Biotech’s defining moments

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Confusion about terms related to biotechnology – genetic modification, GMOs, genetic engineering, transgenic, and all the rest – has been around for decades. This definitional dysfunction has created myriad opportunities for mischief and given rise to widespread over-regulation, diminished agricultural R&D, ill-advised conferences and risk assessment studies, flawed analyses (including a recent tome from the OECD), fear-mongering by NGOs, and a perplexed public. Greater precision in terminology would improve the lot of scientists, the quality of public policy and, eventually, human and environmental health.

Introduction
Twenty years ago, the then-FDA Commissioner Frank Young and I began a Wall Street Journal opinion–editorial thus:

Defining the terms “biotechnology” and “genetic engineering” isn’t an easy task, since the terms don’t represent natural groupings of processes or products. They connote something different to individual commentators, journalists, organizations, congressional staffers and members of the public. The terms are ambiguous, the source of much confusion and little advantage, and we would do well to return to more specific and descriptive terms [1].

Lamentably, these observations remain valid today. Misapprehensions about the meaning of biotechnology, genetic engineering, genetically modified (GM) and other obscure terms (vide infra) have led to mischief of many kinds. Whether the confusion derives from ignorance or from denial of the scientific consensus that genetic improvement is a continuum from older, conventional methods to newer and more precise techniques, such as recombinant DNA technology, the ripple effects have been profound – and profusely vexing to progress in agriculture. Several examples of the consequences of such confusion are described below, including a recent report from the Organization for Economic Cooperation and Development (OECD; http://www.oecd.org/home/0,2987,en_2649_201185_1_1_1_1_1,00.html), in which the statistics were rendered completely uninterpretable by the use of inconsistent definitions (but were published anyway).

Stigmatization of superior techniques by unscrupulous NGOs
By claiming that the use of recombinant DNA technology somehow circumscribes a category that is worrisome and requires extra scrutiny, groups such as Greenpeace (http://www.greenpeace.org/international/), the Foundation on Economic Trends (http://www.foet.org/), and the Union of Concerned Scientists (http://www.ucsusa.org/) continue to militate against even the most benign and beneficial uses of these techniques. In more subtle ways, other organizations (such as the Pew Initiative on Food and Biotechnology [http://pewagbiotech.org/] and the Center for Science in the Public Interest [http://www.cspinet.org/]) pretend to be honest brokers but consistently portray recombinant DNA technology, inaccurately, as fundamentally different and discrete from other techniques of genetic modification, and lobby for discriminatory and excessive regulation.

Poorly conceived experiments performed in the name of biotechnology risk assessment
The prototype is the Silwood Study, performed in the UK during the 1980s. In three climatically distinct sites and four habitats, the ambitious experiment compared the invasiveness of three variants of oilseed rape plants during three growing seasons: two varieties were modified with recombinant DNA techniques and one was an unmodified variety. It found no important differences in invasiveness among the three varieties [2].

Although the methodology was elegant and scientifically sound, the result was unsurprising. It is difficult to justify the huge expenditure of resources only to find, predictably, that in the absence of selection pressure, recombinant DNA-modified plants, with genes for resistance to an antibiotic or to an herbicide, are no more invasive than unmodified plants. The US Department of Agriculture continues to earmark large expenditures for such worthless research (http://www.csrees.usda.gov/nea/biotech/in_focus/biotechnology_if_risk.html).

Worthless conferences and reports
A common feature of these, lately, is endless, pointless dithering about the possibility of coexistence of recombinant and non-recombinant plants and crops. We have done the real-world experiment hundreds of thousands of times, and plant breeders and farmers have catalogued the techniques and separation distances that are necessary to maintain the integrity of different varieties of the same species. Real science does not make categorical distinctions between recombinant and non-recombinant organisms. For example, when planning scientific meetings, the Gordon Conferences and Keystone Symposia do not segregate on this basis.

Unscientific, inconsistent and excessive regulation
This is applied to the pseudo-category of products made with the newest, most precise and predictable molecular techniques – namely, recombinant DNA and related...
technologies. The products of recombinant DNA technology are no more a distinct and meaningful category than are organisms whose Latin names begin with the letter M. However, in defiance of the broad and long-standing scientific consensus that the technology is essentially an extension or refinement of less precise and predictable genetic techniques, case-by-case reviews are performed on every recombinant DNA-modified plant variety that is to be field-tested. (With few exceptions, plants modified by conventional techniques are essentially exempt from regulation.) With the possible exception of the FDA, virtually no regulators in the world have approached, in a scientifically defensible way, the scope of what requires case-by-case reviews.

The brave old world of genetic modification

Anti-biotech activists, and others who are ignorant of the history of plant breeding, might be leery of messing with Mother Nature, but that does not alter the fact that we have been doing it for thousands of years. No one—not even devotees of a brown rice and carrot juice diet—can avoid it. Currently, dozens of genetically improved varieties that are produced through hybridization and other traditional methods of genetic improvement enter the marketplace and food supply each year without any governmental review or special labeling. A technique in use since the 1950s, induced-mutation breeding, involves exposing crop plants to ionizing radiation or toxic chemicals to induce random genetic mutations. These treatments most often kill the plants (or seeds) or cause detrimental genetic changes, but on rare occasions the result is a desirable mutation. For example, a mutation might produce a new trait in the plant that is agronomically useful, such as altered height, more seeds, larger fruit or enhanced resistance to pests.

One anti-biotech group even managed to persuade some seed companies that serve home gardeners to sign on to something called the Safe Seed Pledge: ‘We pledge that we do not knowingly buy or sell genetically engineered seeds or plants’ (http://www.gene-watch.org/programs/safeseed/sourcebook.html).

This is fascinating because, with the sole exception of wild berries and wild mushrooms, all the fruits, vegetables and grains in North American and European diets have been genetically modified or engineered by one technique or another. This even includes ‘heirloom’ varieties of fruits and vegetables, such as tomatoes, melons, beans, squash and aubergines. Often, this genetic modification has involved radical changes at the level of DNA (e.g. the wheat variety Triticum agropyrotriticum, which is discussed below).

The risible Safe Seed Pledge is no more realistic than the rejection of ingredients from recombinant plants that, by any reasonable scientific criteria, wide crosses also involve transgenesis.

The T. agropyrotriticum example illustrates the inconsistency and imprecision of the term ‘transgene’: a gene that is moved from the genome of one organism into the genome of another organism. In the argot of regulators and anti-biotech activists, only the use of recombinant DNA techniques gives rise to a transgene, despite the fact that, by any reasonable scientific criteria, wide crosses also involve transgenesis.

A regulatory feeding frenzy

The confusion about terminology has led to unscientific, discriminatory and excessive regulation of recombinant DNA-derived crops and foods by national and international authorities. The opportunistic regulator wannabes, particularly at various UN agencies, have indulged in a veritable feeding frenzy of unnecessary and unscientific regulation that has been particularly damaging to developing countries (http://www.hooverdigest.org/052/hmiller.html). The efforts of the UN to become the bio-cop for the world is worth exploring in some detail—not because their approach is worse than elsewhere but because of the low probability of the organization seeing the error of its ways and rationalizing regulation.

During the past decade, delegates to the UN-based Convention on Biological Diversity have negotiated and implemented a regressive biosafety protocol to regulate the international movement of recombinant DNA-modified organisms, which they chose to call living modified
organisms (LMOs) (http://www.nationalreview.com/comment/henrymiller200502150749.asp). This regulatory scheme is based on the bogus ‘precautionary principle’, which dictates that every new product or technology must be proven completely safe before it can be used and is a travesty that flies in the face of sound science.

Many other UN agencies have got in on the anti-biotech act. A technical working group of the UN Environment Program (http://www.unep.org/) is considering whether to recommend a moratorium on the testing or commercialization of recombinant DNA-modified trees. Such a suggestion is absurdly anti-social and alarmingly anti-environmental – plant biologists are engineering trees to grow more rapidly to combat deforestation; to require lower inputs; to resist pests, diseases and drought; and to enhance output traits that afford greater efficiency for uses such as making paper and ethanol.

A task force of the Codex Alimentarius Commission (http://www.codexalimentarius.net/web/index_en.jsp), the joint food standards program under the auspices of the WHO and the Food and Agriculture Organization, has singled out only food products made with recombinant DNA techniques for draconian and unscientific restrictions. These conflict with the worldwide scientific consensus that such techniques are merely a refinement or improvement of the less precise and predictable methods for genetic manipulation that have been used for centuries. Thousands of greenhouse and field studies, as well as widespread commercialization in almost a dozen advanced countries, have shown that the risks of gene-spliced plants and foods are minimal; their benefits proven; and their future potential, extraordinary.

Another Codex group is discussing mandatory labeling for foods that contain ingredients from recombinant DNA-modified plants. This could spell disaster for the use of recombinant DNA technology applied to foods (as has happened in Europe).

The preoccupation with recombinant DNA-modified organisms has distracted attention and diverted essential resources from real problems, such as the introduction of exotic species, bacterial contamination of crop plants and the sufficiency of water supplies. In a scathing critique of the recombinant DNA-focused regulations of the Cartagena Protocol – criticism which is applicable to the assaults on recombinant DNA techniques for draconian and unscientific restrictions. These conflict with the worldwide scientific consensus that such techniques are merely a refinement or improvement of the less precise and predictable methods for genetic manipulation that have been used for centuries. Thousands of greenhouse and field studies, as well as widespread commercialization in almost a dozen advanced countries, have shown that the risks of gene-spliced plants and foods are minimal; their benefits proven; and their future potential, extraordinary.

The now-defunct Group of National Experts on Biotechnology of the OECD made some valuable contributions to science-based public policy during the 1980s, but its attempts to survey biotechnology regulations and other developments in OECD countries were repeatedly stymied by inconsistent definitions – even when countries were asked to use a specific one. As discussed above, terms such as biotechnology and GM are not genuine, discrete, easily circumscribed categories; therefore, it is not surprising that no-one is sure what the terms define. Broad definitions encompass too much to be useful, and narrow ones that focus on the use of one technique or another are artificial, arbitrary and meaningless.

The 2006 report by the OECD on biotechnology statistics illustrates that if we are ignorant of history, we are doomed to repeat it. The data were amassed with various responders, once again, using different and incompatible definitions of biotechnology – but, this time, the results were published anyway.

The OECD had asked member countries to submit various kinds of data – the number of biotechnology companies, field trials, patents and alliances; product sales figures; acreage planted; and amount of venture capital invested. Inexplicably, they offered the intended respondents two definitions of biotechnology from which to choose. The first was what they referred to as a single definition – namely, ‘the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or nonliving materials for the production of knowledge, goods and services’. That would encompass not only most biomedical R&D and commercial activity that involves laboratory animals or humans but also virtually all of agriculture, baking that uses yeasts, and the production of fermented beverages and foods – ranging from beer and yogurt to kimchi (a traditional Korean dish of fermented chili peppers and vegetables). The use of such a broad definition is destined to yield worthless results, not unlike asking for all of the R&D and commercial data in the world concerning doors, whether they are found on dollhouses, igloos, kitchen cabinets or nuclear submarines.

The second definition was a kind of Chinese restaurant menu-like list of various techniques and activities: synthesis, manipulation or sequencing of DNA, RNA or protein; cell and tissue culture and engineering; vaccines and immune stimulants; embryo manipulation; fermentation; using plants for cleanup of toxic wastes; gene therapy; bioinformatics, including the construction of databases; and nanobiotechnology.

The grand debacle of the OECD
An egregious and recent example of definitional dysfunction can be found in a massive document published by the Paris-based OECD – OECD Biotechnology Statistics – 2006 (http://www.oecd.org/dataoecd/51/59/36760212.pdf). The OECD, the thirty member countries of which account for most of the commerce in the world, boasts that it ‘plays a prominent role in fostering good governance’ and ‘helps governments to ensure the responsiveness of key economic areas with sectoral monitoring’.

Not with this report.

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However, respondents deviated even from these two different definitions, and, consequently, the report contains this extraordinary passage:

The OECD list-based definition, or close variants, were used in surveys in 15 countries, but different definitions of biotechnology were used in the other 11 countries: 7 studies limit biotechnology to “modern” or third-generation biotechnologies that are similar to the OECD list-based definition in practice, 2 studies use mixed definitions that include second generation biotechnologies (Japan and South Africa), and 2 do not define biotechnology, but leave it to the survey respondent to decide if their firm is active in biotechnology. As the latter two studies cover Denmark and Sweden, a large majority of the respondents are likely to interpret biotechnology as modern biotechnology.

To obtain the data for the United States, one agency used the OECD definition (but substantially under-reported), and another seems to have asked companies for information about biotechnology without defining it. Canada supposedly used the single definition but grossly under-reported its activities, which, as noted above, would include all agriculture, the production of fermented foods and beverages, and most baking.

This chaotic state of affairs brings to mind the old computer saying, ‘Garbage in, garbage out’. The data in the OECD report are garbage.

Conclusion
In our two-decade-old article, Frank Young and I quoted a 1986 report on biotechnology from the US General Accounting Office (as the agency was then known), which concluded: ‘Because of the inconsistent interpretation of the term “biotechnology”,...[i]t may be useful, for the purpose of discussing possible regulatory approaches, to avoid the term “biotechnology” and instead use more specific terms...’ [4].

That is still good advice, and not only with respect to regulatory issues. Greater clarity and discipline in terminology might promote greater perspicacity in how we view and formulate policy toward biotechnology. That would certainly benefit the bureaucrats at the OECD (and many others, as well), vex the fear-mongering activists and force regulation to be more appropriately focused.

References
1 Miller, H.I. and Young, F.E. (1987) Biotechnology: a ‘scientific’ term in name only. The Wall Street Journal

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