Issues in bringing back extinct species 32

How reefs recover 34

LETTERS

edited by Jennifer Sills

NextGen VOICES

Results: Science Communication's Future

Ideally, how will scientists share their results with each other and the public in 50 years? In January, we asked young scientists to use their imaginations and send us their best ideas. We heard from nearly 150 readers, many of whom share a vision of a world in which scientific results are online, interactive, and easily accessible to both scientists and the public. A sample of the best responses can be found below. To allow for as many voices as possible, in some cases we have printed excerpts of longer submissions (indicated by ellipses) and lightly copyedited original text for clarity. To read the complete versions, as well as many more, go to http://scim.ag/NextGen6_Results.

Submit Now: Science Time Travel

Add your voice to *Science*! Our new NextGen VOICES survey is now open:

You can travel back in time to share one piece of scientific knowledge from today. Where do you go? Describe the date and place you choose, the information you share, and how it might change the course of history.

To submit, go to http://scim.ag/NextGen7

Thanks to Jon Tennant at the Department of Earth and Engineering, Imperial College London, for submitting this question.

Deadline for submissions is 17 May. A selection of the best responses will be published in the 5 July issue of *Science*. Submissions should be 250 words or less. Anonymous submissions will not be considered. Please submit only once.

NextGen Speaks

FEBRUARY 12, 2063. TODAY I UPLOADED my manuscript to the reviewing system of the General Platform. I chose my subsection such that it will end up with the right reviewers.… Luckily, manuscripts can't get rejected anymore, but I wonder what remarks, suggestions, and initial ratings my paper will receive and how much I will need to revise. What's most exciting is whether after revision, my paper will be selected for a journal: From the General Platform, journals make weekly selections of new and important papers that best suit the interest of their subscribers.… I hope my paper will be selected by a widely read journal. Maybe the journal will also publish an additional comment! Still, most important are the comments and ratings readers will give my paper, since even without journal selection, it will remain available on the General Platform.… As the ratings are given anonymously, papers are really graded for their worth, and I will get a good sense of what my paper contributes to the field. Well, let's stop hoping and wait for the reviews!

ANNELINDE R. E. VANDENBROUCKE

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IN THE NEXT 50 YEARS, I BELIEVE THAT BREAKthroughs in visualization of huge data sets will revolutionize the way science is communicated, making results much more accessible to scientists and the public alike. Genomics gives a perfect example of where visualization may be heading. In coming decades, I believe that laypeople will be able to upload personal genomic data (which will soon be easily affordable) onto a data-rich genome browser, which displays many levels of information in navigable format. The browser may, for example, present a three-dimensional view of a DNA helix, bundled onto histones and studded by proteins and polymerases, that may be uncoiled and queried by voice or touch. From any DNA region of interest, users will be able to toggle articles, blogs, and social media posts, as well as demographic, lifestyle, and disease-related histograms. Portions of the browser might light up to announce new scientific findings, with confidences of individual results noted via some standardized criteria. Software developers and scientists will provide various specialized viewer plugins that people can run as apps. All this will give the public unprecedented access and exposure to cutting-edge science. Big data browsers will by no means be limited to genomics; we already see their prototypes in tools such as Google maps, which may soon support toggling and viewing of geological and climate data. These tools will fundamentally alter the way scientific findings are disseminated and will go a long way toward improving trust and dialogue between scientists and nonscientists.

MATTHEW OBERHARDT

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ONCE SCIENTIFIC FINDINGS ARE SUBMITTED to communication portals, machine intelligence will distill scientific results into packets relevant to every demographic: other scientists, informed citizens, teachers and students, and children. These packets will be made into annotated, high-definition, holographic

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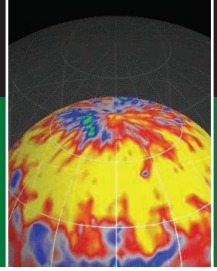
A new era for insomnia treatment? 36



Modeling solar magnetism 42

interactive, multimedia presentations appropriate for each demographic. Specialized devices, equipment, methods, and procedures will be virtually simulated to create a tactile experience for the audience, especially for education and training. Successive publications get consolidated into a timeline of science communication, both at the individual scientist level and at the level of the larger area/field. Conferences for specialized and general audiences will bring people together, but virtual participation will be the norm.

ANIL KUMAR CHALLA

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IDEALLY, AS SCIENTISTS, WE CAN HOPE FOR A greater scientific understanding by the general public as myths are replaced by facts. This should lead to a greater allocation of space in newspapers, television, Internet webzines, and social media for science. More knowledgeable discussion among the general public would lead to an improvement in scientific research and funding….

K. CHRISTIAN KEMP

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…IN 50 YEARS' TIME…SCIENCE COMMUNICATION will be in some form of social media, most likely, personalized blog posts that are updated and edited by individuals, or highly targeted short message links that automatically seek out the right audience at the right time, like heat-seeking missiles, to achieve highest impact….

FREDROS O. OKUMU

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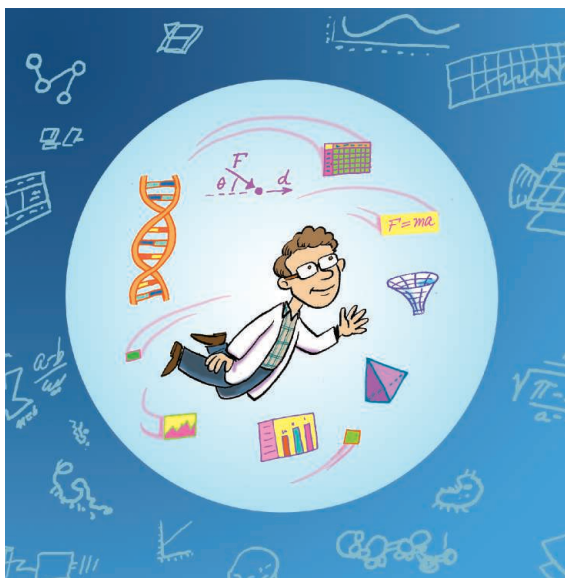

…RESEARCHERS SHOULD NOT HAVE TO WAIT to share results (even negative ones) until the entire project is established with enough data to be worthy of publication in a journal. Experiments and their results could be posted one by one in a forum or database-like environment, with proper acknowledgment and enough protection for the respective researcher…. Groups working on similar projects could communicate, share thoughts, generate ideas, or even combine efforts, hence accelerating the project and the publication process…. The real essence of scientific research would be captured and tailored to the fact that in this day and age, the world has no boundaries.

YASMINE MUSTAFA MOHAMED

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…PERHAPS SCIENCE COMMUNICATION should completely abandon the research paper as we know it. Ideally, scientific communication would be a single, completely open, digi-pedia combined with a simple rating system and powerful search engine. Textbook-like, hierarchical organization of content would end with links to primary data of any type, topic forums, and tutorials, all unrestrictedly posted by the user. Articles, experimental techniques, primary data, researchers, and institutes would each be subjected to mass ratings by the reader…. Points of contention would be quantified and used as an additional sorting factor to identify critical questions. Negative data would be communicated and confirmed. Ratings would act as guides for rewarding achievement in all aspects of the scientific process….

SCOTT ALLEN LACADIE

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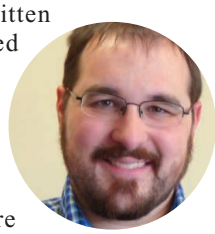
THE UBIQUITY OF SMARTPHONES, robotic assistants, and wearable sensors will usher in an era of Big Data never before seen: Scientific publications won't be written so much as aggregated from an unceasing supply of images, assays, raw numbers, and composite text edited with e-mail-screening software. Once reports are "published" (physical printing will have mostly ceased, so this word sounds arcane), you'll be able to view an AutoCAD-like experimental layout using any heads-up display, perhaps projected onto your lab goggles. When you stare at an empty wall or table, a full experimental manifold will expand in front of you—outlines tracing equipment, animals, and reagents, showing experiments in real time. Tactile gloves will provide haptic feedback in real time; you'll "touch" and manipulate the objects you see. Dedicated media professionals will incorporate the best experimental animations into an annual movie, available for download at any public Sci-terminal. Digital awards, like today's Oscars or Emmys, will signify the high-quality research, driving tenure decisions and funding.



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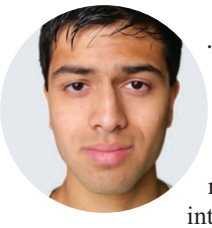

...IN 50 YEARS, WE CAN diversify our audience by refocusing our nations' education systems. We can integrate the current methods of sharing results into curricula of secondary schools and undergraduate programs.... Researchers must take on an additional responsibility: They must orient their published results toward not only the knowledgeable but also the curious. They need not alter the technicality of their results; instead, they can draft secondary articles focusing on the applications of their research.... Teachers and professors who keep their students up to date on current scientific developments will foster a sense of determination and purpose in the next generation of scientists. Within 50 years, several generations will have grown up surrounded by scientific innovation. The general population will finally constitute the majority of a scientist's audience.

VIKAS ARAGAM

College of Arts and Sciences, University of Pennsylvania, Philadelphia, PA 19104, USA. E-mail: vikasar@sas.upenn.edu

...I ENVISION A FUTURE of...scientists who as easily construct an exquisite phrase as a well-planned experiment. Ideally, we will be a generation of savvy bloggers, social media personalities, and passionate public speakers. We will do this out of interest, but also by necessity. The fate of research funding rests on our ability to communicate science topics widely and well, both to our peers and to the public. We cannot afford to let other people speak for us; we must be trained to speak for ourselves.

ERIN E. COFFEY

Department of Anatomy and Cell Biology, Neuroscience Graduate Group, University of Pennsylvania, Philadelphia, PA 19104, USA. E-mail: coffeye@mail.med.upenn.edu

...EVERY LABORATORY WILL HAVE FAN PAGES ON social media platforms, and scientists will share their insights on a daily basis with the general public on current issues. I see, in 50 years, a situation where crowd funding of research is the main funding instrument that will reward scientists with stronger public engagement skills.... **PATRICK KOBINA ARTHUR**

Department of Biochemistry, Cell, and Molecular Biology, University of Ghana, Legon-Accra, Ghana. E-mail: parthur@ug.edu.gh

GOVERNMENTS SHOULD buy all the major publication houses and release their information for free, while maintaining the journal structure at public expense. The costs would be trivial relative to the tax revenues captured from the growth spurred by the open-access policy. I cannot think of a better way for the world's governments to spend a few billion dollars up-front and several hundred million per year.

CHAD BRICK

Sumitomo Bakelite Corporation, Kobe, Japan. E-mail: chad_brick@sumibe.co.jp

...AS THE POTENTIAL OF UNLIMITED ONLINE publishing becomes clear, we will see a greater number of publications that end in negative, unexpected, or less interesting results. From the perspective of students, who have limited time, the publication of experiments that they should avoid would be remarkable. For researchers with limited funds, it would be invaluable, and to those organizations providing funds, it would be of great commercial interest as it provides a means of ensuring they do not keep funding research that has already been carried out.... **RODDY GRIEVES**

Centre for Cognitive and Neural Systems, University of Edinburgh, Edinburgh, EH8 9JZ, UK. E-mail: r.m.grieves@stir.ac.uk

...IN THE FUTURE, SCIENCE WILL DICTATE policies. Governments will ask for scientific reports every time there is the need for a new law. Voters will have extensive scientific knowledge and will make their daily life decisions based on science's latest findings.... How will science gain such importance in society? Because tomorrow's scientists, research institutes, and universities will open their lab doors to the general public, as well as to designated political and civil representatives, on a regular basis! A visit to a lab will be just like any other way of spending a free afternoon; to many, more interesting than a museum, a park, or even retail therapy...

ANA NEVES-COSTA

Cell Biology of the Immune System Unit, Institute of Molecular Medicine, Lisboa, 1700-202, Portugal. E-mail: ancosta@fm.ul.pt

TECHNOLOGY WILL PUSH THE BOUNDS OF science communication in the next half-century. We'll share our results via Star Trek–like holodeck simulations: 3D interactive environments where we can walk through a molecule to see its structure, or traverse simulated forests to understand changes in biodiversity. These technologies will help the public understand science by making it real—they can feel the effects of increasing CO_2 on their skin, rather than just staring at a graph of yearly temperature changes. But the core of science communication won't change; our ability to explain complicated concepts using regular language and our passion for scientific discovery can only be conveyed when we talk with someone face to face....

ALLISON COFFIN

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...TRYING TO READ ALL THE PAPERS ON, SAY, autism or brown dwarfs 50 years from now (or even today) will be impossible....You'd spend too much time manually prowling databases for what is relevant.... You want truly personalized structure, integration, and filters? You want it fast? Cut out the middle man....Individuals will each possess their own private brain Internet cache, and when a new experiment is performed, the cache will update. The way each update is processed will be unique to each individual, because plasticity—what is perceived as important enough to remodel dendrites, thus linking past with present experiences—is unique. Plus, you can buy a special filter to keep from turning into a zombie.

JUSTIN JEE

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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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Editor's Summary

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