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LETTERS

Light and Gravity

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Correspondents this week shed light on the management of national laboratories in China, the purpose and appropriate use of math and science test scores, Earth's supply of fossil fuels and global warming (at right, urban smog), NASA's research in the life sciences (which often involves microgravity) and collaboration with other institutions, and progress in the challenging field of antisense oligonucleotide research.

Reducing Greenhouse Gases

The Perspective "The United Nations climate convention: Unattainable or irrelevant" by Pekka E. Kauppi (1 Dec., p. 1454) says that the goal of stabilizing greenhouse gas concentrations at less than twice the preindustrial level is probably unattainable. Kauppi writes (p. 1454) that "reasonable emission scenarios indicate that a doubling of the greenhouse gas concentrations is inevitable in the 21st century." Such scenarios require continued growth in rate of fossil fuel consumption. With the current rate of CO_2 emissions, well more than a century could pass before atmospheric CO_2 concentrations doubled. But fossil fuel reserves and recent estimates of undiscovered producible fossil fuels indicate that we lack the fuel resources to maintain even *current* fuel consumption rates beyond another half-century (*1*).

If these estimates are correct, it is continued growth in fossil fuel consumption rate that will be unattainable after the early decades of the coming century. In this case, decline in rate of greenhouse gas emission during the coming century is not only attainable, but inevitable.

Craig Bond Hatfield
Department of Geology,
University of Toledo,
Toledo, OH 43606, USA

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1. C. D. Masters, D. H. Root, E. D. Attanasi, *Science* **253**, 146 (1991); C. B. Hatfield, *J. Geol. Educ.* **42**, 432 (1994).

Response: Since the year 1800, humans have released 220 to 250 pentagrams (1 pentagram = 10^{15} grams) of C from fossil reserves into the atmosphere. This has been the main reason for the recorded increase of atmospheric CO_2 by 30% (*1*). Current annual emissions of fossil C are about 6 pentagrams.

The reservoir of all fossil fuel occurrences in the Earth's crust is estimated to amount to some 25,000 pentagrams of C (*2*). The C reservoir in fossil fuels that may become technically and economically recoverable in the foreseeable future has been estimated at 3500 pentagrams (*2*).

Improved geological knowledge, improved technology, and changing prices have tended to increase the fossil energy reserves (*2*). Although the conventional petroleum reserves, which were the focus of the article by Masters *et al.* (*3*), are relatively small, coal reserves are larger. They account for more than half of all fossil reserves (*2*). After 100 years, the reserves of conventional cheap petroleum will have become scarce, but there is likely to be lots of coal left.

Pekka E. Kauppi
Finnish Forest Research Institute,
Unioninkatu 40 A,
00170 Helsinki, Finland
E-mail: pekka.kauppi@metla.fi

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2. N. Nakicenovic *et al.*, in *Climate Change 1995: Impacts, Adaptation, and Mitigation: The Report of Working Group II of IPCC* (Cambridge Univ. Press, Cambridge, UK, in press), chap. B.
3. C. D. Masters, D. H. Root, E. D. Attanasi, *Science* **253**, 146 (1991).

NASA's Life Science

In the News & Comment article "Will NASA's research reforms fly?" (17 Nov., p. 1108) Andrew Lawler does not misquote me [in saying that the National Aeronautics and Space Administration (NASA) did "some really poor research" in the life sciences (p. 1109)], but does "underquote" me. I would like to state my firm support for the "Research Institute" concept of Daniel

Goldin and France Cordova. They and their colleagues could enhance NASA's magnificent, if spotty, science record by strengthening university connections, including peer review, and could streamline personnel practices to retain NASA's crown jewel scientists.

NASA, to my knowledge, is the only government agency that supports genuinely original, significant, and compelling science with small, well-planned, and minimally bureaucratic venues. New NASA initiatives include greater collaboration with the National Institutes of Health and the National Science Foundation to replace intramural research with broader based programs and SCRTs (Specialized Centers for Research and Training). These initiatives attest NASA's science policy leadership, which is so sorely needed in this cynical and mercantile age.

Lynn Margulis
Department of Biology,
University of Massachusetts,
Amherst, MA 01003–5810, USA

Lawler states that "those [scientists] in the life and microgravity sciences . . . have come under withering fire from their peers for failing to meet academic standards" and refers to the 1993 Senate directives on peer review. These comments do not reflect the current situation. NASA's Life and Microgravity Sciences Program has taken steps to comply with congressional concerns, and has received favorable comments in that regard from various review panels, for example, the National Academy of Sciences Space Studies Board (*1*).

Lawler then states (p. 1109) that Life and Microgravity Sciences are linked to programs "dominated by a field that typically does not practice academic style peer review," that is, engineering. Space life scientists indeed work closely with engineers, but this has little to do with peer review, which occurs before the development of an experiment.

The main driver for space biology research is to find how gravity and the lack of gravity affect living things. To do that, one must go into space. Extraordinary means are taken preflight and during flight to preserve the science. I learned these lessons first hand as a principal investigator on the first International Microgravity Laboratory in 1992. When last minute changes to the mission threatened my experiment, new hardware, new procedures, and new crew training were put in place with incredible speed thanks to cooperation between life scientists and engineers. The Spacelab crew, guided by Norm Thagard, agreed to add additional procedures to maximize the benefit to science. Cooperation of this sort can be expected to ensure the success of the many life sciences experiments currently planned for the space station.

The statement that "experiments on mammals aboard orbiting capsules . . . produced little of value" apparently refers to the unmanned Cosmos missions flown previously with the Soviet Union, and now with the Russian Space Agency. These studies of rats and rhesus monkeys were highly successful (*2*). Before the U.S. space shuttle, the Cosmos missions allowed a U.S. space biology community to develop and refine hypotheses and build a foundation for the scientific studies that would be performed aboard the shuttle and spacelab. The eight Cosmos missions in which the United States has participated had more than 100 American experiments, resulting in more than 90 peer reviewed publications (see the cover of *Science*, 22 September 1978).

Comments by those interviewed characterizing life science experiments in the early years as "rinky dink" and "not particularly useful" are misleading. In the 1960s and 70s, access to space was limited, and little progress was made, but we were learning about the uniqueness of the space environment and the difficulties of conducting experiments in a low gravity laboratory. To the uninitiated, some of these experiments may appear "rinky dink" because they are so simple on Earth. However, to complete even a seemingly simple experiment successfully in space is another story.

I heartily agree with the cautionary comments regarding the establishment of institutes. As Lawler indicates, ambiguity of purpose and procedure are serious threats to the success of this reorganization. It is especially difficult to see how handing peer review over to institutes would improve the science.

*Pauline Jackie Duke**
Department of Craniofacial Growth and Development, Dental Branch, University of Texas Health Science Center, Houston, TX 77225, USA

References and Notes

1. National Academy of Sciences Space Studies Board, letter to J. Vernikos, 26 July 1995 (http://www.nas.edu/ssb/csbmvern.html).
2. See special issues of *FASEB* **4**, 1 (1990) and *J. Appl. Physiol.* (suppl.) **73**, 2 (1992).
3. The web address of the American Society for Gravitational and Space Biology is (http://baby.indstate.edu:80/asgsb).

*President, American Society for Gravitational and Space Biology

Beyond Test Score Comparisons

The Policy Forum, "Myths about test score comparisons" (Dec. 1, p. 1446), by Iris C. Rotberg is on target in emphasizing the damage that can occur in instruction and learning (at primary and secondary schools) if inappropriate practices of assessing student learning are used by those responsible for developing and administering school policy. She presents a degree of caution that needs to be transmitted to state education policy makers who have, without enough caution and questioning, jumped on the so called "authentic assessment" bandwagon.

This caution and concern, however, should not be construed to mean that student assessment and procedures adopted for higher stakes testing by state departments of education cannot be improved. It does not mean that we should eliminate efforts by the National Assessment of Educational Progress (*1*) to determine the extent to which we are achieving the educational goals set by the U.S. Congress in 1994 (*2*).

Reform in the "assessment of student learning movement" is especially significant in the Sciences and Mathematics for several reasons. (i) National education goal number 5 (*2*, p. 16) specifically addresses these two related subjects. (ii) The *National Science Education Standards* (*3*) and the parallel document, *Curriculum and Evaluation Standards for School Mathematics* (*4*) both propose substantial change in teaching and assessment. In a nut shell, both "standards documents" emphasize reducing didactic lecture-verification and increasing inquiry-based instruction through hands-on experiences.

Research and personal professional experiences indicate that the approach teachers use in instruction is often determined by the approach mandated for assessing student learning. Therefore, the desired reform in instructional approach will only occur if reform occurs in assessment. The present system of assessing learning continues to emphasize recall of content, with little emphasis placed on students' abilities to apply higher order thinking (*2*, *5*).

*Frank X. Sutman**
Curriculum Development Council, Rowan College of New Jersey, 201 Mullica Hill Road, Glassboro, NJ 08028–1701