

## WHY RICH COUNTRIES DISLIKE AGRICULTURAL GMOS

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The application of genetic engineering to food and agriculture is unpopular in all rich countries, even among many consumers in the United States as well as Europe. Different regulatory systems have emerged in America (a permissive system) versus Europe (a highly precautionary system) but these regulatory differences mask an underlying similarity: most ordinary citizens on both sides of the Atlantic dislike genetically modified crops and will avoid GMO foods if given an easy means of doing so. Here we explain the origins of this important underlying pattern of rich country dislike for GMO foods and crops, learning that new risks to human health or to the environment are not the explanation, since no such risks have yet been documented. Nor is a dislike of genetic engineering the explanation, since the same citizens who dislike GMOs in agriculture welcome GMOs in medicine. The comparison to GMO medical drugs also suggests that it is not a popular dislike of multinational corporations, or of their private patenting of science, or of the high cost of their products, or even of their corrupting influence over regulators that explains why rich societies dislike GMO foods and crops, since all of these disagreeable elements are also present in the case of GMO drugs, and we do not reject those.

From a social acceptance perspective, there are two dimensions along which GMO crops and foods differ significantly from GMO drugs: environmental release and

involuntary consumption. GMO crops grow in the open environment while recombinant GMO drugs are produced under strict containment in medical laboratories. GMO foods are also sold into commercial food markets often without segregation or labeling, whereas GMO drugs are strictly segregated, labeled, and individually prescribed by trusted physicians. Both these factors emerge as more plausible explanations for why citizens in rich countries like GMO drugs but not GMO foods and crops. Yet the single best explanation is not linked in any way to risk, cost, or even control over exposure. The best explanation for why rich countries dislike GMO foods and crops is the absence for most citizens of a direct and noticeable benefit.

The first generation of GMO foods and crops on the market provided significant cost savings for farmers and profits for seed companies and patent holders, but in today's wealthy post-agricultural (indeed, post-industrial) societies these beneficiary groups are numerically small. Only 2-5 percent of citizens in rich countries work today in any kind of farming. For the 99 percent or more of citizens in rich countries who did not plant the corn, soybean, or cotton crops that had been genetically modified (or sell the seeds of these crops, or own the patents on those seeds), these first applications of genetic engineering to agriculture provided essentially no tangible benefit. Recombinant GMO drugs, in sharp contrast, provided potential lifesaving benefits to citizens from every demographic category. It is not risk or cost or uncontrolled exposure that drives citizen perception of GMO science in rich countries, but instead a calculation of likely benefits.

*Citizen opinion toward GMO foods and crops in rich countries*

The United States and Europe have made different regulatory choices toward GMO foods and crops, yet on both sides of the Atlantic most ordinary citizens tend to dislike this new technology. Ordinary Americans are not known for refined taste or high standards when it comes to food, yet when asked about eating genetically modified foods a plurality say they would rather not. In response to a Pew Initiative survey in 2005, half of a representative sample of Americans said they would oppose the introduction of genetically modified foods into the US food supply, with 33 percent saying they would oppose strongly. (Pew Initiative 2005) This is a response that reveals considerable ignorance along with opposition, since food products with GMO ingredients (mostly corn and soy ingredients) have of course been pervasive in American supermarkets since 1996.

As of 2006 an estimated 61 percent of all corn grown in the United States and 89 percent of all soybeans were GMO varieties. In the United States these GMO crops have always been marketed and processed with no mandatory segregation from conventional corn and soybeans, and as a result roughly 70 percent of all supermarket products in the United States have at least some GMO content. The only Americans today not consuming at least some GMO foods are the tiny minority who are consumers *exclusively* of organically grown foods. Yet the Pew survey found that in 2005 only 25 percent of U.S. respondents believed they had ever eaten genetically modified foods. An earlier 2005 survey by the International Food Information Council found only one third of consumers in the United States were aware that GMO foods were being sold in stores. (IFIC 2005)

One reason for this consumer ignorance in the United States is the absence of GMO labeling requirements. The Federal Food and Drug Administration (FDA) holds to

a view that labeling of GMO foods should only be mandatory if they are shown to differ significantly in composition from their conventional counterparts in some way that might pose a risk to the consumer – such as through the presence of an allergen, a changed level of a major dietary nutrient, an increased level of toxins, or a change in the expected storage or preparation characteristics of the food. (Miller and Conko 2004) So far, none of the GMO foods on the market has been shown to differ enough from the conventional counterparts to require such added labeling. Yet when Americans are asked directly if they would like to see all GMO foods labeled, 94 percent say yes. (Hallman, et al. 2003) Lawsuits and lobbying by consumer advocate groups have so far failed to force a change in FDA's position, so GMO foods continue to appear on store shelves in the United States unlabeled. In the European Union labeling became mandatory in 1997, but by then most retail stores had already decided voluntarily not to stock any GMO products so as to avoid criticisms or boycott campaigns from activists. Labeling outcomes in Europe and the United States are thus quite different, but with neither measuring up to an ideal of “informed choice.” In the United States consumers have a choice between GMO and non-GMO but no information, while in Europe consumers are guaranteed information but there is no choice since only non-GMO products can be found on the shelf.

When American consumers are questioned directly about GMO foods the responses are surprisingly negative. A 2003 survey done by the Food Policy Institute at Rutgers found that fewer than half (45 percent) of Americans felt it was safe to consume GMOs, while more than half (54 percent) felt that “GM food threatens the natural order of things,” and 62 percent felt that “serious accidents involving GM foods are bound to happen.”(Hallman, et al., 2003) Two thirds of all Americans assert they would oppose

importing GMO foods into the country (a surprising view from residents of the world's largest producer and exporter of GMOs). (Pew Initiative 2005) A 2006 Cornell University survey found that trust in agricultural biotechnology in the United States was not only low but actually declining between 2003-05. (Peterson 2006)

Food companies and fast-food franchises in America have sensed that consumers might turn away from any foods known to be GMOs and have therefore been shy about using them. Genetically engineered potatoes resistant to viruses and beetle's were successfully planted in the United States between 1995 and 1999, but fast food chains such as McDonald's and Burger King and food companies such as McCain's and Pringles decided to play it safe and began demanding from processors only GMO-free potatoes for their French fries. Potato processors then began contracting with farmers only for non-GMO potatoes, and eventually in 2001 the Monsanto Company voluntarily withdrew its GMO NewLeaf potatoes from the market. Similarly in 2000, Pepsico's Frito-Lay company decided to require GMO-free corn from its contract growers for the manufacturing its snack products. Del Monte and other food companies have rejected GMO sweet corn. GMO popcorn has been approved for consumption by regulators in the United States, but U.S. popcorn manufacturers have decided voluntarily not to use it, fearing consumer resistance. (CFS 2006)

Citizen dislike of GMO foods is stronger in Europe than in the United States, but not by any order of magnitude. A comparative survey of attitudes in 2001 found the ratio of Americans who said they "supported" the use of biotechnology in crop production versus those that did not was essentially balanced, with 32 percent in support versus 31 percent opposed, the rest saying they did not know. When the same survey was

administered in the UK, the balance between supporters and opponents in the UK was 38 percent in support versus 46 percent opposed, less favorable than in the United States but not dramatically so. (Moon and Balasubramanian 2001)

Beyond rich countries, citizen opinion about agricultural GMOs tends to be somewhat less hostile. In 2000 an internationally comparable opinion survey asked 35,000 respondents in 35 different countries if they agreed with the (admittedly complex) statement, “The benefits of using biotechnology to create genetically modified food crops that do not require chemical pesticides are greater than the risk.” Only 22 percent of citizens in France and Greece said they agreed, and only one third of Japanese respondents agreed the benefits exceeded the risks, but in China and India the level of citizen agreement with this statement was higher than the level in the United States (65 percent) and citizen approval of GMOs was actually highest in Cuba (79 percent) and Indonesia (81 percent). (Hoban 2004) A 2006 study by the global market research company Synovate found that, among consumers who were aware of GMOs, 89 percent of Greeks believed they may be harmful, yet only one third of citizens in South Africa felt the same way. (Marketing Web 2006) Citizens in poor countries who have less reason to be satisfied with the status quo should logically be more open to the use of new technologies, yet we shall see that most governments in Africa, at least, have not followed this more flexible tendency in local citizen opinion.

Citizen views toward GMOs can of course differ dramatically person-by-person and state-by-state. In the United States disapproval is strongest among people over 64, among women, and among people with low levels of education. An identical pattern emerges in Europe. (Gaskell, et al. 2000) Americans with post-graduate degrees are

among those most likely to approve of GMOs. Approval also correlates with high income, but not independent from educational attainment. Different eating preferences are of course also a key variable. Americans who have adopted restrictive dietary practices (vegetarian, vegan, Kosher) and those who say they favor “natural” or “healthful” or “organic” foods are among those most likely to oppose GMOs. (Hallman, et al., 2003) In some cases, citizen opposition to GMOs in the United States has been strong enough to dictate local political outcomes. In 2004 when an organization of organic farmers championed a ballot initiative in California’s Mendocino County to ban genetically engineered crops and animals from the county, the measure passed by a margin of 56 percent to 44 percent. By 2006, three other California counties – Marin, Santa Cruz, and Trinity – had adopted similar measures.

Social skepticism about GMO foods and crops in America has been strong enough in recent years to slow approvals of new products by government regulators. During the first five years of the GMO era, from 1995-1999, a total of 47 new GMO crops were reviewed by FDA, EPA, and APHIS (Animal and Plant Health Inspection Service, at USDA) and granted de-regulated status. No subsequent damage to human health or the environment from any of these approved products was ever documented, yet during the second five years of the GMO era, from 2000-2004, the number of new GMO crops completing the FDA review process fell from 47 down to just 15, and by the end of 2004 only 13 of these had been commercialized. During this second five-year period caution was indicated by the fact that the only new GMO varieties commercialized were crops that had been previously commercialized in a GMO form (corn, cotton, canola, sugar beet) with transgenes either identical or similar to those already approved. Also,

regulators had begun taking twice as much time, on average, to reach their decisions. (Jaffe 2005, 2006) Even in America, then, agricultural GMOs have remained under a cloud of latent but widespread citizen suspicion, and the technology has encountered escalating regulatory caution.

*Citizen skepticism despite no evidence of new risks*

Explaining this pattern of citizen skepticism and regulatory caution toward GMOs in all in rich countries is a challenge, given the absence so far of any scientific evidence of new risks from the technology. Risk is conventionally defined as the probability (high or low) of an unwanted event. Citizen opposition to GMO foods and crops is often expressed in terms of risk avoidance, but the presence of new risks has yet to be detected and documented by scientific authorities. In both Europe and the United States scientific authorities have repeatedly asserted there is not yet any credible evidence of new risks to human health or the environment from any of the GMO foods or crops approved by regulators and placed on the market so far.

In Europe this finding by scientists was first summarized in 1999, when Britain's Nuffield Council on Bioethics published a report stating, "We have not been able to find any evidence of harm. We are satisfied that all products currently on the market have been rigorously screened by the regulatory authorities, that they continue to be monitored, and that no evidence of harm has been detected." (Nuffield Council 1999, pp. 126-127). Experts at the European Union (EU) drew the same judgment two years later in 2001, when the Research Directorate General of the EU released a summary of 81 separate scientific studies conducted over a 15 year period (all financed by the EU rather

than private industry) aimed at determining whether GM products were unsafe, insufficiently tested, or under-regulated. (Kessler and Economidis, eds. 2001) The EU Research Directorate concluded from this study, “Research on GM plants and derived products so far developed and marketed, following usual risk assessment procedures, has not shown any new risks on human health or the environment...” (EU Research Directorate 2001).

National academies of science in Europe began drawing this same conclusion one year later. In December 2002, the French Academy of Sciences stated that “all the criticisms against GMOs can be set aside based for the most part on strictly scientific criteria.” (French Academy of Sciences 2002, p. xxxviii) At the same time the French Academy of Medicine announced it had found no evidence of health problems in the countries where GMOs had been widely eaten for several years. (French Academy of Medicine 2002) In the UK in May 2003, the Royal Society presented to a government-sponsored review two submissions that found no credible evidence GM foods were more harmful than non-GM foods, and the Vice-President and Biological Secretary of the Royal Society, Professor Patrick Bateson, expressed irritation at the undocumented assertions of risk that continued to come from anti-GMO advocates: “We conducted a major review of the evidence about GM plants and human health last year, and we have not seen any evidence since then that changes our original conclusions. If credible evidence does exist that GM foods are more harmful to people than non-GM foods, we should like to know why it has not been made public.” (Royal Society 2003) In March 2004, the British Medical Association (BMA) which had earlier withheld judgment endorsed these Royal Society conclusions. (BMA 2004) In September 2004, the Union

of the German Academies of Science and Humanities produced a report which concluded, "...according to present scientific knowledge it is most unlikely that the consumption of the well characterized transgenic DNA from approved GMO food harbours any recognizable health risk."(Helt 2004, p. 4) This report added that food from insect resistant GMO maize was probably healthier than from non-GMO maize due to lower average levels of the fungal toxins that insect damage can cause.

A strong consensus also emerged at the global scientific level that no new risks had been linked to any of the GMO crops and foods to have reached the market so far. In March 2000, the Organization for Economic Cooperation and Development (OECD) in Paris organized a conference with 400 expert participants from a variety of backgrounds. These experts announced their agreement that "No peer-reviewed scientific article has yet appeared which reports adverse effects on human health as a consequence of eating GM food."(OECD 2000, p. 2) In August 2002, the Director-General of the World Health Organization (WHO) endorsed consumption of GMO foods, saying, "WHO is not aware of scientifically documented cases in which the consumption of these foods has negative human health effects. These foods may therefore be eaten."(Mantell 2002).

Some who accept that GMO foods are probably safe to eat still question their safety for other living things in the biological environment – their "biosafety." Since all farming disturbs and changes nature, it is difficult here to agree on what standard of non-disturbance should be considered acceptable. If planting a GMO variety of beet or rapeseed helps farmers control weeds in the field (compared to conventional beet or rapeseed) and if as a result there are more insects in the farm field (using the weeds for food and shelter) and fewer weed seeds for some farmland birds to eat, is this a troubling

disturbance of nature? Only by taking the extreme view that diversity of life should be protected *in a farm field* can we view this as a problem.

Using more conventional definitions of biosafety, the GMO crops currently on the market have apparently not disturbed nature more than conventional crops. A 2003 study conducted by scientists from New Zealand and the Netherlands published in *The Plant Journal* examined data collected worldwide up to that time, and the authors concluded from this data that the GMO crops approved so far had been no more likely to worsen weed problems than conventional crops, no more invasive or persistent, and no more likely to lead to gene transfer. There was no evidence that GMO crops had transferred to other organisms (including weeds) new advantages such as resistance to pests or diseases or tolerance to environmental stress. (Connor, Glare and Nap 2003) Later in 2003 the International Council for Science (ICSU) examined the findings of roughly 50 different scientific studies that had been published in 2002-03 and concluded, “[T]here is no evidence of any deleterious environmental effects having occurred from the trait/species combinations currently available.” (International Council for Science 2003, p. 3) In May 2004, the United Nations Food and Agriculture Organization (FAO) issued a 106 page report summarizing evidence that, “[T]o date, no verifiable untoward toxic or nutritionally deleterious effects resulting from the consumption of foods derived from genetically modified foods have been discovered anywhere in the world.” On the matter of environmental safety, this FAO report found the environmental effects of the GM crops approved so far, including effects such as gene transfer to other crops and wild relatives, weediness, and unintended adverse effects on nontarget species (such as butterflies), had been similar to those that already existing from conventional agricultural

crops. (FAO 2004) Finally in 2007, a study done for the journal *Advanced Biochemical Engineering/Biotechnology* surveyed ten years of research published in peer-reviewed scientific journals, scientific books, reports from regions with extensive GM cultivation, and reports from international governmental organizations and found that, “The data available so far provide no scientific evidence that the cultivation of the presently commercialized GM crops has caused environmental harm.” (Sanvido, Romeis, and Bigler 2007)

A scientific consensus even exists that the GMO crops on the market so far are producing measurable benefits for the natural environment, due primarily to their ability to thrive with reduced sprayings of toxic chemicals and in some cases with reduced soil tillage. Country studies of cotton production in Australia, China, South Africa and the United States have shown reductions in insecticide spraying of 40 to 60 percent for GMO cotton compared to conventional cotton crops (International Council for Science 2003). Reduced spraying of insecticide means less pollution of ground water and surface water and also less damage to non-target species such as the beneficial insects that live in and around the farm field. According to one 2005 calculation, the planting of GMO crops up to that point had made possible a global reduction of 15 percent in the total volume of insecticides applied to cotton since 1996, and a reduction of 4 percent in the total volume of herbicides used on soybeans. (Brookes and Barfoot 2005) Herbicide tolerant GMO soybeans can be grown not only with fewer, less toxic, and less persistent herbicide sprays, but also with less soil tillage, a factor that reduces erosion and the siltation of water bodies downstream. (International Council for Science 2003) GMOs even help cut greenhouse gas emissions by reducing the burning of diesel fuel linked to lower

mechanical tillage requirements and a less frequent need for field applications of herbicides and insecticides. The adoption of “no till” and “reduced till” weed control systems (made possible with herbicide tolerant GMO crops) has also been an environmental benefit in the form of less soil erosion and more carbon sequestration. Over the period 1996-2004 a cumulative reduction in fuel use equal to 4.9 billion kg of carbon dioxide was made possible by farmers switching – mostly in North and South America – to GMO crops. In 2004, an additional 9.4 million kg of carbon dioxide was sequestered in the soil, thanks to reduced tillage made possible by GMO crops. (Brookes and Barfoot 2005)

It is quite unusual for any powerful new technology to deliver so many measurable benefits during its first dozen years of commercial use with no documented evidence of any new harms or risks. Try to imagine the first dozen years of organ transplantation without anyone dying on the table, or the first dozen years of commercial aviation without a single plane crash. Skeptics try to deny this safety record by saying “absence of evidence is not the same thing as evidence of absence.” It may not be *proof* of absence (proving any negative is an impossible requirement) but it is in fact *evidence* of absence. If you look for new risks for a dozen years and fail to find any, that surely counts as evidence of something. Skeptics who hold out against GMOs because the *nth* year of exposure to *nth* hypothetical risk has not yet been tested for are judging the technology by an impossible standard. If employed consistently, such a standard would oblige us to reject every new technology that appears, and in fact every old technology as well.

Some critics try to argue that the strong GMO safety record to date reflects not any inherent safety in technology but instead the success of their highly precautionary regulatory approach. In one famous case, when the Pioneer Hi-Bred company inserted a Brazil-nut gene into a soybean plant hoping to improve the nutrient quality of soybeans for animals, the United States Food and Drug Administration (FDA) worried about some of the beans leaking into the human food supply and advised allergenicity tests on human subjects. When these tests revealed that a Brazil-nut allergen had been transferred to the new GMO soy, Pioneer discontinued product development and this potentially dangerous product never reached the market. (Nordlee, et al. 1996)

In this case, however, a possibly dangerous application of the technology was caught in time not by highly precautionary regulators in Europe but instead by regulators in the United States, where the standard is not a highly precautionary one. GMO technologies in the United States have always been regulated in much the same way that conventional food and crop technologies are regulated. In fact, most of the GMO technologies currently on the market have been put there by relatively lax American regulators rather than precautionary European regulators, yet the safety of the technology appears not to have been compromised. Up to November 2006 regulators in the U.S. had approved 77 different crops, compared to just 27 in Europe, yet despite this larger number of more permissive American approvals the unblemished safety record has remained intact.

So long as genetic engineering is applied to the improvement of domesticated agricultural crop plants, a significant measure of safety to the larger biological environment is likely to be maintained. Even when they have been engineered to carry

new genes, GMOs crop plants are still domesticated plant species that will not be well suited to competing in the wild. Consider what would happen to all of the seemingly robust corn, soybean, and cotton plants currently filling farm fields in the United States if all human interventions were suddenly taken away. Within a season these fields would be smothered by invasive wild plant species with much greater competitive fitness because they have evolved not dependent on the weeding, watering, and insect control interventions provided by farmers. While farm fields tend to fill up with weeds if humans do not intervene, observe that untended wild fields and woodlands do not tend to fill up with farm crops. The “genetic contamination of nature” by domesticated crop species is thus an exaggerated fear. Even if genes from a GMO farm plant were to outcross with a hardier wild relative of the plant, the progeny of the cross would almost certainly be less competitive in the wild because it would be inheriting a large set of thoroughly domesticated crop genes along with any advantageous transgenes that might come through. Domesticated agricultural plants seldom become bioinvasive; the greatest risks are from exotic wild plant species such as leafy spurge (introduced from abroad into grazing pastures in America), or from animal species such as Asian long-horned beetles (that destroy trees) or Zebra mussels (that clog water intake pipes).

Measuring the *inherent* safety of genetic engineering, or of any other crop science technique, is conceptually problematic. Conventional risk assessment considers hazards only on a case-by-case basis, and only when a technologies is being used as its developer intended. For example, conventional risk assessment does not try to judge the inherent safety of electrical power; it only rates the safety of a specific electric power cable or battery when used in the intended manner. Electrical cables that are unsafe when

plugged into the wrong power source can still be rated as safe in their intended use. Still, efforts have been made to rate the inherent safety of genetic engineering in farming. In 2004 the U.S. National Academy of Sciences estimated the inherent potential for different genetic manipulation techniques to introduce unintended effects at the crop development stage. This study concluded the crop improvement technique most likely to produce such unintended effects was mutation breeding (a technique called mutagenesis), not genetic engineering. This report then went on to note that even conventionally bred crops can produce unintended and harmful effects such as high levels of natural toxins. The NAS study pointed to past problems with various non-GMO tomatoes, potatoes, and celery varieties that had to be withdrawn from the market because of elevated levels of natural toxins. (NAS 2004)

#### *Absence of consumer benefit*

Citizens in rich countries dislike GMO foods and crops not because these products carry new risks but instead because they so far have provided consumers with no new benefit. The first generation of genetically engineered crops released to the market in 1995-96 was designed to provide benefits primarily to crop producers rather than food consumers. The new genetic traits engineered into these crops allowed farmers to control insects and weeds with fewer and less toxic chemical sprays and with less soil tillage, all of which reduced on-farm chemical input costs, fuel costs, and labor costs. The private biotechnology companies that developed this first generation of GMO crops, led by the Monsanto Company in St. Louis, saw seed-buying commercial farmers as their first customers so they developed seed technologies with the needs of these farmers

uppermost in mind. As for the final food consumer at the end of the marketing chain, the companies assumed an absence of specific new benefits would not be a problem. As long as the new GMO seeds resulted in products that didn't cost any more, look any different, taste any different, prepare any different, or deliver any different nutrient properties, and as long as they measured up to the existing food and environmental safety standards, consumers should be willing to accept them. Bad guess.

When GMO seeds first went onto the market in 1996, farmers immediately noticed and appreciated the production cost reductions and began taking them up quickly, particularly in the United States where the adoption rate for GMO soybeans exceeded even the high rate of adoption half a century earlier for hybrid maize. GMO cotton and GMO maize spread nearly as fast. The gains farmers realized from these technologies were substantial. By one calculation, soybean farmers in the United States saved from \$25 to \$78 per hectare by switching to GMO herbicide tolerant soybeans, even after the higher seed purchase costs were taken into account. Farmers who switched to GMO insect resistant corn reduced production costs by \$5 to \$9 per hectare, even with the higher seed costs factored in, and in addition they enjoyed an average yield increase of 5 percent. Farmers switching to GMO insect resistant cotton saw their profitability level increase by \$53 to \$116 per hectare. The cumulative net farm income benefit in the United States between 1996 and 2004 was subsequently estimated at \$10.7 billion. (Brookes and Barfoot 2005) By 2006, farmers in the United States were using GMO varieties on 89 percent of their acreage planted to soybeans, on 83 percent of their acreage planted to cotton, and on 61 percent of their acreage planted to corn. (USDA 2006)

Farmers were not the only beneficiaries, comparable commercial gains were made by the private companies that sold the GMO seeds plus the innovators that licensed their patented technology. For GMO cotton and soybeans, the gains captured by farmers represented 59 percent and 20 percent of the total economic surplus respectively, while the patent-holding innovator, the Monsanto Company, took in 21 percent of the total surplus generated by GMO cotton and 45 percent of the surplus generated by GMO soybean. Economic gains made downstream from farms by commodity purchasers in the food and fiber industry were substantially smaller. In the United States downstream purchasers capture only 9 percent of the economic surplus generated by GMO cotton, and only about 10 percent of the surplus generated from GMO soybeans. (Falck-Zapeda, et al. 2000)

This lack of significant downstream benefits was critical. By the time these new products reached ordinary citizens at the end of the marketing chain, nearly all the economic surplus they had generated had been captured by someone else, and as for non-economic benefits, there weren't any. The first generation of GMO soy and corn products looked, tasted, prepared, and nourished no better than conventional soy and corn. The resulting absence of a direct and discernable consumer benefit made it easy for the critics of the technology to sway citizens in rich countries against it, and in today's rich countries consumer opinion is sovereign. The downstream consumer is always right. Farmers are not going to defend GMOs – or plant them – once processors, wholesalers, retailers, and consumers begin avoiding them. As for the seed companies, they were not going to defend something farmers wouldn't buy. This has left only the heavily invested technology innovators, such as the Monsanto Company, defending GMO foods and crops

in the end. Monsanto in particular was poorly cast for this role; when it became the world's leading purveyor of GMO crops in the 1990s, its public reputation in the industrial world was still recovering from having earlier supplied American military forces in Vietnam with a dioxin-contaminated chemical herbicide named "Agent Orange."

Survey research has confirmed the salience to consumers of benefits over risks. Only when the use of a genetic technology confers no added benefit will public attitudes tend to be strongly influenced by secondary concerns like views toward the company supplying the technology, views toward the scientists who developed it, or views toward the government regulators who approved it. (Hossain, et al. 2003) Surveys also show that even in Europe, where sensitivity to perceived risk is high, consumers will still tend to allow the presence or absence of a benefit to dominate their final judgment. (Gaskell, et al. 2004) The easiest way to demonstrate the truth of this proposition is to compare GMOs in agriculture to GMOs in medicine.

### *Rich countries welcome GMOs in medicine*

Genetic engineering has been widely used in commercial medicine since 1982, when FDA approved the first "bioengineered" drug, a recombinant form of human insulin. This drug was created by inserting the appropriate human gene into a bacterium, which then manufactured insulin as it grew, a vast improvement over the previous method of deriving insulin from beef or pork pancreatic tissue at much greater expense. The first recombinant vaccine, approved in 1986, was produced by engineering a gene from hepatitis B virus into yeast. Valuable therapeutic proteins are now routinely

manufactured from genetically engineered versions of living bacteria, yeast, or cultured mammalian cells. Genetically engineered cells from the ovaries of Chinese hamsters (known as CHO cells) are a favorite for recombinant drug production.

In the United States more than 130 recombinant drugs and vaccines have now been approved by FDA, and in contrast to agricultural GMOs the pace of new approvals has been speeding up rather than slowing down, with more than 70 percent of all FDA approvals coming in the past six years. (Clearant 2006) In the EU a total of 87 recombinant therapeutic proteins have been approved by the European Medicines Agency (EMA) with 60 percent of all approvals coming in the past six years. (EMA 2006) Approximately one quarter of all new drugs coming on the market today are recombinants produced using GMOs and the boom in GMO medical drugs is likely to continue. In 2006 a New York based market research company, Kalorama Information, projected that transgenically produced biopharmaceutical drug sales would increase by 140 percent in the coming six years, to reach \$12 billion by 2012. (*AgraFood Biotech* 2006)

The widespread use of GMOs to produce medical drugs generates little or no social or political controversy in rich countries. Surveys confirm ordinary citizens support the use of modern biotechnology significantly more in medicine than in agriculture. According to one weighted survey study, in Europe modern biotechnology in medicine was supported by 59.3 percent of the population, versus a smaller 33.7 percent who support modern biotechnology in food. In the United States, according to this same study, 77.9 percent supported biotechnology in medicine compared to 57.7 percent who supported it in food. (Priest, et al. 2003) Broad citizen support for GMOs in medicine

developed early in Europe and was little affected during the second half of the 1990s by the controversy over GMOs in food and agriculture. According to one survey of European citizens who had well-formed attitudes, support for GMO foods fell from 61 percent down to 47 percent between 1996 and 1999, but during the same period support for GMO medicines remained strong, falling only slightly from 91 percent down to 87 percent. (Gaskell et al. 2000)

This divergence in social support for medical versus agricultural GMOs confirms that it is not the practice of genetic engineering that citizens in rich countries find objectionable but instead the purpose to which this science is being applied. When applied for the purpose of improving human health it is strongly supported by citizens in rich countries, but when applied for the purpose of increasing the productivity of farming it is supported far less. Such preferences make perfect utilitarian sense in rich countries where more agricultural productivity is scarcely needed, in contrast to needs – or at least desires – for constantly improving health outcomes and longevity.

The divergent social response to GMOs in medicine versus agriculture tells us other things as well. Just as we cannot blame this divergence on the presence or absence of GMOs, neither can we blame it on public fears or misunderstandings of science, or on the role of multinational corporations in creating and delivering the products, or on the patent claims made by those companies, or on the high product costs that result from those patent claims, or even the suspect competence of the regulatory authorities that approve the products – because all these factors are visibly present in the case of recombinant medical drugs no less than in the case of genetically engineered foods and crops.

*Public fears of poorly understood science?*

The basic rDNA techniques that lie at the foundation of both GMO drugs and crops are equally misunderstood by nearly all citizens in rich countries, few of whom have any training in modern molecular biology. Because the underlying science for both applications is the same, and because public understanding in both cases is equally low, differences in technology acceptance cannot be explained using science comprehension as a variable.

Despite the greater salience of GMO food issues in Europe, the science of genetic engineering is understood there even less well than in the United States. A Eurobarometer survey technique first developed in the EU employs a set of eleven true/false questions to test public understanding of GMO science in foods and crops, and the average score for Americans is 64 percent correct, versus just 52 percent correct in the EU. The questions are of the most elementary nature, yet just 57 percent of American citizens appear to be aware that “ordinary tomatoes contain genes.” In Europe an even lower 36 percent of respondents got this simple question right, and most Europeans believe erroneously that a person’s own genes can be modified from eating GMO food. (Hallman, et al. 2003, Gaskell, et al. 2003) Yet it is not this slightly weaker comprehension of the science in Europe that explains Europe’s weaker acceptance of GMOs foods and crops compared to GMOs in medicine, since the science of both is equally incomprehensible to consumers. Moreover, Claire Marris, a sociologist of science at the French National Institute for Agronomy Research, has been able to show that most ordinary citizens in Europe fully acknowledge their lack of comprehension in

this area and do use issues related to the science as the basis for their opinions one way or another. (Marris 2001)

*Mistrust of globalization or of multinational corporations?*

Explaining citizen reactions to GMO crops as a possible backlash against corporate power and globalization is equally difficult, since the market for GMO drugs is just as globalized and corporate-led as the market for GMO crop seeds, and since social mistrust of multinational drug companies is just as widespread as social mistrust of biotech seed companies. Multinational drug companies can get away with being mistrusted because they deliver products with benefits valued by large numbers of citizens, whereas multinational seed companies do not. Large drug companies are often their own worst enemy in the public perceptions department. In 2001, in what the *Guardian* newspaper described as “one of the great corporate PR disasters of all time,” a collection of 39 pharmaceutical companies filed a heavy-handed lawsuit against the Government of South Africa in an effort to protect patent claims on HIV/AIDS drugs. The resulting public outrage forced the companies to withdraw the suit, but not before the companies had made themselves the world’s new Pariah du Jour. Drug companies are now often used in popular culture as iconic global villains, as with John Le Carre’s 2000 novel *The Constant Gardener* premised on the illegal actions of a greed-driven drug company in Africa. Mistrust of the drug companies does not, however, spill over into a mistrust of the drug products, because the tangible benefits are valued by so many. In fact, the most frequent complaint against these companies is that they are not making their products available early enough or cheap enough to a wide enough pool of beneficiaries.

### *High Product Cost?*

The low popularity of GMO crops in rich countries also cannot be blamed on the fact that these products are costly and protected by patents, since the same obviously goes for GMO drugs. Cerezyme, an intravenous recombinant treatment (not a cure) for Gaucher disease developed by Genzyme costs \$200,000 *per year* for the average patient. The company actually keeps a separate staff of 34 professionals working full time to help patients find insurance plans able to pay these outlandish costs. The total value of all prescription drug purchases in the United States tripled between 1980 and 2000 to reach approximately \$200 billion per year, yet these costs are paid without lasting resentment toward the companies – because of the valued benefits. In contrast, because there is no broad social benefit from GMO foods and crops in rich countries, the profits made by Monsanto from selling this technology comes to be seen as unforgivable.

### *Mistrust of government regulators?*

Nor can the greater social acceptance of medical versus agricultural GMOs in rich countries be attributed to factors such as mistrust of government in general or of government regulators in particular. Surveys do show that citizen fears about food safety will be highest in those countries where political institutions are trusted the least, yet this finding applies to fears about all foods, not specifically GMO foods. (Kjaernes, Dulsrud, and Poppe 2006) Moreover, this finding fails to explain the continuing support given to GMO medicines even in low-trust countries. Survey research in Europe has yet

to find any strong link between broad trust in government and a specific comfort or discomfort level with agricultural GMOs. (Bocker and Nocella 2005)

Regarding the more narrow issue of untrustworthy governmental regulators, we have seen that mistrust in Europe of food safety regulators following 1996 BSE scandal spilled over to make citizens wary of newly approved GMO crops. Yet this wariness never spilled over to affect citizen attitudes toward GMO drugs, even though drug regulators in Europe have had a dodgy track record for caution. By 1999 only 47 percent of citizens in Europe supported biotechnology in food, but 87 percent still supported it in drugs. (Gaskell et al. 2000) Drug regulators in Europe have had a spotty record going all the way back to the hasty approvals given for the German drug thalidomide in the 1950s, a drug never approved in the United States, yet consumers show little fear. Europeans are so forgiving of lax drug regulations that by 1999 they were citing the thalidomide case as a *positive* example of regulators being able to withdraw a product once it demonstrated a harmful effect. (Marris 2001)

The current willingness of Europeans to trust GMO drug regulators more than GMO food regulators, no matter what, finds expression in an informal color code. Drugs made with rDNA have come to be referred to as “red” biotechnologies, distinguished from foods and crops developed with exactly the same science that have come to be called “green” biotechnologies. (Bauer 2005) This arbitrary distinction makes it easier to impose stifling regulations on the GMO crops that people don’t like without having to block development of the GMO drugs they do like. (Falkner 2006)

In the United States GMO medicines are trusted more than GMO crops even though both are regulated under the same relatively permissive “Coordinated Framework

for the Regulation of Biotechnology,” created in 1986 by President Ronald Reagan’s Office of Science and Technology Policy (OSTP). Under the guidelines of this framework, new products developed using genetic engineering – including drugs, foods, pesticides, and crops – would not be treated differently, for regulatory purposes, from new products conventionally developed. (Jasanoff 2005) In the United States, as a result, both medical and agricultural GMOs have been regulated under the same statutes earlier used to regulate conventional foods and drugs. GMO foods do get closer regulatory scrutiny from FDA than conventional foods, but through mechanisms that remain largely voluntary.

If regulatory stringency were the key to citizen trust, GMO foods and crops would be trusted far more in Europe today than in the United States, but instead it is the other way around. Europe, from the start, regulated agricultural GMOs with a separate set of more stringent statutes and procedures. The Single European Act of 1987 had launched a process of harmonizing regulatory standards around a high level of social protection in Europe, and as early as 1990 the EU (then still the EC) promulgated a separate directive (Council Directive 90/220/EEC) to regulate, according to a more precautionary standard, the deliberate release into the environment of genetically modified organisms. Although the various GMOs originally approved under this system in 1996 never led to any documented harms in Europe, standards were nonetheless tightened in 1997 through introduction of a mandatory labeling system for GMOs and then through a suspension of new approvals in 1998, pending a drafting of even tighter rules. These tighter approval rules were finally set in place in 2004, accompanied by an even more comprehensive labeling and tracing regulation.

Despite all this regulatory stringency in Europe, citizen support for GM foods went down rather than up. One opinion survey analyst noted this anomaly in 2006, and offered an explanation:

Even the EU's recently overhauled regulatory framework for GMO authorisation and labeling has yet to make Europeans more accepting of food made from genetically engineered plants. In fact, only 27 percent of survey participants believe that the technology behind GM foods should be encouraged. It seems that most consumers have a hard time seeing any clear benefits associated with genetically engineered crops. (GMO Compass 2006, p. 1)

In Europe the politics of GMO food acceptance are dominated in the end by benefit calculations, not risk calculations or trust calculations. Helge Torgersen at Austria's Institute of Technology Assessment uses comparisons to medicine to make this point: "Medical applications with substantial benefits get support despite some risk, but GM crops lack support even if risks are low." (Torgersen 2000)

To illustrate how much risk European regulators are ready to accept from GMOs in the medical area, consider the case of a new anti-clotting drug, ATryn, manufactured in the milk of genetically engineered goats – in fact, *American* GMO goats. A U.S. company named GTC had developed this new drug technology using a herd of about 1,400 transgenic goats it kept on a farm in central Massachusetts. A strict application of the precautionary principle would have dictated against approving a new drug extracted from the milk of gene-spliced goats, as this milk could be carrying potentially risky animal proteins, yet in June 2006 the European Medicines Agency announced it would recommend approval in Europe of this new treatment. In this case the anticipated health benefits would not be especially widespread, since only one out of every three to five thousand people has the hereditary condition that leaves them without the needed anti-

clotting protein in their own blood, but for those who did have this condition the benefit would be substantial, so the precautionary principle went out the window. The only previous commercial source of the needed protein had been donated human blood, which was an expensive option. Thanks to milk production from the new GMO goats, commercial prices would fall. A single one of these remarkable “pharm animals” would be able to produce about \$150,000 worth of the protein every year. (Heuser 2006)

Citizens accept GMO drugs more than GMO foods and crops despite clear evidence, developed from clinical trials, that the drugs are more dangerous. Zevalin, a popular recombinant drug for non-Hodgkins lymphoma, can cause severely reduced white cell counts resulting in both gastrointestinal and respiratory complications; Avastin, used to slow tumor growth, can cause gastrointestinal perforations and hemorrhage; Raptiva, used to treat psoriasis, can leave the patient vulnerable to serious infection and malignancy. Yet all these drugs have been approved for sale both in Europe and the United States. The risky GMO drug Tysabri, developed in the United States for MS patients by the Biogen company, was in such demand that it was given accelerated approval by FDA in November 2004, only to be pulled from the market three months later following the occurrence of a brain infection known as PML in two patients, in one case fatal. (Walsh 2005) Yet due to the known benefits and popularity of this drug it was brought back onto the market 18 months later, this time under a slightly more rigorous “risk management” plan.

Survey researchers like to divide those who support medical biotechnology into two different categories: those who support it because they see no risk, and those who support it despite the risks they see. In Europe in 1999, nearly half (47 percent) of all

those supporting biotechnology in medicine said they were doing so despite the risk.

This “risk tolerant” share of supporters in Europe was actually higher than in the United States, where only 35 percent of all supporters were positive despite seeing a risk.

(Gaskell et al. 1999)

### *Uncontrolled exposure*

In addition to the difference in anticipated benefit, there is one other plausible explanation for why citizens in rich countries accept GMO medicines much sooner than GMO foods and crops. Risk theorists know that public acceptance is less likely when personal exposure to a risk is perceived as involuntary. (Fife-Schaw and Rowe 2000) Exposure to GMO medicines is something the individual can control, because the technology is physically contained inside laboratories, the carefully labeled and prescribed by physicians. In contrast, GMO crops and foods are grown openly in the environment and then distributed through commercial channels, sometimes without labels so ordinary citizens can purchase them unknowingly.

Even a small or imagined risk can be felt as threatening when people are unable to control their exposure to the risk. (Frewer, et al. 2004) Lack of personal control over exposure helps explain the occasional public outrage when small amounts of fluoride are added to public drinking water supplies in an innocent effort by public health officials to prevent tooth decay. There still is no evidence of harm from this practice, and there is ample evidence of benefit, yet because public exposure is essentially involuntary many communities even today hold back from initiating the practice. Similarly when GMO foods first appeared on the market in Europe in 1996, there was not yet in place a system

of mandatory labeling to give consumers a means to avoid consuming them. Conversely when exposure to a new technology is controlled individually, as in the case of microwave ovens, cell phones, dangerous dietary supplements (like Ephedra), or GMO medicines, fear and anger is usually neutralized because a personal choice to avoid the technology is always available.

Exposure control is important, but if control over individual exposure to GMO foods were really the first concern, much greater anxieties about GMOs would be expected in the United States where the technology remains unlabeled in the marketplace rather than in Europe where stringent labeling is now mandatory. Even though individual exposure can now be effectively controlled, European consumers remain opposed GMO foods and don't want them in the marketplace – because they have not yet seen any prospect of an individual benefit.

When benefits are available, food consumers pay surprisingly little heed to uncontrolled risk exposures. We know that food can be dangerous to eat if carelessly handled or prepared, yet food consumers in rich countries are increasingly entrusting these vital tasks to complete strangers. In the United States alone, food borne diseases routinely cause roughly 5,000 deaths every year, and they make an additional 76 million people sick. (Mead, et al. 1999) Yet Americans are preparing fewer and fewer of their own meals every year, in pursuit of valued benefits such as greater food variety and convenience, and greater social pleasure. Likewise in Europe, where a rapid move of more women into the workforce has triggered a dramatic increase in the consumption of processed and convenience foods, all prepared by others. In France time spent on meal

preparation at home has fallen by half since the 1960s, and fast food restaurants are on the rise even in Greece, Portugal, and Sweden. (Mitchell 2004)

American and European food consumers today value access to variety and convenience much more than personal control over handling and preparation. American supermarkets carry as many as 400 different produce items, up from an average of just 150 different items in the 1970's. (Putnam, Allshouse, and Kantor 2002) Hypermarkets like Wal-Mart offer one-stop discount shopping with plenty of parking space, but little or no individual consumer control over the provenance of the food items being purchased.

Consumers willingly relinquish even greater food risk control when they purchase heat-and-serve prepared foods, and when they take their meals in restaurants. They do so, again, because the benefits are so obvious. For two-income households, single-parent households, and working individuals who live alone, the convenience of heating and serving foods prepared by others is viewed not as uncontrolled risk exposure but as an upscale amenity. Restaurant patrons have no way of knowing how long the canned cheese sauce has been out of the refrigerator, or if the workers in the kitchen have separated the meat from the vegetables on the cutting board, or washed their hands, or perhaps come to work sick and sneezing, and restaurant kitchens are seldom inspected by health officials and almost never visited by patrons. American restaurant goers are fully aware that official safety inspection systems are weak and 27 percent actually believe restaurants to be the number one source of food borne illness, yet the pursuit of a tangible direct benefit – the undeniable convenience, variety, and social pleasure they take from enjoying a meal at restaurant – is far more important than even a known food safety risk.

In the United States by 1997, roughly 40 percent of all food expenditures went for meals prepared by others rather than at home. In the UK the share was 27 percent and in Spain 26 percent.

So in the end it is the absence of a compelling consumer benefit that has done most to undercut social support for GMO foods and crops in rich countries. Margaret Mellon, director of the agricultural and biotechnology program of the Union of Concerned Scientists in Washington, D.C., and a prominent skeptic regarding GMO crops, admits candidly that the meager consumer benefits are more important in rich countries like the United States than any hypothetical risks:

“[M]y colleagues and I at the Union of Concerned Scientists are not opposed to biotechnology. We think its use in drug manufacture, for example, makes a lot of sense. The therapeutic benefits of the new drugs outweigh the risks, and often there aren’t any alternatives....Agriculture isn’t like medicine. We in the U.S. produce far more food than we need. And we are so wealthy that whatever we can’t produce we can buy from somebody else. As a result there are 300,000 food products on our grocery shelves and 10,000 new ones added every year. The notion that consumers in the U.S. fundamentally need new biotechnology foods isn’t persuasive.” (Mellon 2001, p. 64)

*What about GMO foods with consumer benefits?*

The first generation of GMO agricultural crops was designed with improved agronomic traits valuable to farmers, with nothing new for consumers. A second generation of GMO crops is just now emerging from the research pipeline designed to give specific food benefits to consumers, such as enhanced Beta-carotene content (for Vitamin A) or higher Omega-3 content (found in heart-healthy seafood diets). The private biotechnology industry has high hopes that the delivery of these clear benefits to consumers will break down the high social resistance that GMO foods and crops have

met so far. (Shoemaker, Johnson, and Golan 2003) Not a sure thing. Nutrient traits such as Beta-carotene could be quite a valuable benefit if engineered into the nutrient-deficient staple food crops that dominate the inadequate diets poor people in the developing world, but they are unlikely to be highly valued by consumers in rich countries, who have plenty of other ways to get enough Vitamin A or Omega-3 oils.

Consumers in rich countries today do not need GMO foods to attain adequate nourishment, since they have that available any time they want through a diverse diet of inexpensive and nutritious non-GMO foods, as Margaret Mellon points out. American diets are notoriously deficient in adequate daily servings of vegetables and fruits, yet this is not for lack of access – remember the 400 different produce items that are currently available in each American supermarket. Any American or European citizen who cares to be serious about dietary improvement can achieve this goal without having to consume any GMOs, and surveys confirm this is how most would prefer to proceed – eating conventional foods, not GMOs. Attitudes on this subject are particularly strong in Europe; when asked if they would continue buying a nutritionally enhanced food if they learned it was GMO, a majority of survey respondents in Germany, Australia, and Great Britain said they would stop buying the food. (Hoban 2004)

### *GMO foods and crops in a larger context*

In addition to lack of consumer benefits and uncontrolled exposure, citizens in rich countries today tend to disapprove of GMO foods and crops because of what they think this new technology will do to farming. In rich countries today because farmers are already highly productive (perhaps too productive, as Margaret Mellon suggests) new

scientific applications that could bring still more productivity have become suspect and stigmatized. Well before GMO foods and crops came along, citizens in rich countries had already become concerned about earlier applications of modern agricultural science such as high-yielding crops grown with heavy applications of chemical fertilizers or pesticides. Citizens had come to see too much agricultural science as moving modern societies away from something they liked – traditional small-scale family farms working in harmony with nature – and instead toward a distasteful “factory farming” model that treated the growing food as just another industrial enterprise. In the chapter that follows we explore this turn against agricultural science in greater detail. We find that well before the GMO era, growing numbers of citizens both in Europe and the United States were drawing a conclusion that the farming practices they saw around them needed no additional productivity gains from science. In both the United States and Europe, citizens had come to believe that farming was productive enough and government should pull back from using taxpayer money to promote still more agricultural science. This priority change was completely understandable and affordable in the United States and Europe, but highly inappropriate when exported to Africa.

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