2.11

GM crops have altered levels of nutrients and toxins

> *"No one can scientifically claim to be able to predict all consequences of the presence and functioning of a new gene (and even less for several) in a genome which has never been exposed [to] or contained this gene. The potential hazard here is not a consequence of the action of modification [of] the plant genome, but of the fact that it generates high levels of unpredictability."*[103]
>
> — European Commission

1. Numerous studies on GMOs reveal unintended changes in nutrients, toxins, allergens, and small molecule products of metabolism.
2. These demonstrate the risks associated with unintended changes that occur due to genetic engineering.
3. Safety assessments are not adequate to guard against potential health risks associated with these changes.

Previous pages in this section describe how the GM transformation process may alter the composition of GM crops. Unfortunately, biotech companies avoid using modern techniques to identify and quantify many known nutrients, antioxidants, mutagens, carcinogens and toxins in plants. Instead, they typically measure only a few items at a gross compositional level (e.g. total protein, total carbohydrates) rather than specific components (e.g. what proteins, what carbohydrates). Furthermore, studies are designed to make it difficult to identify significant differences (see part 3).

Reviews of safety assessments for GM crop approvals in the United States[104] and Europe[105] show that compositional analyses are highly inconsistent between submissions. In several, "no declarations even on essential inherent plant toxins and antinutrients could be found."[106] Reviewers call for "consistent guidelines" that specify harmful compounds to be evaluated for each species[107] and the US National Academy of Sciences recommends "the establishment of a database for natural plant compounds of potential dietary or other toxicological concern."[108] Even without consistent and meaningful measurements, there is plenty of evidence of unexpected compositional changes in experimental and commercialized GMOs.

Changed metabolites

Metabolites are small molecules that are the intermediate and end products of metabolism. They can be beneficial or harmful (e.g. nutrients or toxins). In four lines of potatoes engineered to alter sugar metabolism, scientists measured the presence of 88 metabolites. Most levels had been changed and 9 of the 88 were only present in the GM potatoes—not controls.[109] David Schubert writes, "Given the enormous pool of plant metabolites, the observation that 10% of those assayed are new in one set of transfections [GM transformation events] strongly suggests that undesirable or harmful metabolites may be produced and accumulate."[110]

In most cases, changed metabolites in GM crops are not measured. By knowing which major compound has been altered, sometimes one can infer changes in intermediate products. For example, the stems of *Bt*-corn varieties MON 810 and *Bt*-11,[111] as well as Roundup Ready soybeans, have markedly increased levels of lignin (by 20%)—a woody, non-digestible compound.[112] Lignin is produced through a complex series of steps, which also create other important plant constituents. Since lignin has increased, the amount of the other related compounds may have changed. According to David Schubert, "Components of this same biochemical pathway also produce both flavonoids and isoflavonoids that have a high nutritional value, and rotenone, a plant-produced insecticide that may cause Parkinson's disease."[113],[114] No tests have been done to evaluate changes in these other components. In fact, even the increased lignin content in corn was not discovered until the varieties had been on the market for five years. The higher lignin in soybeans was only identified after the stems of plants inexplicably split in the heat at the height of the growing season.

It is odd that lignin increased in three separate GM products. Schubert and Freese write, "Normally, one would expect that each non-repeatable, unique transformation event [gene insertion] would yield unique unintended effects." They suggest that an increase in lignin, and possibly other undetected effects, may be an unintentional response to the insertion of a unique gene, as opposed to the usually random mutations caused by the genetic engineering process.

Examples of unpredicted changes

Tobacco: When genes were inserted into tobacco to produce a particular acid, the plant also created a toxic compound not normally found in tobacco.[115]

Yeast: Yeast DNA was inserted with multiple copies of its own genes in order to increase alcohol production. This unexpectedly raised levels of a naturally occurring toxin and potential carcinogen by 40 to 200 times. The authors said that their results "may raise some questions regarding the safety and acceptability of genetically engineered food, and give some credence to the many consumers who are not yet prepared to accept food produced using gene engineering techniques."[116]

Potatoes: When Oxford University scientists attempted to suppress a potato enzyme, the starch content increased substantially. Plant scientist Chris Leaver said, "We were as surprised as anyone. . . . Nothing in our current understanding of the metabolic pathways of plants would have suggested that our enzyme would have such a profound influence on starch production."[117] In other potatoes inserted with a soybean gene (glycinin), some vitamins were reduced and dangerous toxins (solanine and chaconine) increased. And although the insertion was designed to increase protein content, the transgenic version has *less* protein than the controls.[118]

Potatoes engineered to produce an insecticide (GNA lectin), contained 22% less protein than their own parent line. And the nutritional content of two different GM potatoes from the same parent line grown in identical conditions was significantly different. Other GM potato varieties had problems with tissues[119] and carbohydrate processing.[120]

Wheat: One GM wheat variety showed lesions,[121] another variety had higher levels of toxicity.[122]

Rice: One GM rice unexpectedly produced 50% more vitamin B6.[123] Another designed to produce vitamin A altered other compounds (carotenoid derivatives).[124]

Peas: GM pea varieties showed a fourfold increase in lectins and a doubling of trypsin inhibitor.[125]

Squash: A USDA-approved GM squash contains 67 times less beta-carotene and 4 times more sodium than non-GM squash.[126]

Soy: Monsanto's own study on Roundup Ready soy showed significant differences in the ash, fat, and carbohydrate content as well as a 27% increase in trypsin inhibitor,[127] a known allergen. Additional differences (which Monsanto had omitted from their paper but were later recovered in journal archives) showed that GM soy had significantly lower levels of protein, a fatty acid, and phenylalanine (an essential amino acid). The toasted GM soy meal contained nearly twice the amount of a lectin, which may interfere with assimilation of nutrients.[128]

There was also a disturbing finding related to trypsin inhibitor. Cooking normally breaks down (denatures) this potential allergen, making it safer to consume, but "heat treatment appeared to have a far lesser denaturing effect on the trypsin inhibitor content of the GM lines."[129] The cooked soy had nearly as much trypsin inhibitor as the uncooked variety—as much as seven times more than non-GM soy.

In the same study, both rats and catfish fed various lines of Roundup Ready soybeans exhibited different growth rates, suggesting that the nutrition content of the soybeans varied significantly. Also, cows fed GM soy produced milk with a higher fat content than those fed non-GM soy.[130]

In a 2004 study, cooked soybean meal from Argentina had about 18.5% less protein than meal from China and India. US soybean meal had about 8.5% less. These differences might be attributable to the genetic modification. At the time of the study, soy from Argentina was almost all GM, while soy from the United States was mixed. Soy from China and India, which had the higher protein content, was non-GM.[131]

Corn: In *Bt*-corn MON 810, 8 out of the 18 amino acids measured (44%) were significantly different than the controls. The Public Health Association of Australia (PHAA) points out that the expected new protein created from the transgene "constitutes less than 0.001% of the total protein … the change in amino acid profile cannot be attributed to the presence of this new, expected protein in the plant. It indicates that other proteins may have been produced, which may be potentially toxic."[132] The calcium and beta tocopherols levels were also significantly different.[133]

Roundup Ready corn varied significantly in five amino acids. As amino acids may form potentially harmful proteins, the PHAA, said it was "of concern that these results have not been followed-up with experiments of the whole food to determine if any new, unexpected substances are present which may cause disease."[134]

In Liberty Link corn, two of six fatty acids, 7 of 18 amino acids, and calcium, phosphorus, protein, and carbohydrate levels were statistically different. (Calcium was down 64%.)[135]

A high-lysine corn under review for commercialization "had higher levels in all of the 18 measured amino acids among the four commercial varieties used as references."[136] (115.17 mg/g compared to an average of 77.8 mg/g.)

Canola: Although the vitamin A (carotene) content of canola seeds was successfully increased (50-fold) with the addition of a bacterial gene, there was an unexpected and significant decrease in vitamin E (tocopherol). The fatty acid composition was significantly altered and chlorophyll levels were also reduced.[137]

Monsanto's Roundup Ready Canola line Gt173 has significantly higher levels of amino acids compared to its parent line. The increase is greater that the additional protein produced from the inserted genes and, according to the PHAA, should have been further evaluated for possible toxicity.[138] The canola also had a significantly altered fat content.[139]

Unexpected agricultural performance

In addition to lab tests, we can infer other compositional differences based on varied agronomic performance of GM crops and the reactions of plants to various conditions of disease and stress. The levels of certain toxins in potatoes (sesquiterpenes and the glycoalkaloids—PGAs), for example, differed between GM potatoes and non-GM potatoes, after they were exposed to a variety of stresses in the field and at the store.[140]

GM cotton has greater susceptibility to nematodes[141] and other pests, and in various conditions, dropped their cotton bolls, died on contact with the herbicide they were engineered to tolerate, succumbed to disease or drought, failed to germinate, or had smaller cotton bolls and poorer cotton quality. Monsanto paid millions in settlements with farmers.[142]

Yields of GM Roundup Ready soy have been on average 7%–10% less than equivalent conventional varieties.[143]

Furthermore, a study consisting of side-by-side field trials over a two-year period at four different locations of GM and equivalent non-GM varieties of glyphosate-resistant (GR) soybean cultivars concluded that, "Yields were suppressed with GR soybean cultivars. … The work reported here demonstrates that a **5% yield suppression was related to the gene or its insertion process** and another 5% suppression was due to cultivar genetic differential."[144] Given that yield is dependent on the overall physiological condition of the plants and not just on the function of a single gene, the results from these controlled studies demonstrate the general disruptive effect that the GM transformation process has on the genome and consequent biochemical functioning as a whole.

In spite of the overwhelming evidence of substantial compositional changes in GM crops, advocates continue to deny the presence of these unpredictable, potentially harmful changes. In a 2002 article, for example, the authors claimed that "transgenic varieties expressing a single agronomic trait (are) not expected to (have an) altered nutrient composition."[145] According to Pusztai and Bardocz, "It would be helpful in the interests of science to generally recognize and accept that views such as that . . . fly in the face of the facts and published data."[146]

New studies reveal more unknowns

Modern techniques can provide data on a full range of RNA transcripts, proteins, and metabolites (transcriptome, proteome, and metabolome) that are produced by an organism. Scientists have been calling for GM foods to be submitted to these analyses for some time. A 2005 UK government-funded study concluded that "a combination of proteomic, metabolomic, and genomic approaches would seem to be necessary for any safety assessment to be as comprehensive as possible."[147]

Recent studies using these techniques demonstrated that the impacts of the GM transformation process vary considerably from one "event" to another, producing both intended and unintended effects. In one study, the expression of "up to 58 genes" was increased or decreased "more than fivefold."[148] Another study concluded that "the unintended effects" of GM transformation were greater than the natural biological variation of the plant, when comparing plants grown under a specific experimental condition.[149]

Using these techniques to quantify how many proteins change and by how much, is limited by our lack of understanding of biochemical pathways. In a study of GM potatoes for example, researchers found that only 9 of the 730 proteins they analyzed showed significant differences. But they were at a loss to explain how such small differences could result in some potato lines being extremely stunted with low tuber yield.[150]

Scientists have been cataloging various enzymes and their effects in their native organism for years. But according to Richard Firn, this "is only partly useful because it is the properties of the enzyme in its new biochemical environment that will determine which chemicals it transforms and at what rate."[151] Similarly, the European Commission says that "Even if a given protein per se does not represent an allergen, its expression in another host organism may indirectly upregulate the expression of potential allergens."[152]

Our lack of understanding of the effects of transporting material between species is compounded by our inability to grasp the holistic complexity at work inside plants and animals. "If a biologist is shown a map of all known biochemical pathways," says Firn, "they are unlikely to see any patterns—to most biologists it is just a collection of names and arrows. There is much knowledge, and some understanding, of many individual enzymes and most biochemical pathways, but how and why has evolution shaped biochemistry as an entity? If we cannot answer that question how can we confidently predict the outcomes of attempts to change an organism's biochemical repertoire by genetic manipulation?"[153]

The quest to understand these mechanics at work in plants is made more complicated by the finding that patterns of gene expression vary considerably due to changing environmental conditions. Variations in response to the environment, according to recent studies, were "generally greater than the effect of the genetic transformation."[154] This doesn't minimize the potential harm that can arise from the GM transformation process. Quite the contrary; changes due to genetic engineering would be added onto—and possibly interfere with—changes caused by the environment. For example, suppose that a gene or gene cluster designed to protect the plant from a specific infestation is disabled. If an infestation occurs, the plant may compensate by producing compounds that are toxic to humans. Safety assessments of GM crops grown only under a narrow range of conditions would overlook this risk and might not even identify that the genes were impaired.

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82. G. Meister, and T. Tuschl, "Mechanisms of gene silencing by double-stranded RNA," *Nature* 431 (2004): 343–349; and C. Mello, C. C. and D. Conte, Jr., "Revealing the world of RNA interference," *Nature* 432 (2004): 338–342.
83. "Elements of Precaution," The Royal Society of Canada, January 2001.
84. Richard D. Firn. "The genetic manipulation of Natural Product composition—risk assessment when a system is predictably unpredictable," *Epigenetics, Transgenic Plants & Risk Assessment, Proceedings of the Conference, December 1st 2005*, (Frankfurtam Main, Germany: Literaturhaus, 2005).
85. Ibid.
86. U. Roessner, et al., "Metabolic Profiling Allows Comprehensive Phenotyping of Genetically or Environmentally Modified Plant Systems," *Plant Cell* 13 (2001): 11–29.
87. Susan Benson, Mark Arax, and Rachel Burstein, "Growing Concern: As biotech crops come to market, neither scientists—who take industry money—nor federal regulators are adequately protecting consumers and farmers," *Mother Jones*, January/February 1997; http://www.motherjones.com/mother_jones/JF97/biotech_jump2.html
88. Royal Holloway, University of London, "Study G02005: The application of metabolic profiling to the safety assessment of GM foods," October 2001 to October 2004.
89. Mark Rasmussen, "Pest Resistant Plants: A New Frontier for Animal Nutrition," Iowa State University, hand out for *Animal Science* 519 (Digestive Physiology and Metabolism in Ruminants), 2006.
90. "Elements of Precaution," The Royal Society of Canada, January 2001.
91. B. Meldrum, "Amino acids as dietary excitotoxins: a contribution to understanding neurodegenerative disorders," *Brain Res* 18 (1993): 293–314.
92. Rasmussen, "Pest Resistant Plants: A New Frontier for Animal Nutrition."
93. N. J. Bate, J. Orr, W. Ni, A. Meromi, T. Nadler-Hassar, P. W. Doerner, R. A. Dixon, C. J. Lamb, Y. Elkind, "Quantitative relationship between phenylalanine ammonia-lyase levels and phenylpropanoid accumulation in transgenic tobacco identifies a rate-determining step in natural product synthesis," *Proc. Natl. Acad. Sci. USA* 91 (1994): 7608–12.
94. "Elements of Precaution," The Royal Society of Canada, January 2001.
95. S. L. Franck-Oberaspach, and B. Keller, "Consequences of classical and biotechnological resistance breeding for food toxicology and allergenicity. *Plant Breeding* 116 (1997): 1–17.
96. Richard D. Firn, "The genetic manipulation of Natural Product composition."
97. Mark Rasmussen, "Pest Resistant Plants: A New Frontier for Animal Nutrition."
98. Schubert, "A Different Perspective on GM Food," 969.
99. U.S. Department of Agriculture, "Phytonutrients Take Center Stage," Agricultural Research Service Web site, http://www.ars.usda.gov/is/AR/archive/dec99/stage1299.htm
100. Freese and Schubert, "Safety Testing and Regulation of Genetically Engineered Foods."
101. Marc A. Lappé, et al, "Alterations in Clinically Important Phytoestrogens in Genetically Modified, Herbicide-Tolerant Soybeans," *Journal of Medicinal Food* 1, no. 4.
102. Life Sciences Network, "Food can be 'More Powerful than Drugs,'" December 13, 2002; reporting on Barbara Demmig-Adams and William W. Adams, III "Antioxidants in Photosynthesis and Human Nutrition," *Science* 13 (December 2002): 2149-2153.
103. European Communities submission to World Trade Organization dispute panel, 28 January 2005 , cited in Friends of the Earth Europe and Greenpeace, "Hidden Uncertainties What the European Commission doesn't want us to know about the risks of GMOs," April 2006
104. Doug Gurian-Sherman, "Holes in the Biotech Safety Net, FDA Policy Does Not Assure the Safety of Genetically Engineered Foods," Center for Science in the Public Interest, http://www.cspinet.org/new/pdf/fda_report__final.pdf
105. W. K. Novak, and A. G. Haslberger, "Substantial equivalence of antinutrients and inherent plant toxicants in genetically modified foods," *Food Chem. Toxicol.* 38(2000):473-483.
106. Ibid.
107. Ibid.
108. National Research Council. "Genetically Modified Pest-Protected Plants: Science and Regulation" (Washington, DC: National Academy Press, 2000).
109. U. Roessner, et al., "Metabolic Profiling Allows Comprehensive Phenotyping of Genetically or Environmentally Modified Plant Systems," *Plant Cell* 13(2001): 11–29.
110. David Schubert, "Regulatory regimes for transgenic crops," letter in *Nature Biotechnology* 23(2005): 785–787, citing E. Grotewold, "Plant metabolic diversity: A regulatory perspective," *Trends Plant Sci.* 10: *57–6.*
111. D. Saxena, and G. Stotzky, "*Bt* Corn Has a Higher Lignin Content than Non-*Bt* Corn." *American Journal of Botany* 88, no.9 (2001), 1704–1706.
112. For an excellent discussion of these type of changes, see William Freese and David Schubert, "Safety Testing and Regulation of Genetically Engineered Foods," *Biotechnology and Genetic Engineering Reviews* 21 (November 2004); and

David Schubert, “Regulatory regimes for transgenic crops,” letter in *Nature Biotechnology* 23 (2005): 785–787.

113. R. Betarbet, T. B. Sherer, G. MacKenzie, et al., “Chronic systemic pesticide exposure reproduces features of Parkinson‘s disease,” *Nature Neuroscience* 3(2000): 1301–1306.
114. Schubert, “Regulatory regimes for transgenic crops,” 785–787.
115. A. S. Reddy and T. L. Thomas, “Modification of plant lipid composition: Expression of a cyanobacterial D6-desaturase gene in transgenic plants,” *Nature BioTechnology* 14 (1996): 639–642.
116. T. Inose and K. Murata, “Enhanced accumulation of toxic compound in yeast cells having high glycolytic activity: A case study on the safety of genetically engineered yeast,” *International Journal of Food Science and Technology* 30 (1995): 141–146.
117. U.K. Biotechnology and Biological Sciences Research Council, “Making Crops Make More Starch,” *BBSRC Business*, January 1998: 6–8.
118. W. Hashimoto, K. Momma, T. Katsube, Y. Ohkawa, T. Ishige, M. Kito, S. Utsumi, K. Murata, “Safety Assessment of Genetically Engineered Potatoes With Designed Soybean Glycinin: Compositional Analyses of the Potato Tubers and Digestibility of the Newly Expressed Protein in Transgenic Potatoes,” *Journal of the Science of Food and Agriculture* 79 (1999): 1607-1612.
119. S. C. H. J.Turk, S. C. M. Smeekens, “Genetic modification of plant carbohydrate metabolism,” as quoted in V. L. Chopra, V. S. Malik, S. R. Bhat, eds, *Applied Plant Biotechnology* (Enfield: Science Publishers, 1999), 71–100.
120. Th. A. Dueck, A. van der Werf, L. A. P. Lotz, W. Jordi, “Methodological Approach to a Risk Analysis for Polygene-Genetically Modified Plants (GMPs): a Mechanistic Study,*AB Nota* 50 (Wageningen: Research Institute for Agrobiology and Soil Fertility (AB-DLO), 1998).
121. E. Delhaize, D. M. Hebb, K. D. Richards, J. M. Lin, P. R. Ryan, R. C. Gardner, “Cloning and expression of a wheat (Triticum aestivum) phosphatidylserine synthase cDNA: Overexpression in plants alters the composition of phospholipids,” *Journal of Biological Chemistry* 274 (1999): 7082–7088.
122. F. Murray, D. Llewellyn, H. McFadden, D. Last, E. S. Dennis, W. J. Peacock, “Expression of the Talaromyces flavus glucose oxidase gene in cotton and tobacco reduces fungal infection, but is also phytotoxic,” *Mol. Breed* 5 (1999): 219–232.
123. K. Momma, W. Hashimoto, S. Ozawa, S. Kawai, T. Katsube, F. Takaiwa, M. Kito, S. Utsumi, K. Murata, “Quality and safety evaluation of genetically engineered rice with soybean glycinin: analyses of the grain composition and digestibility of glycinin in transgenic rice,” *Bioscience Biotechnology and Biochemistry* 63 (1999): 314–318.
124. X. Ye, S. Al Babili, A. Kloeti, J. Zhang, P. Lucca, P. Beyer, I, Potrykus, “Engineering the provitamin A (beta-carotene) biosynthetic pathway into (carotenoid-free) rice endosperm,” *Science* 287 (2000): 303–305.
125. Arpad Pusztai, “Facts behind the GM pea controversy,” *Epigenetics, Transgenic Plants & Risk Assessment, Proceedings of the Conference, December 1st 2005* (Frankfurtam Main, Germany: Literaturhaus, 2005)
126. USDA Application # 95-352-01, cited in Latham et al, “The Mutational Consequences of Plant Transformation, Journal of Biomedicine and Biotechnology 2006:1-7, article ID 25376, http://www.hindawi.com/journals/JBB/index.html
127. Stephen R. Padgette et al, Table 2 in “The Composition of Glyphosate-Tolerant Soybean Seeds Is Equivalent to That of Conventional Soybeans,” *The Journal of Nutrition* 126, no. 4 (April 1996).
128. Stephen R. Padgette et al, “The Composition of Glyphosate-Tolerant Soybean Seeds Is Equivalent to That of Conventional Soybeans,” *The Journal of Nutrition* 126, no. 4, (April 1996); including data in the journal archives from the same study.
129. Pusztai and Bardocz, “GMO in animal nutrition: potential benefits and risks.”
130. Padgette et al, “The Composition of Glyphosate-Tolerant Soybean Seeds Is Equivalent to That of Conventional Soybeans.”
131. Lisa K. Karr-Lilienthal, et. al., “Chemical Composition and Protein Quality Comparisons of Soybeans and Soybean Meals from Five Leading Soybean-Producing Countries,” J. Agric. Food Chem. 2004, 52, 6193-6199
132. Food Legislation and Regulation Advisory Group (FLRAG) of the Public Health Association of Australia (PHAA) on behalf of the PHAA, Comments to ANZFA about Applications A346, A362 and A363; http://www.iher.org.au/
133. Ibid.
134. Ibid.
135. Food Legislation and Regulation Advisory Group (FLRAG) of the Public Health Association of Australia (PHAA) on behalf of the PHAA, Comments to ANZFA about Applications A372, A375, A378 and A379; http://www.iher.org.au/
136. Cretenet, et al, Submission on the DAR for Application A549 Food Derived from High-Lysine Corm LY038.
137. C. K. Shewmaker, J. A. Sheely, M. Daley, S. Colburn, D. Y. Ke, “Seed-specific overexpression of phytoene synthase: increase in carotenoids and other metabolic effects,” *Plant Journal* 22, (1999): 401–412.
138. Food Legislation and Regulation Advisory Group (FLRAG) of the Public Health Association of Australia (PHAA) on behalf of the PHAA, “Food produced from glyphosate-tolerant canola line GT73,” Comments to ANZFA about Applications A346, A362 and A363; http://www.iher.org.au/
139. FLRAG, comments to ANZFA about Applications A346, A362 and A363.

140. Derek Matthews, et al, "Toxic Secondary Metabolite Production in Genetically Modified Potatoes in Response to Stress," *J. Agric. Food Chem.*, ASAP Article 53 (20), 7766 -7776, 2005. Web Release Date: September 2, 2005
141. Patrick D. Colyer, et al, "Plant Pathology and Nematology: Root-Knot Nematode Reproduction and Root Galling Severity on Related Conventional and Transgenic Cotton Cultivars," *The Journal of Cotton Science* 4 (2000): 232–236; www.jcotsci.org
142. A. R. Myerson, "Seeds of discontent: cotton growers say strain cuts yields," *New York Times* Nov. 19, 1997; K. L. Edmisten, and A.C. York, "Concerns with Roundup Ready Cotton," North Carolina Cooperative Extensive Service, 1999. [Extracts] http://www.biotech-info.net/Cotton_agronomic_problems.html
143. C. M. Benbrook, "Troubled Times Amid Commercial Success for Roundup Ready Soybeans: Glyphosate Efficacy is Slipping and Unstable Transgene Expression Erodes Plant Defenses and Yields" (Sandpoint, Idaho: Northwest Science and Environmental Policy Center, 2001), http://www.biotech-info.net/troubledtimes.html; J. Fernandez-Cornejo and W. D. McBride, "Adoption of Bioengineered Crops," USDA ERS Agricultural Economic Report No. AER810 (2002), http://www.ers.usda.gov/publications/aer810/
144. R. W. Elmore, F. W. Roeth, L.A. Nelson, C. A. Shapiro, R. N. Klein, S. Z. Knezevic, and A. Martin, "Glyphosate-Resistant Soybean Cultivar Yields Compared with Sister Lines," *Agron. J.* 93 (2001): 408–412; see also R. W. Elmore, F.W. Roeth, R.N. Klein, S.Z. Knezevic, A. Martin, L.A. Nelson, and C.A. Shapiro, "Glyphosate-resistant soybean cultivar response to glyphosate," *Agron. J.* 93 (2001): 404–407.
145. A. Aumaitre, et al., "New feeds from genetically modified plants: substantial equivalence, nutritional equivalence, digestibility, and safety for animals and the food chain," *Livest. Prod. Sci.* 74 (2002): 223–238.
146. Pusztai and Bardocz, "GMO in animal nutrition: potential benefits and risks."
147. John Innes Centre, "Study G02002," September 2001 to January 2005.
148. Ibid.
149. Royal Holloway, University of London, "Study G02005," October 2001 to October 2004.
150. Lehesranta Satu, et al., "Comparison of tuber proteomes of potato varieties, landraces, and genetically modified lines," *Plant Physiol.* 138 no. 3(July 2005): 1690–1699.
151. Firn, "The genetic manipulation of Natural Product composition—risk assessment when a system is predictably unpredictable."
152. European Communities submission to World Trade Organization dispute panel, 28 January 2005 , cited in Friends of the Earth Europe and Greenpeace, "Hidden Uncertainties What the European Commission doesn't want us to know about the risks of GMOs," April 2006
153. Firn, "The genetic manipulation of Natural Product composition—risk assessment when a system is predictably unpredictable."
154. Rothamsted Research Centre, "Study G02003: Comparison of the metabolome and proteome of GM and non-GM wheat: Defining substantial equivalence," September 2001 to January 2005; see also Institute of Food Research, Norwich Research Park, "Study GO2004: Development and comparison of molecular profiling methods for improved safety evaluation using GM brassicas," September 2001 to January 2005.

PART 1, SECTION 3: THE PROTEIN MAY CREATE PROBLEMS

1. Michael Pollan, "Playing God in the Garden," *New York Times Magazine*, Oct. 25, 1998.
2. Rick Weiss, "Biotech Food Raises a Crop of Questions," *Washington Post*, August 15, 1999: A1.
3. Ibid.
4. Julie A. Nordlee et al, "Identification of a Brazil-Nut Allergen in Transgenic Soybeans," *N Engl J Med* 334 (1996):688–92.
5. Louis J. Pribyl, "Biotechnology Draft Document, 2/27/92," March 6, 1992, Alliance for Bio-Integrity, http://www.biointegrity.org
6. Food and Drug Administration, "Statement of Policy: Foods Derived from New Plant Varieties," Docket No. 92N-0139, 1992.
7. US EPA "Biopesticides Registration Action Document (BRAD)—*Bacillus thuringiensis* Plant-Incorporated Protectants: Product Characterization & Human Health Assessment," EPA BRAD (2001b) (October 15, 2001); http://www.epa.gov/pesticides/biopesticides/pips/bt_brad2/2-id_health.pdf
8. William Freese and David Schubert, "Safety Testing and Regulation of Genetically Engineered Foods," *Biotechnology and Genetic Engineering Reviews* 21 (November 2004); and David Schubert, "Regulatory regimes for transgenic crops," letter in *Nature Biotechnology* 23 (2005): 785–787.
9. FAO-WHO, "Evaluation of Allergenicity of Genetically Modified Foods. Report of a Joint FAO/WHO Expert Consultation on Allergenicity of Foods Derived from Biotechnology," Jan. 22–25, 2001; http://www.fao.org/es/ESN/