Bruce Alberts is Editor-in-Chief of *Science*

Voices of the Next Generation

THE START OF 2012 PROVIDES AN OPPORTUNITY TO TAKE STOCK OF WHERE WE HAVE BEEN AND WHERE we are going at *Science*. Internet technology has been rapidly changing the way that scientists access information. This has advantages, allowing new content to be noticed around the globe as soon as it is published. But it also has disadvantages, making it easy for a scientist to receive only preselected information focused on his or her specialty. Because innovative breakthroughs often come from the intersection of disparate ways of thinking, scientists need to continually expose themselves to a broad range of disciplines and approaches. They also must work together as a community to build the strong scientific enterprise needed to create the paradigm-breaking innovations that will be required by an ever-more crowded and resource-limited world. How can we promote the wide-ranging conversations that will be necessary to meet these critical challenges?

We know from surveys that younger scientists primarily read our magazine online, finding specific articles from specialized searches, such as those on Google Scholar or PubMed. As a result, they often miss the valuable, community-building articles in *Science*'s News and Commentary sections, as well as exposure to research in other fields. Many of these young people are already actively engaging in conversations about the issues presented in *Science* on social media sites such as Facebook.* But to bring such conversations to a broader community of scientists, *Science* is providing a prominent space for young scientists in the front half of the print magazine with a new feature called NextGen VOICES. In this issue, we publish the first set of essays from young scientists who responded to our question: "How will the practice of science change in your lifetime?" We received answers from many nations and publish a selection in this issue, some in print (see p. 36) and many more online (www.scim.ag/NextGenResults). We also announce the next question in this series, with essays of 250 words or less due by 17 February: "What is your definition of a successful scientist? How has this definition changed between your mentor's generation and your own?" (see announcement on p. 36 and www.scim.ag/NextGen_2).

The short essays published this week come from young scientists in 18 nations: Austria, China, Denmark, France, Germany, India, Israel, Italy, Netherlands, Norway, Russia, Singapore, South Africa, Spain, Sweden, Turkey, United Kingdom, and United States. The answers are encouraging, inasmuch as they dramatically illustrate the wisdom and energy of the next generation of the world's scientists, along with their strong shared culture. Many of the essays express a greatly increased need for interdisciplinary, collaborative science—calling for new mechanisms and better incentive systems that promote it. All in all, *Science* is very encouraged by the response, and we hope that this new feature will—along with new organizations like the Global Young Academy†— help to empower young scientists to play a larger role in both the scientific community and society.

Other new features at *Science* include two new mechanisms designed to encourage wider participation in the issues published by our magazine. Readers can now post comments on all Commentary, News, and Research content immediately after print publication (see www.comments.sciencemag.org). We also welcome Technical Comments that address core conclusions and methodologies, and will publish those as soon as possible (see www.sciencemag.org/site/feature/contribinfo/prep/gen_info.xhtml). We hope that all of these changes—NextGen VOICES, and the facilitation of both general and technical comments—will allow many more people, and especially young scientists, to participate more effectively in an increasingly global conversation on central issues. Only by heeding the voices of the next generation can we succeed in building a broad-based scientific community that can address the daunting challenges of our times—for in a very real sense, the future is in their hands. **–Bruce Alberts**

10.1126/science.1218287

*Over 190,000 "likes" on Facebook for *ScienceNow* and 65,000 for *Science*. †B. Alberts, *Science* **332**, 283 (2011).

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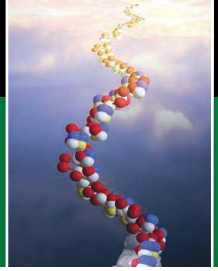

LETTERS

edited by Jennifer Sills

NextGen**VOICES**

Results: Future of a Generation

In October, we called on young scientists to answer these questions: How will the practice of science change in your lifetime? What will improve and what new challenges will emerge?

We received more than 100 responses from young scientists across the globe. Although concerns about the future are evident, these scientists spoke passionately about meeting the challenges they face and embracing science's potential to address the world's problems. We've included a sample of the best responses here (ellipses indicate excerpted text). To read more, go to http://scim.ag/NextGenResults.

Submit Now: Definition of Success

Would you like to make your voice heard in *Science*? Our second NextGen VOICES survey is now open. We would like to hear your answer to these questions:

What is your definition of a successful scientist? How has this definition changed between your mentor's generation and your own?

To submit, go to http://scim.ag/NextGen_2.

Deadline for submissions is 17 February. A selection of the best responses will be published in the 6 April issue of *Science*. Submissions should be 250 words or less. Anonymous submissions will not be considered. Please submit only once.

NextGen Speaks

…TODAY, UNRAVELING NEW PRINCIPLES OF any system or process typically demands several smaller steps, each warranting publication. The future practice of science will traverse smaller steps in parallel, through online cooperation between experts, each tackling smaller steps while continuously communicating findings to their collaborators. This may be envisioned as skipping the stairs and, rather, taking an elevator. The result? Each paper will contain fewer questions and more answers. If communication truly erases distance in the scientific community, new fields are likely to emerge in the intersections between disciplines. Bridging the gaps between disciplines such as neuroscience and psychology is one of the triumphs I personally hope to see happen.

Again, communication is the key, and it may not come easily. The sharing of knowledge in a competitive world is perhaps the greatest challenge for we who are the next generation of scientists. **ASGEIR KOBRO-FLATMOEN**

The Faculty of Medicine, Kavli Institute for Systems Neuroscience/Centre for Biology of Memory, Medical Technical Research Centre, Norwegian University of Science and Technology, 7491 Trondheim, Norway. E-mail: Asgeirfl@gmail.com

OUR RETIREMENT SPEECH, IN 2045: DURING the first part of this century, the economic recession burned into the collective memory. Society demanded better "value for money" from its scientists, requiring them to demonstrate the impact of their research on global and national challenges. Some of those challenges, such as climate change and resource depletion, have only partially been met as scientists have struggled to adapt in a rapidly changing world. Academics spent too much time doing and too little time thinking; this was perpetuated by a tremendous pressure to perform and succeed. Deep-thinking spaces were eroded by the immediacy of communication, and swathes of information and data. Science and technology have assisted with nature-mimicking algorithms to respond to pedestrian tasks like sifting through e-mail. Virtual connectedness increased international, cross-institutional, and multidisciplinary research with the merging of our social and professional lives, but scientists continued to grapple with disconnected "silo" mentalities and the natural-social science divide. Self-preservation continued to drive research institute agendas. The rise of "super-universities" at the edge of the open-source revolution was always on the horizon. Scientists were so busy that they were often blind to what their universities were morphing into, although things have started to change recently. There have been some major successes to celebrate, such as the use of desiccation-resistant gene technology for plants (developed in South Africa), which turned many African deserts into productive farmland. Like the first heart transplant of the previous century, it shows that Africa has much to contribute.

GENEVIEVE LANGDON* AND CARADEE WRIGHT

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THE BIGGEST CHALLENGE FACING A GENERATION of young scientists is breaking free of the shackles placed on them by their predecessors. We are tasked with fixing large dysfunctional institutions that we are given no authority over nor trained to take the reins of. We are expected to fix broken peer-review systems riddled with small insular cliques.

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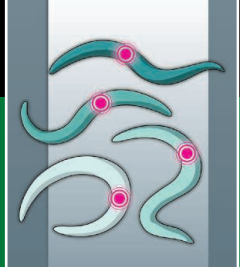
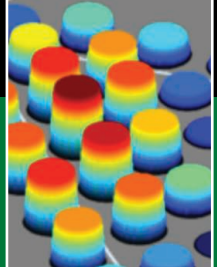


Influencing mutation effects
44



View of fields
47

We are expected not only to flourish in, but to be thankful for a funding structure equipped with scarce resources that are primarily used on contract science for the blessed few rather than discovery based on the merits of ideas and early results. We are expected to survive and contribute to a larger society that no longer trusts scientists, appreciates expertise, or understands the value science brings to the world. Science will continue to be dictated from above, not practiced. Science will be performed by those who are willing, not those best prepared or suited to the task. This future will be brought about in part because of disturbingly low levels of support in our schools for science and math education, spiraling the globe toward all-time lows in scientific literacy during the modern era. This is the future young scientists see ahead of us— a future handed down by a generation who was more interested in glorifying themselves than leaving things better than how they found them. We are expected to rise to this challenge and we're sure as hell going to give it our all. Gosh, who needs a drink?

JEREMY BLOCK

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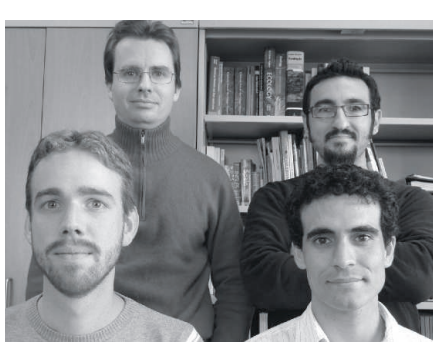
AS WE ACQUIRE KNOWLEDGE, WE CLIMB A LADder that helps us to see farther and observe unexplored territory. Our predecessors made enormous contributions while climbing the ladders of reductionism. As they climbed, they also became more isolated. The distance between disciplines and subdisciplines increased, as they focused on their own research topics. The challenge today is how to connect those ladders. To build taller ladders of knowledge, we have to create bridges among disciplines and not be afraid of the distance to the ground. It is, however, unrealistic to think that single individuals can master several disciplines. A side effect of increasing interdisciplinarity would therefore be an increase in the number of coauthors of scientific publications. Scientists, even more than today, will have to learn how to work together. Because of the current vast amount of knowledge, eclectic research groups will have to play the role that a single scientist played in the 19th century. To facilitate relationships between disciplines, the way we communicate our results among ourselves, and to the society, has to evolve. Scientific communication will be transformed into a multimedia experience. Live talk repositories, animations, and videos will enhance the figures of papers as unique pieces of scientific knowledge. We are therefore entering the Era of Interdisciplinarity. It is the end of many ivory towers. It is the beginning of many bridges.



LUIS J. GILARRANZ,* J. JELLE LEVER, RUDOLF P. ROHR, MIGUEL A. FORTUNA

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SCIENCE IS BECOMING INCREASINGLY ACCESsible to minorities, women, and people from a variety of cultural and socioeconomic backgrounds. Because more people are now being exposed to science, I predict that the speed and significance of scientific advancements will increase dramatically over the next 100 years. My grandmother was an extremely intelligent woman who spoke five languages, but she left high school before receiving her degree so that she could work in a mill to support her family. I wonder what contributions she could have made to the world of science, or any other field, if she had lived in a time of gender equality and financial aid. Today, great minds of all races, religions, and sexes are gathering in universities to collaborate on research and approach problems with their own unique perspectives.…

DIANNE KAMFONIK

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… A NEW CAREER PATH IN SCIence will emerge. The professional scientific data manager will have a unique skill set from areas such as statistics, large database administration, and information design.…

JÖRN GRAHL

Department of Information Systems and Business Administration, Gutenberg University, D-55128 Mainz, Germany. E-mail: grahl@uni-mainz.de

UBIQUITY OF TABLET TECHnology will result in near-real-time textbook updates. School curricula will therefore need to change on a daily basis.…

MICHAEL YOUNG

Arlington, TX 76016, USA. E-mail: mike@youngfam.org

… WITH THE RISE OF TECHNO-ENTREPRENEURship among researchers, science will soon encompass more of other disciplines such as business, marketing, and intellectual property. Collaborative groups will successfully create spinoffs and fund each other's research. A couple of mini-MBAs and certificate courses in finance will align themselves along with scientific publications in a researcher's resume.…

KINGSHUK PODDAR

Institute of Molecular and Cell Biology, A*Star, National University of Singapore, 670219 Singapore. E-mail: kingshukpoddar@gmail.com

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THE COST OF PLASTIC-BASED materials will continue to rise as fossil fuels run dry, but the knowledge to work with glass has faded. When Corning no longer makes disposable, plastic everything, I think our lab will have to shut down.…

NICK BARROWS

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AS A 16-YEAR-OLD MAKING MY FIRST STEPS in the world of research, I fear that it will be hard to find interesting phenomena to study. It seems that most of the major scientific questions have been answered, or will be in the near future. In the past, the major obstacle to vast scientific progress was technology. I'm concerned that few science-catalyzing technological advancements are forthcoming. … Nonetheless, the abundance of research tools presents a big upside: When a scientist from my generation finds a research subject, they will most likely have the instruments needed, instruments that past generations could only dream of.

OR SAGY

Ben Gurion Regional School, Emek Hefer, 42875, Israel; Tel Aviv University, Tel Aviv, 69978, Israel; and Department of Molecular Genetics, Weizmann Institute of Science, Rehovot, 76100, Israel. E-mail: orsagy@post.tau.ac.il

THE KEY THEME DISTINGUISHING the future practice of science will be integration. As access to information reaches unprecedented levels, the ability to interpret information into meaningful patterns will become much more complicated. In this rigorous intellectual environment, collaboration will be critical for scientific discovery. The geologist will contact the sociologist. The psychologist will share a coffee with the physicist. The next generation of scientists will also experience a stronger union (or reunion) between science and the arts. Scientists will find a useful medium in artistic expression for visualizing information in innovative ways that explain fundamental processes in nature. Statistical models will transform in moving mobiles. Two-dimensional graphs will be replaced by three-dimensional sculptures. The canny work of Nathalie Miebach illustrates the useful role that art can play in science. Her musical and visual manifestations of meteorological data are not only remarkably creative, but also reveal obscure relationships underlying the dynamics of weather systems. The preeminent scientific questions of the future will not be answered through convention and self-preservation. Rather, the most influential insights will be gained through integration, artistic expression, and openness.

DAVID R. DAVERSA

Evolutionary Ecology Group, Department of Zoology, University of Cambridge, Cambridge, CB2 3EJ, UK. E-mail: dd384@cam.ac.uk

… WITH IMPROVEMENTS TO data tagging, the Semantic Web, and evolution of Google Scholar, raw data will be published and social science findings will no longer be discovered by individual researchers, but instead validated through simultaneous tests among myriad samples collected by many organizations and researchers, all of whom use a common semantic data-tagging system.…

RAVI IYER

Department of Psychology, University of Southern California, Los Angeles, CA 90089–1061, USA. E-mail: raviiyer@usc.edu

I THINK, IN MY LIFETIME, SCIENCE WILL BECOME more open, accessible, and "democratic." People will have more opportunity to make small contributions in doing big projects. Monopoly of big money and secretive research will break, and the benefits of the latest scientific research will actually reach common people.…

ASHUTOSH GUPTA

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CORRECTIONS AND CLARIFICATIONS

News & Analysis: "Berkeley engineering students demand greater effort to promote diversity" by J. Mervis (2 December 2011, p. 1191). *Science* incorrectly calculated the percentage of underrepresented minorities (URMs) in the freshmen engineering class depicted in the bar chart for the University of California, Los Angeles (UCLA). It should be 10.2%. The number shown for URMs, 47, is correct.

News & Analysis: "Curious cosmic speed-up nabs Nobel Prize" by A. Cho (7 October 2011, p. 30). The last line of the story states that Edwin Hubble discovered that the universe is expanding. In fact, Georges Lemaître made this discovery before Hubble.

TECHNICAL COMMENT ABSTRACTS

Comment on "Nonreciprocal Light Propagation in a Silicon Photonic Circuit"

Shanhui Fan, Roel Baets, Alexander Petrov, Zongfu Yu, John D. Joannopoulos, Wolfgang Freude, Andrea Melloni, Miloš Popović, Mathias Vanwolleghem, Dirk Jalas, Manfred Eich, Michael Krause, Hagen Renner, Ernst Brinkmeyer, Christopher R. Doerr

We show that the structure demonstrated by Feng *et al*. (Reports, 5 August 2011, p. 729) cannot enable optical isolation because it possesses a symmetric scattering matrix. Moreover, one cannot construct an optical isolator by incorporating this structure into any system as long as the system is linear and time-independent and is described by materials with a scalar dielectric function.

Full text at www.sciencemag.org/cgi/content/full/335/6064/38-b

Response to Comment on "Nonreciprocal Light Propagation in a Silicon Photonic Circuit"

Liang Feng, Maurice Ayache, Jingqing Huang, Ye-Long Xu, Ming-Hui Lu, Yan-Feng Chen, Yeshaiahu Fainman, Axel Scherer

Fan *et al*. raised technical concerns about our study regarding the Lorentz reciprocity theorem, with which we completely agree. Unfortunately, we incorrectly used the term "nonreciprocal" to describe the behavior of electromagnetic propagation in our devices. In our paper, this term does not refer to Lorentz reciprocity but to the asymmetric mode conversion that is experimentally demonstrated.

Full text at www.sciencemag.org/cgi/content/full/335/6064/38-c

Letters to the Editor

Letters (~300 words) discuss material published in *Science* in the past 3 months or matters of general interest. Letters are not acknowledged upon receipt. Whether published in full or in part, Letters are subject to editing for clarity and space. Letters submitted, published, or posted elsewhere, in print or online, will be disqualified. To submit a Letter, go to www.submit2science.org.

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