Perceived Risks Incurred Along With Genetic Engineering's Alluring Benefits

Thomas H. Kerr III, Ph.D.[*]

New approaches to the practice of medicine and to food production have arrived on the technological scene as a consequence of the knowledge gained through modern genome sequencing. Now Scientists and genetic engineers can modify and manipulate the fundamental genetic code of certain crops and animals to benefit mankind. Although the stated goals of genetic engineering and genetic modification are noble, these activities are not without associated risks and drawbacks, which apparently have received much less attention. The discussion below is an attempt to remedy that oversight by discussing both aspects in one gulp in a form that is easy to understand, without hype, with the venom removed and the invective wording toned down (from how it was originally stated elsewhere in many cases). We eschew being extreme in portraying either view; otherwise, adversaries would dismiss it out-of-hand as not being worthy to even consider further.

In compiling the list of risks (and benefits) here below, we rely only on information and facts provided by internationally recognized scientific journals, nationally recognized newspapers, and three of the Public Broadcasting System's (PBS) NOVA series [1]-[3]. Each of these particular sources is well known for thoroughly crosschecking its supporting facts and, moreover, is available from most U.S. public libraries for further confirmation. We specifically avoided visiting or viewing Web sites, pro or con (such as those of the USDA, FDA, EPA, *The Foundation for Economic Trends*, *Friends of the Earth*, *International Green Peace*, or the *Earth Liberation Front*) because information posted on the Web, in general, is notorious for being self-serving (by disseminating biases interspersed with truth), ephemeral (since it can vanish), and time-varying.

Our aim here is not to convert or dissuade any existing views away from the current U.S. policy of encouraging progress in genetic engineering/genetic modification because the apparent consensus is that it is important for the long-term welfare of the U.S. and the world, both scientifically and economically, to continue on this course. The objective here is merely to delineate the benefits (as perceived by its advocates) and the drawbacks (as perceived by its opponents) of Genetically Modified Organisms (GMO), all in one place. The worries of the GMO critics appear to all pertain, at a high level, to one or more of the following four questions:

1. Why do we need GMO's? (Reasons for pursuing GMO's are surveyed in Sec. 1 below.)
2. Will GMO's damage the environment? (It is the EPA's responsibility to approve them.)
3. How do we know that GMO's are safe? (It is the USDA's responsibility to approve that they are safe to grow and the FDA's to approve that they are safe to eat.)
4. Are shell games being perpetrated on the government regulators and GMO overseers? (Therefore leaving the GMO critics unsatisfied, as cautioned about in Sec. 4 for reasons raised in Secs. 2 and 3, with a summary of sorts provided in Sec. 5.)

This up-to-date amalgamation of perceived worries offered here should help specialist answer these concerns more conveniently and, hopefully, refute them and thus placate the critics. Only by also considering or acknowledging the risks as well as the extensive benefits is a balanced view of GMO availed. Otherwise, just sweeping risks under the rug will likely make the general public more uneasy with the U.S.'s current policy of going forward with GMO in relative secrecy (i.e., with decisions out of view of the general public and so without feedback or debate).

1. Noble Motivations for Pursuing GMO

The U.S.'s $600 billion food industry has already quietly introduced GMO into existing products for the last six years without distinguishing labeling betraying them as they began infiltrating but

[*] Principal Investigator, **TeK Associates,** P.O. Box 459**,** 9 Meriam St., Suite 7-R, Lexington, MA 02420-5312.
e-mail: thomas_h_kerr@msn.com Web Site: TeKAssociates.biz

now permeate the U.S. food supply, but, apparently, also without incident or disruption so GMO's are apparently safe enough. "According to the U.S. Department of Agriculture, about 75% of year 2002's soy crop in this country was genetically engineered, up from 68% in 2001 and 54% in 2000. About 32% of the corn crop included biotech varieties and it is predicted to be 38% of the 79 million acres of corn to be produced in 2003. Indeed in 2004, about 76% of the products on American grocery store shelves already include some kind of biotechnology, mostly in the form of soy oil, corn oil, or corn sweetener" [35]. The percentage is so large that a worry was that the European Union, fearing an increased risk of accidental cross-contamination, may possibly boycott all food from the U.S. and not just the GMO food that EU has already boycotted for the last 4 years [39].

Europe, which initially vehemently resisted GMO a decade ago, is still slow to follow the U.S. lead and the current "European moratorium on GMO foods has already cost U.S. farmers an estimated $300 million/yr in lost (export) sales" [35]. In contrast to the European Union's embracing a "precautionary principle" of basing regulatory policy on the ***significant possibility of risk,*** the U.S. regulations are *not imposed until* ***after there is concrete evidence of harm*** [38]. China was initially very enthusiastic about developing and introducing GM food but is now proceeding with extreme caution [34]. However, a turn of events occurred in May 2004 when the EU (under further pressure from the U.S.) became receptive by allowing limited imports of GMO foods to start. The US had earlier officially objected to the EU's blocking actions as "being hostile to US trade interests". In 2003, Bolivia complained that it tested USAID food and that it contained Starlink corn, which is prohibited for human consumption in the US. It would seem that sovereign nations have the right to establish their own internal polices to which exporters should comply.

GMO critics respond that current world food production is enough to feed 9 billion people so why is hunger even an issue today since there are only 6 billion mouths to feed worldwide? If enough food is already produced, why is there a need for GMO? The lack of money available to the current 800 million chronically malnourished poor of the world to pay for "further distribution of the excess food to where it is needed" is cited as the reason why hunger still persists.

Agricultural scientists continue to seek methods of increasing farm productivity to compensate for how population growth increases the total number of mouths to feed (where the world population is predicted to be 9 billion by 2025) and to allow local solutions to remedy the distribution problem. It is reasonably speculated that the best local solution for developing countries that currently engage in mere subsistence farming is to greatly improve their productivity and to also avoid likely crop failures due to known insect or fungal pests by embracing the most advanced, high technology GMO remedies as they endeavor to meet their own needs in availing sufficient nourishment *to their own people by their own efforts* thus fostering self reliance and pride (see [4] for complicating aspects thwarting this simple remedy in certain 3rd world countries due to rampant HIV/AIDS severely reducing available agricultural manpower).

The potential remedy to ameliorate world hunger offered by GMO is only possible because of the progress of technologists, who through hard work and a progression of scientific achievements, have continued to refute the dire predictions of the 1798 Malthusian theory about population size being expected to eventually exceed the earth's capacity for food production.

There are also other health benefits of genetic modification such as transgenic organ transplants and claims of curing "bubble boy" immune system deficiency by early intervention, as two successful permanent cures were announced in July 2002 (however, adverse evidence has recently emerged [6]-[8], [32] of leukemia being a side effect of such treatments). It has been revealed that over the last 12 years, an estimated 3,000 patients have been involved in gene-therapy expe-

riments, all using the same technique of employing a retrovirus [9] to deliver new genes to the body to replace missing or defective genes. More than 370 new experimental drugs (some being GMO's) are under development by 144 biotech companies to target nearly 200 diseases [10]. Some scientists seek to use certain GMO crops to obtain pharmaceuticals, where these crops are a cheaper source of the specifically engineered proteins to be used in medicines for humans and animals [35]. Despite the aforementioned obvious benefits, there are other aspects to consider regarding the potential solutions offered by GMO.

2. Food for Thought

First, merely echoing and summarizing the following three concerns regarding genetically engineered products that an evenhanded treatment covered in [1]:

1. Pesticides have been genetically engineered into many crops. (There had previously been wide spread warnings from immunologists for farmers not to over do use of Bt [Bacillus thuringiensis] pesticides without planting a corresponding pesticide free *refuge* to serve as a buffer. The fear is that harmful insects will evolve more quickly with immunity to this particular class of pesticide and, as a consequence, just up the ante on what can be effectively used against them. The realities of farming indicate that the idealized requirement for a *refuge* buffer being present in close proximity may frequently be ignored entirely by overworked farmers driven by their usual market pressures. Another worry is that benign insects nearby may also be killed due to pollen drift. If there is cross-contamination of seeds, as was widespread with Starlink corn, then well-meaning farmers could unknowingly skip the mandatory buffer zone in the mistaken belief that they were planting ordinary corn that didn't require such buffers.)
2. Although not available commercially but only developed in earlier research, nut-like aspects have been genetically engineered experimentally into some crops that are not ordinarily monitored for human allergic reactions, thus potentially foiling the vigilance of parents and school systems trying to protect their allergy-prone kids from exposure to life threatening substances if any sneaks past the battery of tests currently in place by the FDA (as may perhaps occur due to pollen drift [40]). For perspective, traditional foods cause allergic reactions in 8% of children and 2% of adults [1].
3. Salmon farm populations have been genetically engineered to grow to full size more quickly but scientist warn that such salmon should NEVER be allowed on the open ocean because the resulting salmon take priority in mating. Existing mathematical models and corresponding computer simulations for similar fish predict species extinction in 30 generations if a catastrophe were to occur and fertile genetically altered fish get released into the open ocean.

Aqua Bounty (in Waltham, Massachusetts) is pioneering GMO salmon and hopes on a ruling on its acceptability from the U.S. government soon (originally expected: '03). So called "Franken Fish" were developed earlier in Australia/New Zealand but were destroyed after severe mutations appeared.

Almost identically paralleling the wording of Item 2 above, another more recent concern is that antibiotics have been genetically engineered into many crops due to the presence of antibiotic marker genes routinely present in almost all genetically engineered crops. (It has been claimed that the presence of these marker genes represents no risk at all.) However, another concern is the routine use of antibiotics in the food pellets on most salmon farms since 1991. (There had previously been wide spread warnings from physicians not to over do use of antibiotics in humans and cattle feed. The fear is that harmful germs will evolve more quickly with immunity to this particular class of antibiotics and, as a consequence, just up the ante on what can be effectively used against them. This is a worry for both standard hybrids and GMO salmon farms.) The jury's still out as we all wait on further deciphering of long-term consequences. A Fisheries and

Oceans, Canada study [49] reports dire consequences when GMO salmon are mixed with wild salmon as they compete for scarce food. Species extinction was the result in controlled tanks.

From [1], it is revealed that environmentalists have expressed concern for the safety of the beautiful and benign monarch butterflies and their larvae that feed exclusively on the milkweed plant at an early stage of their life cycle. Since milkweed is frequently found in close proximity to corn crops and Bt kills monarch caterpillars, the size of the monarch butterfly population is being closely watched as a gauge of whether the situation is getting worse due to Bt pollen drift. Certain academicians have claimed that since milkweed is in fact classified as a noxious "weed" by the USDA, it would have been removed or cleared away from any corn crops; however, cross-checks of this claim have indicated otherwise and milkweed is occurring quite close to the corn, frequently existing along side the corn in the same fields. The year 2002 crop of monarch butterflies was down dramatically but likely due to colder than normal weather experienced after their migration to their winter sanctuary in Mexico [36]. However, their numbers rebounded nicely the following year [36].

Also from [1], organic farmers parsimoniously use naturally occurring Bt pesticide (originating from a naturally occurring plant virus) and only when Bt is occasionally needed for their crops. Another worry is that widespread use of Bt in GMO crops will also make insects resistant[†] to organic farmers' more benign and parsimoniously used Bt as a pest control tactic. *Monsanto* has assured the organic farmers that *Monsanto* has already identified a whole sequence of other similar naturally occurring pesticides to be used as a replacement follow-on after insect immunity to Bt develops in about 10 years, as *Monsanto* has already anticipated. In this case, *Monsanto* claims to hold the key. Will all others have to come to *Monsanto* for the cure (to a problem that *Monsanto* may have caused and acknowledge that they are aware of)? (Monsanto is also taking heat for developing crop seeds that bloom but don't reproduce so that farmers have to purchase anew each year.)

A lesson from past history is that after ten years of being in vogue, the higher yielding hybrid corn, used throughout the Mid West in the 1960's, was found to be susceptible to corn blight which crippled all the subsequent crops. Only those few farmers who had delayed their conversion over to the hybrid corn were spared and actually saved the day because the older variety was more robust and not bothered by the corn blight. This would suggest that sometimes it takes 10 years or more to discover unforeseen problems with new varieties. Unfortunately, the U.S. FDA law was changed in 1992 to allow food and drugs to be introduced almost immediately with shortened trials (as understandably motivated by the last ditch efforts in the search for cures for Aids victims) where new products are now apparently presumed safe until proven otherwise. Prior to 1992, it was the other way around: presumed dangerous until proven to be safe. (Recall within the last ten years, that a popular diet drug, fen-phen, was later linked with causing fatal heart valve weaknesses and the claimed benefits of Hormone Replacement Therapy were also later rejected and HRT is now recognized as being hazardous to women's health. Such are the risks with relatively instant gratification and *innocents may die*. In 2003, infant formula, possessing unfortunate side effects from its additives, cancer-causing *acrylamide* in a variety of foods, and *ephedrine* have been flagged. In 1997, Selbane and Redux were recalled. Merck recalled Vioxx® in 2004 because of later clinical trials indicating an increased risk of cardiovascular

[†] A well-known precedent is the current insecticide resistance of the Anopheles gambiae (and A. funestus) mosquitoes associated with the spread of malaria (as addressed on p. 179 in a special 4 Oct. 2002 issue of *Science* devoted to malaria and its transmission). Widespread resistance of the Plasmodium falciparum malaria parasite to both Chloroquine and sulfadoxine/pyrimethamine treatments (and to DDT) is documented on pages 74 and 121 *ibid* after having been an effective treatment for 20 years. The recent genome-mapping of both of these mosquitoes and the above malaria parasite are also reported on pages 79 and 182 *ibid* and are hailed as the "key to future remedies".

events such as heart attack and stroke. According to Ref. 52, two studies [involving 2,000 participants] have turned up new evidence that all of the popular arthritis pain killers known as cox-2 inhibitors may put users at greater risk [by a factor of 3] of heart attacks and strokes.) Although lawyers are preparing assault strategies against the drug companies as a consequence [53] and David Graham, a 20 year FDA employee and associate director for science and medicine in the FDA's Office of Drug Safety, has testified to congress in Nov. 2004 that "FDA's problems with ensuring drug safety were 'immense in scope' and left the nation 'virtually defenseless' against the chance that unsafe drugs will reach consumers" [53]. More bad news about the situation within the FDA for monitoring or following up the side effects of drugs is discussed in [54]. A clear and reasonable discussion of the pros and cons of cox-2 inhibitors and prescription drugs in general is offered in [55]. Unfortunately, as of 24 Jan. 2005, it was revealed on CBS News that Pfizer (with the approval of the FDA) had published claims that a 6 month study showed that its drug *Celebrex* had fewer or less severe gastrointestinal problems associated with its use than encountered with using Ibuprofen; however, it now comes out that the second six months of this *same* study that was really a year long, demonstrated the reverse (these later conclusions were originally suppressed and not disseminated to physicians). There is more. It has now been revealed [57] that Pfizer completed a study four years earlier in 1999 that linked *Celebrex* to a "statistically significant" increase in heart problems but chose not to publish it; all the more disturbing since a later independent study in 2004 by the National Cancer Institute also linked use of *Celebrex* to a 3.4 times higher risk of cardiovascular troubles and was immediately halted; yet Pfizer commented that these results were "unexpected" (even though it was consistent with what Pfizer's own earlier study had concluded). More sensationalized discussions on these topics [59] appear on the same page of *The Boston Globe* alongside more conservative, more rational, and apparently more scientific investigations of the same issues [60] as a warning that facts in common can be sensationalized by the messenger. According to [62], Peter Kim, Merck Research Chief, "suggests that Merck might bring back Vioxx" (as confirmed in [64]). "For some patients, apparently, there is no adequate substitute and, presumably, the safety concerns can be addressed by the attending physician." Perhaps the situation for FDA oversight will improve with the new initiative discussed in [61], [63], [66], [67] and new admissions in [65]. These precedents should serve as a warning not to move too fast with GMO's because they *may* have adverse effects and un-foreseen consequences only revealed years later. Indeed, pre-1963 polio vaccine widely contaminated by the SV40 virus from rhesus monkeys has recently been suspected of causing cancers in human recipients 40 years later [12]. (This last hypothesized contamination source was later vindicated.)

When nature makes changes and tweaks in the genetic code, they are made over eons as a considerably longer (and safer) time scale. Such changes are also local and so "mistakes" or degradations of any kind are pruned through *natural selection* and "survival of the fittest" (vice [42]). On the other hand, man-made changes have a near "instantaneous" distribution system by comparison (as with the hybrid corn example) and it is harder to pull back such changes afterwards.

A government-commissioned Blue Ribbon Panel convened by the National Academy of Sciences studied the problem for two years. The conclusion of their report issued in March of 2002 is not totally conclusive but did insinuate that the U.S.'s USDA had previously been somewhat lax in approving and in follow-up monitoring of genetically altered crops and in evolving procedures to rigorously handle the new situation that is now significantly different from that of the past (see both [13] and [14]). Class-action judgments subsequently settled have been reported [15] of $9 million levied against the purveyors of Starlink Corn (i.e., Kraft Foods Inc., Kellogg Co., Azteca Foods Inc., Mission Foods Co., Aventis CropScience, and Garst Seed Co.). Inducing human allergic reactions and cross-contamination of agricultural strains were the main issues of this lawsuit. (It had already cost Avantis $500 million to withdraw Starlink corn from the market but

not before contamination was worldwide. Starlink corn, which was only approved for animals because of the presence of the toxin Cry9C, turned up in *Taco Bell* Taco shells in 1997. Larry Bohlen (Friends of the Earth), who uncovered this Starlink presence in human food, explains that he was suspicious because "most farmers do not separate genetically engineered corn from conventional corn" during the 14 hour days of their rush to harvest.)

Claims have been made that a handful of Nobel Laureates endorse genetically engineered foods (but those that do seem to be affiliated with this same technology of research in GMO and stand to directly benefit if it is condoned). "Appealing to an authority" doesn't always work in a society that has over 25,000 registered lobbyists, many representing drug manufacturers and other GMO companies. The multi-billion dollar tobacco industry eluded FDA censure for over 50 years as an unfortunate precedent. Thankfully, some disclosure rules are now tightening up [44].

3. Other Concerns Regarding Biotechnology, BioInformatics, and GM

The new field of BioInformatics applies computers, information theory, and statistics to the biological sciences in seeking to further unravel the purpose of each gene after it has been sequenced. Since it has been discovered that gene location and makeup within the spiral helix of the human chromosome is not the entire story, the new field of Proteomics has emerged to look specifically at the large variety of proteins and amino acids in three dimensions and seeks to recognize and classify them by how they are folded and where they arise in nature. These three-dimensional deciphering endeavors of Proteomics are even more challenging than the one- and two-dimensional gene sequencings accomplished to date in mapping some human and animal genomes and constitutes an even larger computational burden by orders of magnitude. For those that thought the genome project was expensive at $3 billion, just wait to see what the tally is for Proteomics. Indeed, it was revealed by the featured speaker at a December 2001 meeting of the *Boston Association for Computing Machines*, that the underlying mathematics of protein folding and shape matching (Proteomics) is in its infancy although some useful problems in folding simple shapes have recently been solved (after only 25 years). In 2008, the presence or absence of certain specific genes associated with maladies is now known to not be the whole story. Epigenomics now identifies the presence of certain loose or tightly circumscribing belts or bands that effectively constrict genomes so that their potential effect is "turned off".

It has been lamented that a strong *Bio-Ethics Czar* for the Bush administration had been lacking[‡]. To wit, please consider the following headlines that appeared over a recent two-month interval in the *Boston Globe*:

1. In late November 2001, the conclusion of a new study said that many more people should be taking statin drugs to reduce cholesterol, not just those currently diagnosed with high cholesterol or high blood pressure. Merck and Bristol-Myers Squibb and two universities sponsored this particular study. (Earlier questions of whether this conclusion is rather self-serving were raised in [16] by noting that an existing $5 billion/year market would potentially expand to $30 billion/year as a consequence.) Also see toxic side effects of statin use, as identified in [17] (revealed by a San Diego cardiologist, Dr. Paul Phillips, in October 2002 issue of *Annals of Internal Medicine*). New guidelines being developed recommend that the number of patients to be prescribed statin drugs be raised to 35 million people.
2. In October 2001, researchers reported that contrary to past beliefs, after a heart attack or a stroke, now it is recognized that new blood vessels can develop in the patient's heart and

[‡] The 10,000 person FDA went for 20 months without a chief, however, 39 year-old Mark McClellan was appointed in October 2002 to fill this post [11]. As announced in Dec. 2004, Michael Levitt will replace Tommy Tompson as head of Health and Human Services (HHS).

brain, respectively, all by themselves as a spontaneous reaction (also see [18] and further confirmation in [19]). Claims are that such growth is further promoted by exercise.

3. In late November 2001, a new study was issued that claimed gene therapy was credited with causing or promoting the growth of new blood vessels in the heart after a heart attack. (Evidently, some gene-therapists are now capitalizing on and taking credit for what occurs naturally, as reported in item 2 immediately above. It appears as though gene-therapists were quick to react and capitalize on the situation before the slightly earlier news was widespread. For perspective, also see [20], [58].)

Another disaster occurred and caused Texas-based ProdiGene to be hit with a record fine for its mistake, which may have contaminated up to 500,000 bushels of Iowa and Nebraska soybeans with pharmaceutical corn. The company paid $250,000 in penalties plus $3 million to buy back and destroy the tainted soy crops [35].

While the human genome mapping is widely hailed, the mapping of the single man and woman from Buffalo, New York (pursued with Government funding) and the mapping of the other five people of different ethnic backgrounds (analyzed and mapped by Celera Corporation with private funding) were the only outcomes pertaining to humans at the announced completion of the genome project (during the Clinton administration). This actually represents very little progress in distinguishing human genetic differences since 99.9% of the genes of homo sapiens are identical in everybody across the board (unlike the situation in other older animal species). These facts were revealed in [2]. The hope now (to perhaps be realized in 10 to 20 years) is to decipher the cause and effect relationship between genes, Proteomics, and consequential maladies or vulnerabilities of genetic origin. A noble goal but pretty much pursued by mere “trial and error”. Eleven hundred year old historical Icelandic or Scandinavian records, while touted as offering clear genealogical paths don’t necessarily yield patterns of maladies that are sought since the impressive forensic science and exacting medical autopsies are only of fairly recent vintage. Indeed, only since the time of Louis Pasteur (1850) have scientists recognized germs as being the cause of their specific associated diseases. Recognizing viral causes is even more recent. This earlier weakness in historical genetic records not necessarily pin pointing the maladies of interest should now be remedied with the new voluntary program being offered in the UK to track 35 million people starting in 2002 and proceeding into the future. In 2005, a $100 million International Haplotype Map (HapMap) project will be completed, along with a separate haplotype map assembled by Perlegen. Haplotypes are shared stretches of DNA, as being viewed across 3 (or 4) study populations comprising Utah residents: those with northern or western European; Chinese and Japanese; and Yoruban ancestries. This may start to reveal which DNA variables are involved in common human diseases and how DNA patterns shift across the ethnicities included in the study. Hapmap results will be folded into the *Ensembl* study as well [51]. Before these four programs were initiated, other scientists were able to justify starting these studies by getting specialist to acknowledge that earlier weakness existed in the ability to pinpoint the associated consequential human malady to be extracted from the existing historical Icelandic genealogical data when that was all that they had planned to depend upon for this aspect. During the prior decade, genetic specialists apparently refused to admit to the above weakness. It is unnerving for the general public to put our trust in such specialists, who in the face of the obvious were so recalcitrant.

Initial “cause and effect” patterns revealed in underlying genes within the same related families that exhibit the malady might just be “other patterns also present”. While fundamental “cause and effect” can be more easily ferreted out with Fruit Flies (drosophilae) that yield a new generation every two weeks, the human species requires considerably longer to yield subsequent generations from the same lineage that would aid in confirming such hypotheses. Of course there have already been many impressive genetics-based successes along these lines, as occurred in

identifying the genetic mutations BRCA-1 and BRCA-2 associated, respectively, with an 80% chance of breast cancer over a lifetime while it is only 10% without them being present (identifying DBC-2 is even more recent as is the identification of EZH2 for prostate cancer [22]). HIV resistance (and, historically, resistance to the Black Plague germ as well) has been linked to the presence of the delta32 mutation of the CCR-5 gene within the human genome. Tools for identifying and introducing desirable genes through use of gene-therapy have been recently condoned and further developed [5] to benefit mankind. However, these are a few useful successes (as indicators of likely predisposition to the disease) within many questionable activities such as genetically engineering firefly nighttime radiance or luminescence into tobacco and into mice. These last two endeavors appear to serve no useful purpose other than to just show that it can be done[§].

Two glaring discrepancies between what was "originally promised as an ideal" vs. "what was actually delivered":

1. Genetic modification of a plant "to exhibit fire-fly-like radiance to signal when it needs watering" but only the capability of exhibiting such radiance was achieved as an event, independent of whether or not it really needed watering. Genomes evidently may not be linked at will as in an "If…Then…" statement of computer codes (despite the scientist's stated desire to do so). The plant also lacked the firefly's flashing duty cycle that would avoid the constant power drain.
2. So-called "Franken fish" were developed in Australia/New Zealand in an attempt to produce a much larger species (as a hopeful addition to the world food supply) while the genetic scientists promised that these fish would also be routinely altered to be sterile and incapable of reproducing (for the reasons already provided above) yet when severe mutations occurred and stirred a public outcry, these fish were destroyed before any independent scientist could confirm that these fish were indeed sterile. The "Franken fish" were ground up and their remains stored, ostensibly for later study.

One especially enticing benefit claimed of modern genetic engineering is the ability to develop donor swine with organs designated specifically for eventual human transplant without the usual fear of rejection by the recipient's immune system. The previous practice of administering drugs to suppress the recipient's normal immune responses left their bodies susceptible to other foreign invasions (but at least only the recipient incurred this risk). By using these transgenic hosts, such immune system suppressing drugs are no longer needed by the receiver. This bridge between man and swine, accomplished by this feat of genetic modification for xenotransplants, is widely hailed by many as a boon to mankind. However, this same bridge, by providing heroic methods[**] to save the few who need it, can be a threat to millions of others by allowing diseases and viruses previously confined to only pigs to now be transmitted to humans. Should we risk the *many* of all future generations merely to save the *few* now? Ref. [68] may perhaps indicate that it has started?

4. Aspects that Fuel Conspiracy Theories

BioInformatics papers currently being published frequently don't include the data or the computer-based algorithms used for deducing the conclusions. Such a situation is a far cry from the standard peer-review (where the reviewers should be able to duplicate and confirm results). This aspect underlies the true scientific method but, by sidestepping it, the worry is that some less

[§] A recent 2004 GMO claim is that researchers have recently succeeded in engineering luminescence into some aquarium fish so that they glow under UV light and that such fish will be available for public purchase at local pet shops. We remember when similar naturally occurring fish with this property were widely available in pet stores in the 1950's before the fad passed. Is this just a marketing trick now for GMO to favorably catch the public eye?

[**] A new non-GMO technique [48] offers great potential by utilizing a conventional bone marrow transplant from the same organ donor to avoid rejection without any need to suppress the recipient's normal immune system response.

scrupulous BioInformatics researchers are now being allowed to build "castles in the sky". It turns out that this is a prevalent criticism of the entire BioInformatics industry in general. Substantiation of this claim appears in [21], which contains the following direct quote "'The new disregard for the peer review process is turning basic science into a circus!' says Glenn McGee, editor of the *American Journal of Bioethics*." Scientific authors, potentially influenced by underlying financially motivations and commercial links, are now being identified [44].

Only favorable views were expressed as the Proteomics topic was featured in the April 2002 issue of *Scientific American* and the BioInformatics topic was featured in the *Boston Globe* Business Section in the spring of 2002. However for many BioInformatics companies, controversy still surrounds patenting of genes, a prior lack of *any* near-tem products, huge business loses somewhat defying usual sound business practices (p. D3 of 17 April 2002 issue, *Boston Globe*), use of genetic testing as a basis for pre- or post-employment considerations and for insurance coverage instead of using actuarial tables[††], alleged premature leaks of abstracts in April 2002 for an upcoming May 2002 meeting of the *American Association for the Advancement of Science* (AAAS) that affected current stock prices as a consequence based on rumors of significant breakthroughs (while trail of evidence appears to implicate beneficiary company rather than two competitors who lost financial ground as a consequence), comparatively encouraging U.S. policies in this GMO area enticing foreign BioInformatics companies to also relocate here (e.g., Swiss Novartis). [A legal precedent has already occurred, where a settlement of $2.2 million was awarded employees in a case against a Texas railroad company employer, Burlington Northern Santa Fe, that was requiring genetic testing to weed out applicants for certain positions based on a perceived predisposition to developing *carpal tunnel syndrome*.] Again, the jury's still out as we await further deciphering of long-term consequences of the situations discussed above.

From [1], it has been revealed that 10 life sciences companies worldwide have a virtual lock on all the existing patents (and that others who attempt to use them must now pay royalties). Monsanto possesses 28% of all US Biotech patents, accumulated at a cost of $7 billion in research. This was a strategic move that Monsanto made early on to wind down their reliance on the sale of conventional pesticides in favor of embracing Biotech, recombinant DNA research, and GMO's. Recently it was revealed [33] that in 1998, Novartis "secretly" negotiated a 5-year $25 million research funding agreement with U.C. Berkeley in return for first rights to negotiate usage licenses and 30 day head start at seeing research results before general public release. Critics worry that the university may loose its valuable third-party independence, loose the public's confidence, and be perceived as having moved too far to the commercial side. Other similar trends have been revealed with other universities [41] and with supposedly impartial Government Laboratories [47]. Who is going to watch the watchdogs?

There are other unsavory aspects associated with what has been mentioned above that the interested reader may further pursue on their own using the citations provided herein as a jumping off point. Particularly unsettling are:

1. Intrigue associated with the considerable delay (~months) before the Maine salmon escape into the open ocean was actually reported to the Federal authorities with claimed excuses about having forgotten about it and blame being cast that it was the fault of the Feds for imposing tight restrictions on the owner's pens (done to not endanger yet other wildlife) [28].
2. Intrigue also surrounds the "Franken fish". First there was initial reluctance to admit that there was a problem with the "Franken fish" despite the widespread presence of severe

[††] Resolved on 14 Oct. 2003 when the U.S. senate passed a resolution by 95-0 baring insurance companies from using genetic information *and/or family history* from considerations of whether or not to insure or in setting the level of premiums and likewise prohibiting employers from using such information in decisions to hire or fire.

mutations. Later, there was the unexplained speed in the destruction of the "Franken fish" seemingly to avoid the scrutiny of 3rd party independent international scientist that were already dispatched to look further into the claimed sterility of the "Franken fish".

3. Surprisingly loose definition that genetic engineers apply as their "gauge of goodness" criterion regarding acceptability of newly engineered foodstuffs for human consumption and avoiding allergic reactions being based merely on the time it takes for new proteins to break down and be digested and associated wastes passed out of the human digestive track. This concern with just a certain maximum time was apparently without corresponding explicit consideration or follow-up of what exactly is being absorbed or digested before it is passed. Although Cry9C corn failed this test and is officially withheld from human consumption within the US because of this aspect, Cry9C corn is in fact allowed for animal feed. A limitation in the use of this type of test criterion (that has been recently revealed at the end of 2003 with the discovery of Mad-Cow disease in the US) is that Bovine Spongiform Encephalopathy (BSE) tainted meat will likely pass this test criterion (thus exposing how weak this test is as a preventative barrier meant to spare the public from dangerous substances).
4. Despite widespread concerns being expressed, research sponsors have been exclusively responsible for the health and well being of test subjects in human trials [6] rather than any independent advocacy group (a situation that could be perceived as a "conflict of interest"). Along these lines, there are several additional perspectives (more recently in [70]) in [32]:
   - With the evidence of certain human deaths being admitted to be associated with gene-therapy, such trials were suspended for a month but later resumed in October 2002.
   - New complications or side effects that were observed to arise from past gene-therapy on others are only now being advised to be conveyed to other new candidates for such therapy to fully inform them as they wrestle with their decision of whether or not to participate. (Prior to this, the new candidates were evidently kept in the dark regarding potential side effects.)
   - For severe immune deficiencies like "bubble boy" syndrome, there are alternative conventional treatments that can be used (such as bone marrow transplant) but apparently this has deferred to cutting edge gene-therapy instead as the prevalent treatment (even though leukemia is now identified as a possible side effect [6]-[8] of this particular gene-therapy). However, additional clues are now available to mitigate use of gene-therapy in risky situations as benefits have been judged to outweigh the drawbacks.
5. While the special 4 Oct. 2002 issue of *Science* and 3 Oct. 2002 issue of *Nature* portrayed the reported results of detailed genome mappings of both the malaria parasite and the mosquitoes that transmit it to humans as important milestones, there was only a vague explanation of how this information would be useful in the future without clarifying exactly why this expensive mapping accomplishment is now the "key to future remedies" as was claimed since there were no precedents to point at, nor detailed next steps portrayed, nor time-lines offered. Without such constructive steps being provided, current results appear to be an expensive isolated exercise pursued because it can be done, not necessarily because it is actually a useful step toward mitigating the spread of malaria in humans by offering a remedy to the current situation of apparent resistance to previously effective insecticides and drug treatments. Other approaches to the cure could be less expensive [24] and more effective [25].
6. Consumer requests that genetically engineered foods be distinctly labeled are continually misinterpreted and diverted to considerations of only labeling organically grown foods or focusing instead on (miniscule) dangers associated with organically grown foods (admitted to be common to all crops, organic and otherwise) from trace presence of residuals of

historically used pesticides (such as DDT while acknowledging that such residuals really represent very little present danger) as the detailed tally was being made.

While item 1 above has already been acknowledged to be a standard hybrid, the lesson for future GMO salmon that are planned is that there are no laws on the books requiring that the salmon farms report accidents like this to the EPA or to any other U.S. agency. This was yet another loop-hole and this ploy was in fact used successfully. The apparently intentional *red herring* reported on in item 6 above that continues to persist is infuriating. Few people seriously advocate organically grown food as the ultimate solution to efficient and economic food production for the masses. Indeed, organically grown food only accounts for 2% of our current food production. Subsistence farming in developing countries is in fact organic farming and it is far from satisfying local needs. However, in lieu of no identifying labeling yet being present on genetically engineered foods, eating only organically grown foods avoids the underlying risk but at a considerably higher monetary cost (instead of at a potential cost to one's health). Other tactics used to switch attention from the *real issue* of distinguishing GMO from non-GMO is dredging up *irradiation in food production* as a criterion that will preclude receiving a label of being "organic" (thus apparently "stacking the deck" so that organic foods [including meat] so labeled will be more susceptible to *salmonella*, *E.coli*, and *listeria* in packaging and, consequently, be a greater health threat than GMO, as gauged by frequency of more immediate adverse reactions).

In the *doublespeak* warned about in George Orwell's novel *1984*, the manufacturer's contradictory claims in (1) and (2) below are that:

1. In order to gain EPA, USDA, and FDA approval, GMO foods are demonstrated to be *substantially equivalent* to its conventional counterpart (as verified when run through a Mass Spectrometer and both patterns align, molecule by molecule);
2. In order to patent it, GMO foods are argued to be *substantially different*.

It appears to be hard to justify that a GMO is *substantially equivalent* and *substantially different* at the same time yet this is what is presently claimed. (As in item 3 above, use of this test fails to distinguish the prions associated with mad cow disease from the harmless normal version of this protein.) These are the only two tests imposed to date in deciding whether GMO foods are fit for human consumption. Many find this paucity in testing a little worrisome.

Two unfortunate trends recently reported on in [26] are described as *tricks* being used by Institutions seeking human trials for their planned studies. These tricks are reportedly being perpetrated against the U.S. Food and Drug Administration. One form such tricks have taken is a strategy of actually intimidating individual members of review panels who express their concerns to the study sponsor by telling them that no one else was worried about that particular consequence (when actually several or all had expressed a concern about the same aspect). Another form such tricks take is that once an Institutional Review Board (IRB) had turned the sponsors down, the study sponsors or collaborators then seek out another IRB to approve of their human testing research plans (without conveying the prior history of having already been turned down before). This tactic was possible and used for at least one proposed study when more than one institution participates in a joint project or study. Other unsavory tactics now in vogue are identified in [26]. A slew of deaths of human test subjects participating in such trials is the reason cited for the FDA's current interest in tightening up the procedures to thwart such trickery.

The pharmaceutical industry has also been accused of playing marketing tricks in their pursuit of further human trials following well after initial FDA approval and acceptance [27]. (However, on p. C-1 in the *Health and Science* section of the same issue of the *Boston Globe* can be found two articles that explain at length the benefits of finding alternate uses for existing drugs that are already approved by the FDA.) More disconcerting is that in September 2002 under pressure from the Biotech Industry to expedite approval of GMO medications, the Bush administration directed

the FDA to abandon its previous classifications and instead reclassify new drugs awaiting approval only according to their intended use or target, thus essentially blurring the GMO/non-GMO distinction that many believe is more prudent to retain. In February 2003, House Representative Nathan Deal (R-GA) introduced a provision as an attachment to a larger bill (subsequently already signed into law by Pres. George W. Bush) that loosens the federal standards for what constitutes "organic" foods. According to the new provision, farmers would now be allowed to raise livestock on previously excluded conventional feed (with higher concentrations of pesticides, herbicides, and fungicides) and still sell and label the meat, eggs, and dairy products as being "organic" [37]. A repeal of this recently passed measure (Feb. 2003) is currently underway [37]. Apparently, the Bush administration continues to reduce the regulations imposed upon GMO's [43].

If this were only *science* at work, we would have fewer qualms because we believe the truth would eventually emerge. Our fear is that the above stepping stones are the earmarks of heavy handed policy makers bulldozing things through in favor of GMO before all the facts are in.

5. Tentative Conclusions

Summarizing, a worry is that the U.S. may be at some risk from our own scientists with good intentions of feeding the masses more economically and improving health but, perhaps, with insufficient "checks and balances" in place. The breeding ground is so radically different from how things were done in the past (and therefore, perhaps, not yet thoroughly thought out because some aspects may yet reveal themselves as coming from far left field). The crosschecks previously in place were totally adequate only for the conventional slow evolutionary hybrid and chemical-based approaches rather than for the radically new genetically modified departures [29] even though the USDA and FDA heroically struggle to keep up with the GMO revolution in the U.S. The situation is aggravated by the lack of clear labeling to uniquely distinguish bio-engineered genetically modified food (offering consumers the option of selecting what they prefer even if it is more expensive). This apparent lack of adequate traceability is another prominent issue that is not yet being remedied and may mask or postpone deciphering of true underlying causes or obscure any "concrete evidence of harm" if problems do arise as a consequence of the consumption of some particular bio-engineered food. It only takes "one bad apple to ruin the barrel" so to speak. We are not condemning genetically modified food in general, but merely being cautious about possible mishaps because of apparently lax crosschecks previously or even currently in place and something detrimental perhaps slipping through in the future. Quoting Jane Rissler (Union of Concerned Scientist, previously with the FDA): "How would we know if someone had gotten ill from genetically engineered food if it's not labeled?" It makes many U.S. consumers uneasy that the U.S converted over to GMO food in relative secrecy over the course of the last six years. Another issue is that the FDA has now approved (in Oct. 2003) meat (and milk) from cloned animals to be sold in the U.S. without any distinguishing labeling. If there is in fact a problem that materializes later, no one will be able to identify the source.

These perceived risks and drawbacks were delineated here because the stakes are so high for GMO's in the long term so we should not continue to ignore these risks because some may turn out to be legitimate concerns (especially in the face of *Murphy's Law*, which continues to plague every other branch of engineering so genetic engineering being the only exemption isn't likely). Other engineering disciplines routinely employ factors of safety but none appear to be present in the GMO area. Although, as reported above, several legal cases have already been decided in favor of the environmentalists and in favor of those less enthusiastic about GMO's, the relatively low magnitude of the cash awards or fines from these class action lawsuits may be considered no deterrent at all but instead encourage "business as usual" for genetic engineering and genetic modification. (Many other Starlink court cases are still pending and Peter Resnik leads the de-

fense [30].) Moreover, from [3], it is revealed that there is no mandatory recall capability for the USDA or the FDA currently on the law books and that they must instead rely on the voluntary compliance of the manufacturers, where delays of several days routinely occur before USDA recall requests are honored and followed up on and the amount actually retrieved following the delay introduced is frequently less than 15% to 25% of the product in question. The manufacturing companies incur a loss only for what is actually retrieved in a recall and not for what has already been sold to the public. This definitely does appear to be "business as usual"!

A new development is that in response to a recent public outcry following the British Broadcasting Corporation's airing of what has been described as an anti-GMO propaganda-oriented drama, "Fields of Gold," on 8 and 9 June 2002 in the UK [31], the UK government decided to sponsor televised national debates on GMO food safety. While a public airing, where all the issues are laid on the table and discussed rationally instead of being swept under the rug, should be quite useful and reassuring to an uneasy public, the single round-table debate that did air in August 2002 pitted very glib GMO-advocates against anti-GMO extremists (one of whom was also against indoor toilets being in her home country, India, as being wasteful of scarce water resources) without even touching on any significant GMO issues-hardly a fair match-up. As of Sunday 6 October 2002 and into the future, we were told that occasional segments of "*NOW with Bill Moyers*"on PBS will be devoted to civil, balanced, on-going discussions on both sides of the issues relating to GMO's (but apparently only one such discussion has occurred in 2002-2003).

A recent occurrence is that in 2002, the Biotechnology Industry Organization urged its members to stop *biopharming* in the corn-belt states but to no avail [35]. In February 2003, the National Food Processors Association declared a zero-tolerance policy for Pharmaceutical crops, and the Grocery Manufacturers of America asked the government to **refrain** from issuing any more commercial permits for *biopharming* [35]. Further justification of these worries was provided by a study recently published [45] on the potential for unwanted environmental consequences arising from the hybridization of genetically modified (GM) crops with other nearby species and thus escaping intended confinement intended to be enforced by surrounding buffer zones. This aspect was examined as it affects nation-wide contamination (and not merely local contamination as in previous studies) and demonstrated that merely imposing isolation distances of as much as 3 km was still insufficient to prevent such nation-wide species contamination by GM pollen flow. In 2008, we continue to worry about the cause of the unexplained fairly large scale demise of standard pollinators: bees and bats.

Very thoughtful and reasonable precautions and guidelines were worked out and agreed upon by participating scientists in the 1960's and 70's for avoiding contamination of existing life on earth from outer space research and planetary/moon/asteroid/comet sample retrievals and, similarly, reasonable guidelines had been worked out in the 1980's for biological research along these same lines to avoid cross-contamination and possible ecological disasters. It was hoped that such precedents would be abided by today as scientists are now at the frontier of actually generating new life forms [46] (that may be so simple that such life forms are unintentionally devoid of natural vulnerabilities). Unfortunately, the early precedents appear to be entirely ignored in the exuberance of new discovery. The pros of [46] are claimed to be the possibility of developing microbes tailored to deal with pollution, with excess CO_2, or to meet future fuel needs. The obvious cons hinted at above appear to be ignored yet the 7,000 base man-made virus that was the outcome of [46] (funded by the US for $3 million) was tested to prove that it could in fact infect microbes as predicted. Naturally occurring viruses and microbes usually have genomes consisting of longer bases (with more opportunities for vulnerabilities). The polio virus genome was already synthesized by others last year but took 3 years to accomplish. J. Craig Venter's streamlining accomplishment of [46] makes it feasible to accurately obtain a 300,000 base genome

synthesis in a matter of weeks. It was decided that the novel synthesis procedure of [46] would be published in the open literature describing all aspects because potential terrorists would not exploit it (when they have other easier paths available). Was this a gentleman's agreement or merely a "hope and a prayer"?

Ref. [56] quotes Drew Endy, an MIT researcher who organized the recent Colligate Engineered Biology Competition, "and whose work in synthetic biology is written about in a fairly recent issue of *Wired* magazine, states that we want to engineer biology and make sure that plenty of people know how to do it. It's important to the future stability of society."

In the future, "if terrorists and biohackers are able to design their own dangerous strains of smallpox or Ebola," Drew "Endy thinks it's important to have well-trained forces of good capable of creating" countermeasures consisting of "biological machines to seek and destroy malicious viruses" set loose "on the world" [56], [69].

What may possibly be considered very counterproductive is attempting to win converts or win arguments by hurling insults or engaging in yelling contests (as resorted to by some technologist on both sides of each issue), by protests and demonstrations (as Green Peace is known to exploit on occasion), by violence or by threats of violence (as the Earth Liberation Front is known to resort to). Hopefully, we should all be able to discuss and even disagree without being disagreeable since the outcome affects us all. A recent *Scientific American* editorial [50] calls for a moratorium on the "war of words" regarding GM food and cites findings from the U.N. Food and Agriculture Organizations (FAO) recent report entitled "State of Food and Agriculture 2003-3004". The FAO report states that science has overwhelmingly determined that GM food already on the market poses no risk to human health (although multiple-gene transformations, now in development, need further study). The editorial claimed that 4 million small-scale cotton farmers in China switched to planting insect-resistant GM cotton and that they reaped 20% higher yields while using 78,000 fewer tons of pesticides and observed a drop in the annual death rate among farm workers from pesticide poisoning. While impressive, this claim from [50] and those for GM rice in [71] somewhat contradict what is said about China in [34] and ignores the follow-up Lab tank confirmation of hypothesized dangers posed by GM Salmon if they escape into the wild [49](a negative GMO aspect reported in the same issue of *Scientific American* for which [50] supposedly also included).

References

1. *Harvest of Fear,* a Frontline/NOVA series that aired on the Public Broadcasting System (PBS), 2001.
2. *Cracking the Code of Life-the race to decode human DNA*, Frontline/NOVA series on PBS, 2001.
3. *Modern Meat*, Frontline/NOVA series on PBS, 2002.
4. "AIDS seen spur to Africa famine," *Boston Globe*, p. A1, 7 Oct. 2002.
5. "MIT scientists develop way to catch evolution in the act," *Boston Globe*, p. A-3, 10 Oct. 2002.
6. "Cancer fear halts test of gene cure," *Boston Globe*, p. A16, 4 Oct. 2002.
7. "Panel urges changes in research on humans," *Boston Globe*, p. A1, 4 Oct. 2002.
8. "Gene Therapy a Suspect in Leukemia-like Disease," *Science*, Vol. 298, No. 5591, p. 34, 4 Oct. 2002.
9. "Retrovirus blamed for giving boy leukemia," *New Scientist*, Vol. 176, No. 2364, p. 5, 12 Oct. 2002.
10. "New drugs target nearly 200 diseases," *Boston Globe*, p. D7, 23 Oct. 2002.
11. "White House Advisor Tapped to Head FDA," *Science*, Vol. 298, No. 5591, pp.36-37, 4 Oct. 2002.
12. "Monkey Virus Link to Cancer Grows Stronger," *Science*, Vol. 296, No. 5590, pp. 1012-15, 10 May 2002.
13. "Panel urges U.S. to tighten approval of gene-altered crops," *New York Times*, p. A19, 22 Feb. 2002.
14. "Review of Crops Altered by Genetics are 'Superficial'," *Wall Street Journal*, p. B6, 21 Feb. 2002.
15. "Judge will approve settlement on use of Starlink corn," *Wall Street Journal*, p. A4, 21 Feb. 2002.
16. "Drug Makers' Influence Pondered Eye on US Advice," *Boston Globe*, p. A1, 31 May 2001.
17. "Doctor Ties Statin Drugs to Muscle Aches," *Boston Globe*, p. A5, 21 Sept. 2002.
18. "Doctors Report Inducing Growth of New Blood Vessels in Heart," *Boston Globe*, p. A1, 24 Feb. 1998.
19. "The body's repair shop: Cells growing in transplant spur hope of regeneration," *Boston Herald,* 14 Apr. 2002.

20. "Study Raises Doubts on Adult Stem Cells," *Boston Globe*, p. A2, 6 Sept. 2002.
21. "British Biotech Company Criticized Over Cloned Pigs," (British) *Financial Times*, p. 15, 4 Jan. 2002.
22. "Researchers discover prostate cancer gene," *Boston Globe*, p. A-2, 10 Oct. 2002.
23. "Gene trial advised despite illness," *Boston Globe*, p. A-3, 11 Oct. 2002.
24. "Weedkillers could wipe out malaria," *New Scientist*, Vol. 176, No. 2364, p. 17, 12 Oct. 2002.
25. "Darkside of the genome: Genetic blueprints can hinder as well as speedup medical research," *New Scientist*, Vol. 176, No. 2364, p. 3, 12 Oct. 2002.
26. "Agency wants to Stop Shopping for Best Deal," *Science*, Vol. 296, p. 1953, 14 Jun. 2002.
27. "Critics Say Drug Trials Often a Marketing Tool," *Boston Globe*, p. A-1, 25 Jun. 2002.
28. "Escaped Farm Salmon Raise Alarm in Maine," *Boston Globe*, p. A1, 23 Feb. 2001.
29. "Critics hit FDA monitoring revamp," *Boston Globe*, p. D1, 23 Oct. 2002.
30. "Biotech's warrior," *Boston Globe*, p. C1, 16 Oct. 2002.
31. "TV Drama Sparks Scientific Backlash," *Science*, Vol. 296, p. 1949, 14 Jun. 2002.
32. "FDA Halts Gene Therapy Studies," *Boston Globe*, p. A16, 15 Jan. 2003.
33. "Last of the Big-Time Spenders?," *Science*, Vol. 299, No. 5605, pp. 330-333, 17 Jan. 2003.
34. "China Takes a Bumpy Road From the Lab to the Field," *Science*, Vol. 298, No. 5602, pp. 2317-2319, 20 Dec. 2002.
35. "Corn-belt farmers find modified crops tough sell," *Boston Globe*, p. A2, 20 Feb. 2003.
36. "Monarch butterflies rebounding nobly," *Boston Globe*, p. A4, 22 Feb. 2003.
37. "Move afoot to repeal new rule on 'organic'," *Boston Globe*, p. A15, 28 Feb. 2003.
38. "E.U. Starts a Chemical Reaction," *Science*, Vol. 300, p. 405, 18 Apr. 2003.
39. "System may curb biotech crop's genes," Boston Globe, p. C4, 7 Apr. 2003.
40. Burke, J. M., Rieseberg, L. H., "Fitness Effects of Transgenic Disease Resistance in Sunflowers," *Science*, Vol. 300, No. 5623, p. 1250, 23 May 2003.
41. "Harvard may ease rules on faculty ties to drug firms," *Boston Globe*, p. A1, 8 Jun. 2003.
42. "Rapid Evolution can Foil Even the Best-Laid Plans," *Science*, Vol. 300, No. 5621, p. 895, 9 May 2003.
43. "FDA opposes more biotech food rules," *Boston Globe*, p. D4, 18 Jun. 2003.
44. "Science, Nature Journals eye tightening disclosure policies," *Boston Globe*, p. A3, 3 Sept. 2003.
45. Wilkinson, M. J., Elliott, L. J., et al, "Hybridization Between Brassica napus and B. rapa on a National Scale in the United Kingdom," *Science*, pp. 457-459, Vo. 302, No. 5644, 17 Oct. 2003.
46. "Venter Cooks up a Synthetic Genome in Record Time," *Science*, Vol. 302, No. 5649, pp. 1307, 21 Nov. 2003.
47. "NIH accused of conflict of interest," *Boston Globe*, p. A2, 8 Dec. 2003.
48. "New marrow brings hope for kidney recipients," *Boston Globe*, p. A1, 8 Jan. 2004.
49. "Salmon Versus Salmon," *Scientific American*, p. 28, Aug. 2004.
50. "The Green Gene Revolution," *Scientific American*, p. 8, Aug. 2004.
51. Science, Vol. 306, No. 5704, p. 2014, 17 Dec. 2004. (also see p. 2167 of 24 Dec. 2004 and p. 1305 of 21 Nov. 2003).
52. "Total Class of painkillers said to pose heart risks," *The Boston Globe*, p. D2, Tuesday, 18 Jan. 2005.
53. "A Sick Agency in Need of a cure," *U.S. News & World Report*, Vol. 137, No. 21, pp. 32-33, p. 36, 13 Dec. 2004.
54. "Looking for Some Trouble," *U.S. News & World Report*, Vol. 137, No. 21, p. 36, 13 Dec. 2004.
55. Bernadine Healy, "What is a 'Safe' Drug?", *U.S. News & World Report*, Vol. 137, No. 21, p. 37, 13 Dec. 2004.
56. Scott Kirshner@Large, "Collegians Engineering New Biology," *The Boston Globe*, pp. C-1, C-4, Mon., 24 Jan. 2005.
57. Henderson, D., "Pfizer Reveals Study Linking Celebrex to Heart Risks," *The Boston Globe*, p. A-1, Tues., 1 Feb. 2005.
58. Cook, G., "Heart Cells Discovery Raises Treatment Hopes," *The Boston Globe*, pp. A-1, A-18, 10 Feb. 2005.
59. Associated Press, "Study Links Painkiller to Cardiovascular Risks," *The Boston Globe*, p. F-4, 15 Feb. 2005.
60. Henderson, D., "FDA will Scrutinize Disputed Drugs," *The Boston Globe*, pp. F-1, F-4, 15 Feb. 2005.
61. Henderson, D., "FDA to Create Board to Monitor Drug Safety," *The Boston Globe*, pp. A-1, A-15, 16 Feb. 2005.
62. "Up & Down Wall Street," *Barron's*, p. 6, 21 Feb. 2005.
63. Globe Wire Services, "FDA Clears Graham to Present Findings: scientist feared agency reprisals," *The Boston Globe*, p. C-32, 17 Feb. 2005.
64. Kaufman, M., "FDA Panel Opens Door for Return of Vioxx," *The Washington Post*, p. A-1, 19 Feb. 2005.
65. Harris, G., "F.D.A. Official Admits 'Lapses' on Vioxx," *The New York Times*, p. A-16, 2 Mar. 2005.

66. Roland, C., “FDA Seeks More Authority to Dictate Drug Label Warnings,” *The Boston Globe*, p. C-1, p. C-5, 2 Mar. 2005.
67. Roland, C., “FDA Vows Tough Treatment for Drug Ads,” *The Boston Globe*, p. C-1, p. C-3, 4 Mar. 2005.
68. Enserink, M., “Experts Discuss Pig Flu Scare as Nonsense,” *Science*, Vol. 307, No. 5714, p. 1392, 4 Mar. 2005.
69. Enserink, M., Kaiser, J., “Has Biodefense [Spending] Gone Overboard?” *Science*, Vol. 307, No. 5714, pp. 1396-1398, 4 Mar. 2005.
70. Solomon, J., “Climate of Alarm Described at NIH,” *The Boston Globe*, p. A-2, 11 Apr. 2005.
71. Huang, J., Hu, R., Rozelle, S., Pray, C., “Insect-Resistant GM Rice in Farmers’ Fields,” Science, Vol. 308, No. 5722, pp. 688-690, 29 April 2005.