LETTERS

edited by Jennifer Sills

Scientists: Listen Up!

C. REDDY'S EDITORIAL "SCIENTIST CITIZENS" (13 MARCH, p. 1405) underscores the need for scientists to better explain their work to policy-makers and the general public. If we as scientist citizens want to be understood, we should begin by listening.

AAAS recognized this over 30 years ago when it established its Science and Technology Policy Fellowship program, which gives Ph.D. science graduates the opportunity to collaborate with policy-makers and play an active role in decision-making. Shorter-term immersions can also help. The Consortium for Science, Policy, and Outcomes and the American Meteorological Society both offer 2-week policy experiences in Washington, DC, for early-career scientists. Participants converse with, challenge, and share ideas with policy-makers, including congressional staffers, agency officials, lobbyists, regulators, journalists, academics, and museum curators. In this give-and-take atmosphere, participants discover that many policy-makers understand science far better than most scientists understand policy. This enriched appreciation for the work done by policy-makers helps scientists understand their role and better equips them to contribute constructively.

Science museums also provide excellent practical experience in communication. For instance, the Museum of Science in Boston and Harvard's School of Engineering and Applied Sciences have developed an immersive program that gives graduate students an opportunity to explain the nature of their work (and its impact on society) to museum visitors. These discussions both introduce the public to the questions modern science is tackling and expose scientists to the public's hopes and concerns about the direction of science.

If scientists are going to be citizens, they need practice in not just communicating their ideas, but having a two-way dialogue with policy-makers and the public.

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Type 2 Polio Still in Our Midst

WHEN THREATS TO THE GLOBAL POLIO Eradication Initiative (GPEI) are discussed ("Polio: Looking for a little luck," L. Roberts, News Focus, 6 February, p. 702), type 2 vaccine-derived poliovirus ($VDPV_2$) outbreaks are generally dismissed as rare and easily contained (*1*). However, we should not be in such a hurry to eliminate type 2 polio vaccination. $VDPV_2$-associated poliomyelitis outbreaks have occurred since its eradication in 1995 (*1*). For example, a current Nigerian outbreak (*2*) occurred after resumption of vaccination with trivalent oral poliovirus vaccine (OPV) in the absence of >50% coverage. In addition, two separate clusters of highly diverged, highly neurovirulent $VDPV_2$ have been silently maintained or circulated in limited populations in Israel. They have been detected over long time intervals: more than 3 years in one case and more than 10 years in the other (*3*). Molecular analysis suggests that persistently infected individuals and/or their contacts are the sources of these $VDPV_2$ occurrences, which were isolated intermittently during routine sewage surveillance but did not lead to any reported cases. In 2008, Sabin 2-derived $VDPV_2$s had evolved by about 10 to 15%, compared with less than 3% for Nigerian outbreak $VDPV_2$s.

There is a clear and urgent need to develop new vaccines to replace OPV. High-coverage, global vaccination against all three types of polio must continue as long as such $VDPV_2$s are excreted into the environment.

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2. Centers for Disease Control and Prevention (CDC), *Morb. Mortal. Wkly. Rep*. **56**, 996 (2007).
3. L. M. Shulman *et al*., *PLoS ONE* **1**, e69 (2006).

Synthesizing Knowledge in the Classroom

IN HIS PERSPECTIVE "FAREWELL, LECTURE?" (2 January, p. 50), E. Mazur advocated a shift from the lecture paradigm to interactive models that engage students by fostering discussion and problem-solving. We believe that such innovative, practical concepts can be applied well beyond undergraduate levels and basic science fields. We observed a similar phenomenon in our graduate students, who

Letters to the Editor

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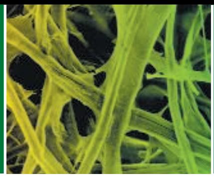

Sizing up quantum states

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transformed from learners of fragmented rote-type knowledge to active participants in our radiation oncology program after we replaced the traditional lecture-based teaching with an intense interactive curriculum and "hands-on" labs.

M. Hadjiargyrou ("For teachers, all the classroom's a stage," Letters, 20 February, p. 1009) proposed that the lecturer should be an actor to captivate students' attention. Perhaps a teacher should be even more: a conductor deployed in the center of the two-way road of information exchange to synthesize knowledge and guide critical thinking. This model can be applied in any field and anywhere.

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When Scientific Data Become Legal Evidence

IN THE 9 JANUARY ISSUE, THE NEWS OF THE Week story "Brain scans of pain raise questions for the law" (G. Miller, p. 195) and the Books review "Grappling with the gulf" (D. Greenbaum and M. Gerstein, p. 210) highlight an important misunderstanding between lawyers and scientists concerning what constitutes "proof." Scientists hesitate to accept evidence for a hypothesis unless they can demonstrate a statistical probability of over 95% that the observations are not due to chance. In civil cases, such as contract or tort cases by insured patients against their insurers, the decision is made on the basis of a "preponderance of the evidence"—essentially a 51% probability (*1*). I fear that by using the scientific criterion of proof rather than the legal one, expert witnesses arbitrarily bias the case against one of the parties.

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Note

1. Criminal cases use a different standard of proof: "beyond a reasonable doubt." In these cases, perhaps even the standard 5% confidence level would not be strict enough.

Response

THE STATISTICAL SIGNIFICANCE OF THE UNDERlying science should not be conflated with the plaintiff's ultimate burden of proof in a trial. Frey's argument that less rigorous standards for science should be applied in a legal case fails: Invalid or unreliable science—as evaluated by the rigorous standards of scientific practice—cannot be of any useful assistance to jurors in making a determination, regardless of the burden of proof required (*1*).

It is also worth noting that under the rules of evidence (*2*), the bar that is set for the ultimate burden of proof is conceptually quite different from that which is set for the admissibility of expert scientific evidence. In American courts, the judge first evaluates the validity of scientific evidence that is sought to be introduced into evidence, either directly or, in some states, by looking for "general acceptance" by the scientific community. In either case, science that is unreliable (e.g., low statistical significance or poor methodology) or irrelevant to the purpose will not be admitted. Only if it is admitted will the judge or jury decide how much weight to accord to that evidence, in light of the relevant burden of proof for the trial (*3*).

Trials are not tidy. They cannot be executed in labs, where the pursuit of truth is generally unconstrained by social values such as deterrence, justice, or liberty. Rather than conflating legal outcomes with *P* values, perhaps trials are more like a tennis match. Scientific experts can help us determine whether the server hit the ball. The state then decides how far from the center to place the net. But it is the job of the jury or the judge, and only theirs, to decide whether or not the ball was inside the line.

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2. USCS Fed. Rules Evid. R 702 (2009).
3. *Daubert v. Merrell Dow Pharms*., 509 U.S. 579 (U.S. 1993).

CORRECTIONS AND CLARIFICATIONS

News of the Week: "Tracking CO_2's comings and goings from space" by D. Normile (16 January, p. 325). Peter Rayner's name was misspelled.

Random Samples: "The priestess's tale" (9 January, p. 189). Lady Meresamun is 2800, not 4800, years old.

TECHNICAL COMMENT ABSTRACTS

Comment on "Atmospheric Hydroxyl Radical Production from Electronically Excited NO_2 and H_2O"

Scott Carr, Dwayne E. Heard, Mark A. Blitz

Li *et al*. (Reports, 21 March 2008, p. 1657) suggested that the reaction between electronically excited nitrogen dioxide and water vapor is an important atmospheric source of the hydroxyl radical. However, under conditions that better approximate the solar flux, we find no evidence for OH production from this reaction.

Full text at www.sciencemag.org/cgi/content/full/324/5925/336b

Response to Comment on "Atmospheric Hydroxyl Radical Production from Electronically Excited NO_2 and H_2O"

Shuping Li, Jamie Matthews, Amitabha Sinha

Carr *et al*. failed to detect hydroxyl radical formation from the reaction of excited state nitrogen dioxide with water, contrary to our findings. We present several reasons, based on energetic and spectroscopic considerations, that the OH radicals we observed from this reaction are not likely to be due to multiphoton excitation as they suggest.

Full text at www.sciencemag.org/cgi/content/full/324/5925/336c