

Letters to the Editor

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The Difficulties of Defining the Term "GM"

I AM WRITING TO URGE THE MAINTENANCE of the commonly understood meaning of the acronym "GM" and in opposition to a changed use that appeared prominently in a recent Perspective by N. V. Federoff ("Prehistoric GM corn," 14 Nov., p. 1158). Through much of the history of genetics, genetic modification was attained only by the classical methods involving crossing, backcrossing, selfing, and so forth, and there was a definite limitation imposed by the relationships among organisms involved or the source of genes that could be combined and recombined. After DNA transfer via *Agrobacterium* and gene guns was developed, that limitation disappeared, the processes of genetic manipulation became much more wide-ranging, and very different problems associated with the new methodologies surfaced. The expression "genetically modified organism," "GMO," or, more commonly, "GM," was coined for these methods. An extensive literature has been built up with a common understanding that associates the term "GM" with genetic engineering. The result has been the evolution of an acronym having a meaning different from the words it symbolizes, for GM is only a small part of the total literature on genetic modification. Major economic implications are tied up with the term, whose recognition may well influence whether GM crops become common in commerce. My point is that the distinctions between classical genetic modification and its acronym are clearly understood.

Fedoroff's Perspective breaks with that usage, even in its title, and so removes the distinction. I do not wish to concentrate on this paper, for there may well be others that use the terms as synonyms, but I do object to the practice. It is not a question of whether genetic engineering is good, bad, or irrelevant, but clarity of understanding requires that a distinction be recognized. If breaking with the identification of GM with genetic engineering becomes common, the distinction will disappear and any genetic modification will be considered a GM. Such a redefinition would confuse readers and

complicate the already complex discussions on this topic. Let's keep communication clear in this controversial field and restrict the term "GM" to its engineering roots.

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N. V. FEDOROFF'S PERSPECTIVE "PREHISTORIC GM corn" (14 Nov., p.1158) seems calculated to obscure important issues in the debate over the safety of genetically modified organisms (GMOs). In any meaningful discourse concerning GMOs, distinctions must be made between the different techniques, ranging from traditional selective breeding to biotechnology based on recombinant DNA, used to incorporate new genetic material into existing organisms.



This genetically engineered barley would fit the most conventional definition of GM.

In her Perspective, Federoff resorts to two deceptive rhetorical devices to obscure the distinction between bioengineering and selective breeding: She defines the term "genetic modification" in such a way as to include prehistoric crop domestication, and she uses the words "fast" and "rapid" in two different time scales. Federoff reports that maize probably originated in southern Mexico about 9000 years ago, describes how selective breeding had yielded corn with a modern genetic profile by about 4400 years ago, and cites findings of maize

cultivation in the southwestern United States more than 3000 years ago as evidence that "[t]he GM corn spread far—and fast." Two paragraphs later, she concludes that "the apparent loss of genetic diversity following the introduction of high-yielding Green Revolution wheat and rice varieties in the 1960s and 1970s, and attending the rapid adoption of GM crops today, is far from a new phenomenon."

In a talk given for the Penn State Lectures on the Frontiers of Science, Federoff defined a genetically modified organism as one that "was modified using contemporary molecular techniques" (1). By this definition, the maize grown by pre-Columbian indigenous peoples does not qualify as a GMO. Contemporary bioengineering techniques create new crops markedly faster than traditional breeding can, and the genetic modifications induced tend to be qualitatively different. Furthermore, the speed with which modern marketing and distribution channels disseminate GMOs is very different from the gradual spread of domesticated crops (2). Federoff's implication that this unprecedented speed of creation and dissemination is "far from a new phenomenon" is, at best, misleading.

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References

1. PowerPoint presentation, available at www.science.psu.edu/alert/frontiers/Fedoroff3-HTML/index.htm (2001).
2. P. Gepts, *Crop Sci.* **42**, 1780 (2002).

Response

MY WORDS WERE CHOSEN WITH CARE. IT IS indeed true, as Ramsay points out, that the contemporary definition of genetically modified, or GM, applies only to plants modified by molecular techniques and that I have used this definition both in writing and in public lectures. But it is becoming increasingly clear that the distinction is not just artificial and unhelpful, but profoundly counterproductive on a global scale.

Both Grun and Ramsay maintain that meaningful discourse requires making a distinction between "traditional selective breeding" and "biotechnology based on recombinant DNA." I disagree. It is precisely this distinction that has created the widely accepted, albeit mythical, view that "traditional" plant breeding is somehow gradual, and, yes, natural, whereas contemporary techniques are rapid and unnatural.

According to the Mutant Variety Database, established by the International Atomic Energy Agency and the Food and Agriculture Organization of the United Nations (1), more than 2000 crop varieties grown today were created using chemical or radiation mutagenesis. Is using neutron radiation to create the popular Rio Red grapefruit variety gradual and natural? Is using the somaclonal variation arising as a result of passage through tissue culture to create mutant herbicide-tolerant Clearfield Corn less rapid and unnatural than introducing bacterial or mutant genes cloned by molecular techniques to create Round-up Ready corn and soybeans?

Pinstrup-Andersen and Schioler ask, "Why, in the debate on natural versus unnatural, should we draw the line right here, right now, at the point where genetic engineering has entered the scene?" [(2), p. 80–81]. And it is indeed a puzzle that people blithely accept churning up genomes with radiation, mutagenic chemicals, and a variety of other techniques, including intergeneric crosses, while looking askance at the newer, very much less disruptive molecular methods. But maybe they don't know what traditional breeders do.

Moreover, the ability to move genes between species is not a recent, or even a human invention. *Agrobacterium* and its plant-transforming plasmids are natural: Quite without human intervention, these bacteria developed a set of plant genes useful to the bacterium, as well as the ability to transfer them to plant cells without killing the plant. Why is using this natural genetic engineering system to introduce genes coding for bacterial Bt proteins to protect plants from insect attack less natural than spraying fields with concentrated preparations of the Bt bacteria grown in huge fermenters and sold in stores? If you have followed the monarch butterfly flap, you will know that the consensus of a very large U.S.-Canadian project to assess the impact of GM corn on the monarch came to the conclusion that only about 3 in 10,000 larvae will be in danger of getting sick or dying from eating corn pollen expressing Bt genes (3). This seems as benign and sensible an approach to crop protection as replacing a drug with a vaccine is in human health care.

It is time to eliminate the altogether artificial boundary between what humans did before molecular techniques were

developed and what they do now to improve their crop plants—a point I sought to make in my Perspective. A mutation is a mutation, whether spontaneous, induced by tissue culture, or induced by radiation mutagenesis. The kinds of genetic changes that underlie the origin of corn from teosinte are not fundamentally different from those that gave us dwarf Green Revolution rice, seedless oranges, or Rio Red grapefruit. And if they spread more slowly than they might today, it was probably only because people hadn't yet invented trucks, trains, and planes.

What's new is that our growing understanding and knowledge of genes and how they function means that we don't have to wait for just the right spontaneous mutation to show up, nor do we have to hurry the process by bashing genomes randomly with radiation. We can instead identify and isolate just one target gene and alter it by molecular methods in a very precise way. We can then introduce it into a plant with minimal genomic disturbance.

I agree with Grun's assertion that the use of the term "GM" has economic implications and may influence whether GM crops are or are not accepted. In 2002, Zambia's president Mwanawasa puzzled

people around the world by rejecting a much-needed shipment of U.S. corn for his starving nation, despite assurances by the United States, the United Nations, and NGOs that the GM corn was safe to eat and was, indeed, the same as that eaten daily in the United States, Canada, and other countries. But he was neither ignorant nor nuts. Along with the rest of Africa, Mwanawasa was confronted with a truly Hobbesian choice: starve now or lose access to European GM-free markets in the future. As Mexico has discovered, seeds from food aid shipments find their way into farmers' fields.

It seems almost beyond comprehending, yet the apparently personal preferences of European consumers for foods made from plants that have been genetically modified in many ways, but not by molecular methods, may set Africa's agricultural and economic agenda. In a recent Op-Ed piece, Normal Borlaug (who won a Nobel prize in 1970 for developing the Green Revolution wheat strains) wrote, "Biotechnology absolutely should be part of Africa's agricultural reform; African leaders would be making a grievous error if they turn their back on it" (4). He strongly urges Africa not to follow the lead of Europe, where biotechnology has been "demonized."

But how can Africa afford to adopt GM technology if doing so precludes future access to European markets? Yet how can Africa afford not to adopt GM technology, which is scale-independent and biologically based, in its struggle to attain food security? Are we not part of the problem with our insistence on hanging a special label on crops genetically modified by molecular techniques, quite without evidence of any kind that these crops pose new environmental problems or that foods made from them create new health risks? As Kenyan plant breeder Judith Wambugu said, "You people in the developed world are certainly free to debate the merits of genetically modified foods, but can we please eat first?" (5).

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References

1. See www-infocris.iaea.org/MVD/.
2. P. Pinstrup-Andersen, E. Schioler, *Seeds of Contention: World Hunger and the Global Controversy over GM Crops* (Johns Hopkins Univ. Press for the International Food Policy Research Institute, Baltimore, MD, 2000).
3. M. K. Sears *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* **98**, 11937 (2001).
4. N. Borlaug, "The next green revolution," *N.Y. Times*, 11 July 2003, section A, p. 17.
5. J. Wambugu, from a 2003 interview with Joe Schwarz of McGill University. Pdf file is available at www.oss.mcgill.ca/biotech/africa.pdf

"Physics First" and High School Teachers

A QUOTE ATTRIBUTED TO ME IN THE RANDOM Samples item "Flocking to physics" (9 Jan., p. 166) may have given the wrong impression. I was asked to comment on the recently released American Institute of Physics survey indicating that 61% of high school teachers surveyed rejected the "physics first" approach, in which physics is taught to high school students before chemistry and biology.

In response to a question about what factors I thought might cause teachers to reject the "physics first" idea, I replied that pedagogical objections would certainly be one, but that inertia is always a problem when a major change is suggested. I certainly did not mean to give the impression that I believe that high school teachers are complacent or lazy, as the quote might seem to imply. To the contrary, I believe that high school teachers have one of the hardest jobs in our society. The teachers I met at a recent workshop on "physics first" were truly impressive in their dedication and willingness to try new ideas.

The main point I tried to make, which was not reported, was that the survey is unfortunately already out of date because it is 3 to 4 years old. This is a long time in the relatively short history of the "physics first" movement. There are now several entire school districts (for example, San Diego) and some 300 individual schools that have adopted the sequence. I suspect that a new survey would show very different results.

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Research on Contraceptives

WE COULD NOT AGREE MORE WITH BRUCE Hannon's Letter in response to the list of "Grand challenges in global health" (H. Varmus *et al.*, Policy Forum, 17 Oct. p. 398) in which he recommends implementation of "a timely and effective birth-control program" ("The grand challenge of birth control," 9 Jan., p. 168). Indeed, effective family planning is a socially beneficial activity that affects the well-being of women, men, children, families, and society as a whole. Hannon reasonably calls on Bill Gates and the NIH to take responsibility for this unmet global need in their spending plans.

In fact, the Bill & Melinda Gates Foundation has done just that, by spon-

soring a study undertaken by the Institute of Medicine. In a report, "New Frontiers in Contraceptive Research: A Blueprint for Action," issued in January by the Institute of Medicine, the Committee on New Frontiers in Contraceptive Research lays out a research plan for development of new contraceptives, including ways that new research can be shared and distributed among public and private institutions, and across the world (1). The recommendations take into account differing needs for contraception by people of varying marital status, age, and culture, as well as the additional factors of usability, cost, access, and protection from sexually transmitted infections. We hope that the report will offer direction and guidance as the NIH and other research institutions, public and private, work to achieve the worthy "15th" goal that Hannon has set out for them.

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Reference

1. S. J. Nass, J. F. Strauss III, "New Frontiers in Contraceptive Research: A Blueprint for Action" (National Academies Press, Washington, DC, 2004) (available at www.iom.edu/report.asp?id=17893).

CORRECTIONS AND CLARIFICATIONS

Essay: "The sinews of war: Ancient catapults" by S. Cuomo (6 Feb., p. 771). Proper credit for the first

figure, on page 771, goes to the German Archaeological Institute, Berlin, and for the second figure, on page 772, to the Institute of Archaeology, Oxford, UK.

News Focus: "Remaking NASA: Versatility is the object for new crew vehicle" by C. Seife (30 Jan., p. 617). It was incorrectly reported that a mass of 120,000 tons could be lifted by the Saturn V rocket. The correct mass is 120,000 kilograms.

News of the Week: "Scientists add up gains, losses in Bush's new vision for NASA" by A. Lawler (23 Jan., p. 444) incorrectly identified astronomer Sidney Wolff. She is the past director of the National Optical Astronomy Observatory (NOAO) and current chair of the Committee on Astronomy and Public Policy for the American Astronomical Society. Richard Green is director of NOAO's Kitt Peak National Observatory.

Random Samples: "Top rung" (9 Jan., p. 167). A listing of available U.S. university presidencies should not have included Duke University, which on 12 December named Richard Brodhead to succeed Nannerl Keohane. Brodhead, an English professor and dean of Yale College, takes office on 1 July.

News of the Week: "A surprisingly ancient cometary visage" by R. Kerr (9 Jan., p. 151). The statement that none of the team members of the Stardust mission to comet Wild 2 are geologists is incorrect. Team member Fred Horz of NASA's Johnson Space Center in Houston is a specialist in impact cratering at a variety of scales.

Perspectives: "T-bet or not T-bet" by R. D. Hatton and C. T. Weaver (7 Nov., p. 993). In the second full paragraph on page 994, the first sentence is incorrect. It should read "In addressing this question, Pearce, Reiner, and their co-workers discovered that a second member of the T-box gene family, *Eomesodermin*, is expressed in developing CD8 T cells (1)." In its original version, the sentence implied that Pearce *et al.* discovered *Eomesodermin*, which is not the case.

TECHNICAL COMMENT ABSTRACTS

COMMENT ON "Contributions of Anthropogenic and Natural Forcing to Recent Tropopause Height Changes"

Roger A. Pielke Sr. and Thomas N. Chase

Santer *et al.* (Research Articles, 25 July 2003, p. 479) reported that the increase in tropopause height over 1979-99 was the result of tropospheric warming caused by increased greenhouse gases. Our assessment of the NCAR/NCEP reanalysis shows that tropospheric warming cannot explain any of the reported tropopause height changes.

Full text at www.sciencemag.org/cgi/content/full/303/5665/1771b

RESPONSE TO COMMENT ON "Contributions of Anthropogenic and Natural Forcing to Recent Tropopause Height Changes"

B. D. Santer, M. F. Wehner, T. M. L. Wigley, R. Sausen, G. A. Meehl, K. E. Taylor, C. Ammann, J. Arblaster, W. M. Washington, J. S. Boyle, W. Brüggemann

The assimilation of biased temperature retrievals may have introduced spurious tropospheric cooling in the reanalysis data highlighted by Pielke and Chase. Evidence from other data sets indicates that the troposphere has warmed over the last several decades, and that this warming contributes to recent tropopause height increases.

Full text at www.sciencemag.org/cgi/content/full/303/5665/1771c