Climate Choices study, it also provided an opportunity to collect feedback and firmly frame the questions and issues the study will address. Four study panels will issue reports, and the project will culminate with an overarching report that identifies short-term actions and the most promising long-term strategies to respond to climate change. — *Jennifer Walsh*

America's Climate Choices. Committee on America's Climate Choices, Board on Atmospheric Sciences and Climate, Division on Earth and Life Studies. The committee is chaired by **Albert Carnesale**, chancellor emeritus and professor at the University of California, Los Angeles. The study is funded by the National Oceanic and Atmospheric Administration.

More information and video of the presentations are available at <americasclimatechoices.org>.

Obama Speaks to NAS, Announces Major Investments in Research and Education

In an April 27 speech to members of the National Academy of Sciences, President Barack Obama announced new initiatives and investments in scientific research, innovation, and education. And he committed to restore science to its rightful place. "The days of science taking a back seat to ideology are over," he said.

Calling science "more essential for our prosperity, our security, our health, and our environment than it has ever been," Obama said he wants to make major investments — 3 percent of the gross domestic product — in research and innovation. This exceeds the amount invested at the height of the space race. He emphasized the importance of using funds to encourage high-risk, high-return research and to support researchers at the beginning of their careers.

Following a welcome from NAS President Ralph J. Cicerone, Obama was introduced to the audience by his science adviser and NAS member John Holdren, who said that Obama "wanted to bring science back into

the center of how the government thinks, what it says, and what it does; and he is doing it."

Obama used the occasion to announce the members of the President's Council of Advisors on Science and Technology (PCAST), a council of leading scientists and engineers that will help the administration formulate policy. Seven of the council's 20 members are NAS members including PCAST co-chairs John Holdren, Eric Lander, and Harold Varmus, as well as Mario Molina, William Press, Barbara Schaal, and Ahmed Zewail.

The president committed to doubling the budgets of three key science agencies — the National Science Foundation, the Department of Energy's Office of Science, and the National Institute of Standards and Technology. He also announced the launch of the Advanced Research Projects Agency-Energy, a new Department of Energy organization modeled after the Defense Advanced Research Projects Agency. And Obama said he would triple the number of NSF graduate research fellowships.

Obama spoke about the outbreaks of swine flu, saying it is cause for concern but not for alarm. He added that "our capacity to deal with a public health challenge of this sort rests heavily on the work of our scientific and medical community. This is one more example why we can't allow our nation to fall behind."

The president challenged NAS members to use their love and knowledge of science to inspire American students to pursue careers in science and engineering. In addition, he urged NAS members to "think about new and creative ways to engage young people in science and engineering,

President Barack Obama standing with Academy members chosen to serve in his administration: (left to right) Lawrence Summers, Nina Fedoroff, Steven Chu, Jane Lubchenco, Eric Lander, John P. Holdren, and Harold Varmus.

like science festivals, robotics competitions, and fairs that encourage young people to create, build, and invent — to be makers of things, not just consumers of things."

Obama reiterated his commitment to education and announced a national initiative, "Race to the Top," designed to improve student achievement in math and science and move U.S. students from the middle of the pack to the top on international benchmarks over the next decade.

The speech took place during the Academy's 146th annual meeting with more than 600 NAS members in attendance including Energy Secretary Steven Chu, Nina Fedoroff, science adviser at the State Department, NOAA Administrator Jane Lubchenco, and Larry Summers, who directs the White House National Economic Council.

President Obama joins John F. Kennedy, George H.W. Bush, and Jimmy Carter as the fourth U.S. president to deliver a speech at an NAS annual meeting. Full text of the speech and a video recording, audio recording, and photos of the event are available at <national-academies.org/obama>.

OPINION

BY RALPH J. CICERONE

HOW TO KEEP SCIENCE **MOVING**

Published in the April 24 issue of *Science*, an editorial by NAS President Ralph Cicerone discusses the importance of building on recent enthusiasm for science.

Recent enthusiasm for science in the United States is cause for celebration, but it's also food for thought: What can scientists do to build on this new excitement and support? If the U.S. Congress and administration are to continue to advance science research and education and to rely on science in policymaking, then scientists must do much more to show how science works and how scientific research contributes to the nation.

President Obama has made strong statements affirming the value of science and his commitment to it. He has appointed outstanding scientists to leadership positions. And by Executive Order, he has reversed the federal ban on human embryonic stem cell research and directed the Office of Science and Technology Policy to propose methods to ensure that science policies are not twisted for political or ideological purposes. Moreover, the federal stimulus package provides a great infusion of funds for research grants, major equipment, and facilities through the major science funding agencies. While testifying at a recent House Appropriations hearing, I witnessed much goodwill toward science, scientists, and science educators in the bipartisan support for items in the stimulus package. Members of Congress on both sides of the aisle also seemed motivated to improve science education at all levels.

However, Congress needs continual, vigorous contact with science and scientists. Its members support science but also must deal with many other demands for their attention: federal budget deficits; immediate social, physical infrastructure, and military needs; rising unemployment; and turmoil in the industrial and financial sectors. Scientists must do more to demonstrate the value of investing in science. Their first duty, of course, is to do good research while adhering to high ethical standards of openness and honesty. Yet to energize the public and its elected representatives, scientists must talk more with them, both through scientific societies and as individual scientists, person to person. As one example, providing

Congress with postdoctoral fellows from scientific and engineering societies has proved to be very valuable for science, Congress, and the fellows involved, opening new career paths and generating critical support for policymakers from the scientific community.

Encounters at home are often more effective than those in Washington. Former Congressman John Porter, who did so much to double the budget of the U.S. National Institutes of Health, once told me that few of his congressional colleagues had much time for science, but that each and every one of them who had visited a science laboratory in his or her home district emerged as an enthusiast. Scientists should be recruiting deans, presidents, chancellors, alumni associations, and press officers to help them communicate with their local community and business leaders, as well as with members of Congress. They should create opportunities to invite the public into their laboratories, introduce them to their students, and give answers to questions such as: What do your results mean? What could they mean to the public? How does your research complement the work of others? How have you created good research experiences for students? Do you have any research connections with new or established businesses? These positive impacts of research are not always visible from a distance.

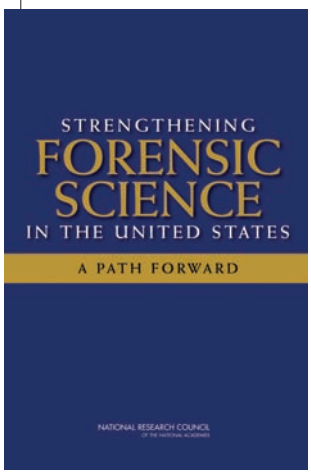
If the U.S. Congress and administration are to continue to advance science research and education and to rely on science in policymaking, then scientists must do much more to show how science works and how scientific research contributes to the nation.

The reinvigorated research community must also engage the interests of new science students, so that U.S. science can maintain leadership in certain fields and be a strong, reliable partner in many critical international research efforts. That means becoming more deeply involved in improving science education at all levels, including working with pre-college students and their teachers and exposing many more students to real science and scientists. Such interactions can raise the career aspirations of young people.

Only if scientists do their part will there be the broad and deep public support that is so essential for science to flourish and for the public to engage with science. Scientists have great stories to tell, and many important people want to hear them. So let's get going and tell them.

Supreme Court Decision Cites Academies Report

A U.S. Supreme Court decision issued in June, which ruled on the right of defendants to cross-examine forensic analysts in court, cited *Strengthening Forensic Science in the United States: A Path Forward,* a National Research Council report on forensic science released in February [available online at <www.nap.edu>].



The case, *Melendez-Diaz v. Massachusetts*, concerned whether the defendant had a right to cross-examine forensic scientists who had submitted affidavits saying that a substance found in his car was cocaine. The Sixth Amendment guarantees the right of the accused in a criminal prosecution to confront any witnesses providing testimony against them, so the case turned on whether forensic science analysts are witnesses in the same way as, for example, eyewitnesses to a crime.

Writing for the majority, Justice Antonin Scalia said that there was no reason forensic analysis should be different from any other testimony given against a defendant, and that forensic analysts were therefore required to appear in court to take questions about their analysis. The court also disagreed with the notion that forensic science testimony is uniquely neutral or reliable, citing the Research Council's findings that forensic labs — which are usually under the control of law-enforcement agencies — may feel pressured to sacrifice appropriate methodology for the sake of expediency and that the reliability of forensic methods varies widely.

Arguing that serious deficiencies have been found in the forensic evidence used in criminal trials, Scalia cited one of the report's major conclusions: "The forensic science system, encompassing both research and practice, has serious problems that can only be addressed by a national commitment to overhaul the current structure that supports the forensic science community in this country." — *Sara Frueh*

National Academies Build New Playground in D.C.

Volunteers from the National Academies, KaBOOM!, and the D.C. Developing Families Center, which offers care to hundreds of women and their families during pregnancy and early childhood, worked together to build a playground at the center in Northeast Washington, D.C., in June. The project, called Science Swings, is part of the National Academies' effort to connect with the local community.

The National Academies and their staff donated funds and time to build the play-

ground, whose design is based on drawings provided by children. Over 200 volunteers participated, moving 170 cubic yards of mulch, assembling the purple, orange, and yellow playground equipment chosen by children who use the center, and grounding it with 15,000 pounds of concrete. Also constructed were 1,200 feet of iron fencing, eight benches, four planters, two arbors, and a peace pole inscribed with "May Peace Prevail on Earth" in eight different languages.

Thrilled about getting a new play space, Linda Randolph, director of the Developing Families Center and a member of the Institute of Medicine, said, "Physical exercise is important. This playground provides a place for the children to exercise."

The day included fun and entertainment as well as manual labor. Nearby, children who were watching the play equipment being erected cooled off under a 20 foot arc of water sprayed from a fire truck, and a DJ played a thumping music mix to keep the volunteers moving. In just seven hours, there was a new playground. — *Maureen O'Leary*

For more information on the DC Developing Families Center, visit <www.developingfamilies.org>. To learn more about KaBOOM! — a nonprofit organization that envisions a great place to play within walking distance of every child in America — visit <www.kaboom.org>.

Futures Conference Takes on Complex Systems

Jorge Luis Borges wrote of an imagined regime that had so mastered cartography, it could create giant, detailed maps, and its crowning achievement was a map of the empire that was the same scale as the empire itself.

> "Less attentive to the study of cartography, succeeding generations came to judge a map of such magnitude cumbersome, and, not without irreverence, they abandoned it to the rigors of sun and rain."

The challenge presented to the 2008 attendees of the National Academies Keck Futures Initiative conference on complex

systems was to understand systems as complex as the world itself, with models that are necessarily nuanced to contain enough detail to be useful, yet not so complex as to render those models impossible to build or understand.

Nine task groups were formed to attack such complexities as achieving a sustainable future, acquiring and organizing the data needed to model human biology, using social networks to map the progression of diseases and ideologies across the Web, to name a few of the assignments. Each group included about a dozen experts from diverse fields: engineers, microbiologists, computer scientists, economists, mathematicians, paleontologists, and neurologists, among others. A graduate science writing student also was assigned to each group to capture the

essence of the process and the possibilities that emerged in the discussions.

Taken as a whole, the challenges were mechanical, chemical, and philosophical, and the answers to the questions posed at the conference could greatly affect the way people fight disease, reverse environmental damage, model disease and biology, understand social groups, and examine their own effects on the planet. Additional information on the conference is available online at <www.keckfutures.org>. — *Noah Barron*

E.O. Wilson Discusses Fate of Earth's Species in NAS Lecture

Edward O. Wilson, professor emeritus at Harvard University, spoke at the National Academy of Sciences building last April about species extinction and natural habitat loss occurring around the world.

Wilson, who first coined the term "biodiversity" at an NAS workshop in 1988, spoke at length of the impact humans have had on specific habitats like the forests of the Philippines — slashed from 70 percent of the country's landmass down to 22 percent during the 20th century — and the diminishing Brazilian rainforest. As habitats shrink, the number of species they can sustain drops as well, and Wilson spent a portion of his talk eulogizing specific species, many of which are thought to already be extinct, such as the ivory-billed woodpecker. A world-renowned conservationist, Wilson showed portraits of these endangered or extinct species because, he says, "you have to get to know them to want to save them."

Despite the losses that have already occurred, Wilson spoke of an increasing global recognition of the importance of saving Earth's remaining plant and animal species. Changes in the way humans value and interact with the natural world are needed quickly, however. It took 3.5 billion years to develop Earth's current levels of biodiversity, but half of the known species could be lost by the end of the century. While a chilling prediction, Wilson reminds us that the biodiversity of the Earth is actually far larger than that which we know. In fact, it is thought that less than 10 percent of Earth's species have been discovered. In many ways, he says, "we live in an unknown world."

Wilson is a university research professor emeritus at Harvard University and honorary curator in entomology of the Museum of Comparative Zoology. He has written 25 books, two of which won Pulitzer Prizes, and is the recipient of more than 100 international medals and awards, including the U.S. National Medal of Science. He is also the creator of the Encyclopedia of Life, now housed at the Smithsonian Institution. Wilson was elected a member of the National Academy of Sciences in 1969.

Wilson's talk, "Evolution and the Future of the Earth," was the ninth annual Sackler lecture. The Arthur M. Sackler Colloquia and Lectures address scientific topics of broad and current interest and are made possible by a generous gift from Jill Sackler, in memory of her husband.
— *Rebecca Alvania*

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