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Biotech's "Generation 3"

What's in the GM pipeline? How will it work? Who will control it? What does it mean for farmers, consumers and policymakers?

Plots - *The Issue:* After choking on its first generation of genetically modified (GM) crops - and frantically fearful that its second generation is equally indigestible, the biotechnology industry is desperately seeking a success story – a genetically modified product that will have broad consumer appeal and obvious nutritional benefits. GM crops were planted on an estimated 43 million hectares in 2000, but GM foods have not proven to be cheaper, better tasting, safer or more nutritious. With nothing to gain, it's not surprising that consumers, processors, retailers and farmers have retreated from the biotech bandwagon. Now, the biotech industry is hoping that the next generation of biotech products, Generation 3, will dazzle consumers and dissolve societal concerns.

Pipelines - *What is Generation 3?* Broadly speaking, biotech's third generation refers to GM products that will offer perceived health and nutrition benefits for consumers – primarily affluent people in industrialized countries. Already in the pipeline are genetically modified plants and animals that produce drugs, vaccines, and plastics. Generation 3 also includes Vitamin-fortified fruits, vegetables and grains such as AstraZeneca's highly-touted "Golden Rice."

Pipe Dreams? - *Financial Stakes*: Industry analysts predict that the global market ($2.5 billion in 1999) for GM seed will be relatively "flat" for some years,[1] and could even drop to $2 billion by 2003. Nevertheless, many analysts still expect the GM market to recover and soar to $25 billion by 2010.[2] Global sales of nutritionally-enhanced food products are currently $65 billion (*without* genetic engineering). The combined science-driven bio-based market (including healthcare, personal care and food as well as specialty manufactures) could exceed $15 trillion by the year 2027 - the largest consolidated economic power on earth.

Pied Pipers - *Who will control Generation 3?* The lure of a technologically-integrated $15 trillion system will attract whole new corporate configurations. The Gene Giants (Monsanto, DuPont, Aventis, Syngenta, Dow, etc.) may slip down the food chain when the food & beverage corporations and / or the grocery retailers buy into Generation 3. Massive consolidation makes it difficult to predict who will gobble whom in the binge buying now underway. Even the life insurance industry could become a player. RAFI examines several scenarios for the "Food Chain Gang" of the future.

Policies - *Implications*: Generation 3 is the disassembly of the food chain. Plant parts become component chips in an "agriceutical" system capable of generating "identity-preserved" ingredients from numerous and diverse GM commodities that are increasingly climate and season insensitive. The practical and policy impacts for civil society organizations, farmers and governments are enormous and far-reaching:

- Patents and Plant Breeders' Rights could become irrelevant when processors or retailers exercise global brand (trademark) control over food / health products.
- The Biosafety Protocol could become meaningless as the distinction between farm and pharma blurs in a "dis-aggregated" economy where biosafety becomes a tool for corporate control, and when transgenics becomes "intra-genics."
- Anti-trust and trade regimes, in a market dominated by global technopolies, must be completely re-thought in order to protect farmers and consumers. Commodity associations and unions could be rendered useless in an era of BioSerfdom that will include consumers.

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Genealogy of Generation 3

Is Biotech batting for Strike 3?

Genealogy of Agbiotechnology

Generation 1 -refers to *input trait* control systems most profitable for the seed / agrochemical industry. These are crops genetically engineered to tolerate chemical weedkillers or to express insecticidal genes. The goal is to modify the use of chemical inputs applied to crops, and to expand or prolong the herbicide and insecticide businesses of the enterprises.
Generation 2 - refers to the modification of *output trait* control systems oriented to the interests of food processors. This involves the manipulation of crops in order to reduce processing energy, storage and transport costs. A classic example is Calgene's slow-rotting tomato engineered for longer shelf life. Generation 2 is just now entering the marketplace but is already suspected of suffering from the same credibility afflictions to which Generation 1 succumbed.
Generation 3 - refers to the next generation of ag biotech products, designed for the food / pharma retail sector, which will offer perceived benefits for consumers, ranging from edible vaccines, anti-cancer vegetables, cholesterol reducing grains, crops fortified with micronutrients, and blue carnations. The fate of agbiotechnology rides on consumer acceptance of Generation 3.

Generation 1:

Travails of a misbegotten childhood

Road Block or Speed Bump? Widespread consumer opposition to genetically modified foods broke out in Europe in the late 1990s, and, in the words of US Secretary of Agriculture Dan Glickman, "spread like an infectious disease" to the rest of the world. Today, opposition to GM crops and foods spans six continents, with the chorus of critics ranging from British royalty to Indian peasant farmers, to South African Catholic bishops. GM jitters in the marketplace have forced many of the world's largest food processors, grocery retailers and industrial farmers to swear off GM seeds or food products. Responding to consumer demands, major distilleries, baby food makers, snack food vendors and dog food manufacturers have all nixed GM ingredients in their consumer products. However, virtually all of the major retailers and food processors that have pledged not to use GM ingredients insist that their decisions are based on consumers' preference – and not because of actual or potential health and safety problems associated with genetic engineering.

> *"StarLink has definitely set back the biotech industry, maybe five years."* -- Lewis Batchelder, Vice-President of Archer Daniels Midland. (*New York Times*, Dec. 11, 2000.

The corporate identity crisis over GM foods is best illustrated by Novartis' pledge in August 2000 not to use GM ingredients in its food products (primarily Gerber baby foods and Ovaltine). Novartis' seed and agrochemical division (recently merged with Zeneca and spun off as "Syngenta") is one of the world's leading GM seed sellers. Novartis can only hope that its farmer customers won't notice that Novartis is effectively refusing to buy its own products.

The Great Taco Debacle: In September 2000 a coalition of US biotech activists (including Center for Food Safety, Friends of the Earth, Institute for Agriculture and Trade Policy, National Environmental Trust, Organic Consumers Association, Pesticide Action Network North America and the State Public Interest Research Groups) disclosed that taco shells sold in grocery stores and restaurants (manufactured in Mexico) contained illegal traces of Aventis's genetically engineered StarLink maize variety.[3] StarLink, altered to contain an insecticidal toxin (Cry9C), was approved by US government authorities for livestock feed, but not for human consumption, because it could potentially trigger allergic reactions. The so-called "Taco Debacle" has become a bio-meltdown for Aventis, with fallout for the biotech regulatory system and the entire food chain. Aventis optimistically projected in early November that StarLink related expenses (product re-call, farmer buy-back, liability and compensatory damages) would be "significantly below" $1 billion. The US government's official recall of StarLink involves over 300 maize products; including more than 70 types of taco chips, over 80 taco shell brands and nearly 100 restaurant foods. StarLink maize is

now showing up in far-flung domestic and export markets such as Japan and Korea – where it was not approved for animal feed or human consumption. Food industry giants have been uncharacteristically critical of biotech companies and the failed GM regulatory system. One food company executive told the *New York Times*, "This whole system [genetically modified crops] has been self-policing by the seed industry. And obviously it hasn't worked." [4]

"**Mad CEO**" **Disease**: In the wake of growing anti-GM sentiment, even corporate CEOs (who approved and championed their companies' biotech strategies) have been forced to admit that they had been tactically stupid, arrogant and myopic in their record-setting introduction of a new technology.

In October 1999 Monsanto's CEO Robert Shapiro acknowledged that his company's aggressive biotech campaign probably "irritated and antagonized" more people than it persuaded, and was perceived as "condescension or indeed arrogance."[5]

William F. Kirk, president of DuPont's agricultural division, said in hindsight, "I think we totally underestimated the effect at the consumer level. Product acceptance went so fast with the farmers that maybe the consumer side didn't get worked on well enough for long enough. There is more work to be done around communicating and talking about benefits and being able to understand and listen for concerns."[6]

The biotech bosses' botched introduction of Generation 1 GM crops will likely be the subject of business school seminars and marketing text books for years to come. The history is brief and embattled. Consider that Monsanto scientists genetically modified a plant cell for the first time in 1982. Twelve years later, the first genetically engineered products for agriculture were commercialized in the US. The area planted with genetically engineered crops jumped more than 25-fold in a five-year period, from two million hectares in 1996 to an estimated 43 million hectares in 2000 (just three countries, the US, Canada and Argentina, accounted for 98 percent of the area.)[7] Pointing to exponential growth rates, social scientists proclaimed that GM seeds were adopted faster than any other agricultural technology in history.[8] But euphoria over GM seed sales faded fast in the absence of consumer acceptance.

What happened? In essence, biotech's first and second generation GM products were rushed to market and the biotech industry failed to consider the fact that none of their products had any basic appeal to consumers: GM foods were not cheaper, better tasting, safer or more nutritious. Meanwhile, critics charged that regulatory frameworks for assessing the safety and environmental impacts of GM crops were "inadequate, nontransparent or completely absent."[9] In the face of growing controversy, most consumers had no reason to support the new technology. The typical consumer asked: Why should I accept <u>any</u> level of risk when there's no apparent benefit and many potential problems associated with genetically modified crops and foods?

The vast majority of Generation 1 crops grown worldwide have been engineered to tolerate chemical weed killers or to express insecticidal genes. Herbicide tolerant crops accounted for 71% of the total GM area in 1999; insect resistance accounted for 22% of the total GM area. About 7% of the total GM area was devoted to "stacked traits" – that is, a GM crop that combines both herbicide tolerance and insect resistance in the same plant.[10] The primary aim of Generation 1 is to modify the farmer's use of chemical inputs applied to crops, and to expand or prolong the herbicide and insecticide businesses of the agrochemical/seed enterprises. Generation 1 can also be understood to be one arm of a pincer move to entrap farmers into a regime of input suppliers and output buyers that leave the grower with few choices.

Generation 2:

Traumas of a blighted adolescence

Following reluctantly on the heels of the first generation of GM seeds is Generation 2. Moving downstream from supplier-oriented inputs to buyer oriented outputs, biotech's second generation involves engineering of crops in order to reduce costs associated with food or feed processing. Only a handful of Generation 2 products are commercially available as yet. Most are oilseed and animal feed crops that have been modified for increased oil, protein levels or starch content. An early example of Generation 2 was Calgene's slow-rotting tomato engineered for longer shelf life (a commercial flop).[11] Other examples include high oleic soybeans that contain less saturated fat than conventional soybean oil (grown on about 20,200 hectares in 1998).[12] Because the oil does not require hydrogenation for use in frying, it reduces processing costs. High-lauric canola (edible rapeseed), produces a fatty acid that is a key ingredient in soaps, detergents, lubricants and cosmetics; it could become popular with industrial processors in the North because it replaces lauric acid previously available only from Southeast Asian

coconut or palm kernel oils. High lauric canola was grown on about 32,000 hectares in 1998.

Although Generation 2 is attractive to traders and processors, it offers nothing to consumers. Nevertheless, Generation 2 might have fared better in the marketplace except for the inherited ill-will that came with Generation 1. Even the processors concede that any cost-savings that might come with new Generation 2 products or processes are unlikely to be passed on, at least discernibly, to the people who have to eat the stuff. With many of Generation 2's inventions still not out of the starting gate, many processors and retailers have already signaled that, for the time being at least, they would rather gargle with Red Dye No.2 than gamble on products whose shelf life may be longer than their patents - and much longer than the patience of their customers.

Desperately Seeking "Gen 3"

Trumpeting the technology that has yet to be

"Perhaps the greatest challenge we face lies not in the area of technology but in marketing." -- David Rowe, Dow AgroSciences

Generation 3 is industry's attempt to convince society that it is now prepared to do what most companies believe they should have done in the first place - produce wholesome healthy foods that consumers will welcome. Unfortunately for the industry, no such products yet exist.

When Deutsche Bank declared that "GMOs are dead" in May, 1999 it sent tremors through the industry and on Wall Street but it was vastly premature to declare ag biotech "toast".[13] The Gene Giants were already desperately seeking an image "makeover". One biotech industry representative suggested, "Let's lose the term GMOs."[14] (Another eagerly offered the term, "GIFTS" - Genetically Improved Foods Through Technology and Science!)[15]

Undaunted by their lack of product, in April 2000 seven companies and the US-based Biotech Industry Organization launched a $50 million per year, 3-5 year advertising campaign to convince American consumers that GMOs are safe and beneficial. Although Generation 3 is nothing more than marketing hype, the corporate propaganda push seems to be more comfortable touting the merits of that which does not exist than that which is in the stores already. Consumers are being bombarded by the message that biotechnology will cure cancer, fight famine and either let you live longer or at least die looking younger.

In their desperation to placate the public, genetically engineered Vitamin A rice, so-called "Golden Rice", has been appropriated as a PR tool for the biotech industry – despite the fact that it was funded entirely by the public sector and is still years away from commercial release.[16] In December 2000 Monsanto announced that it would cooperate with Indian scientists and Michigan State University and the US Agency for International Development to develop a "Golden Mustard" that will yield cooking oil high in beta-carotene for Indians who suffer from vitamin A deficiency.[17] Thus, third generation biotech products are being promoted in the name of the South's poor and hungry. While Generation 3 could have far-reaching applications in the South and the North, the vast majority of these products will have little to do with feeding poor people or promoting sustainable agriculture. The target market is the affluent consumer, and the applications are intended primarily for the commercial pharmaceutical, food and personal care / cosmetics sectors.

"If the industry could snap its fingers, and we could have Golden Rice and other products to try, then this industry would be pulling itself out. Unfortunately, we don't have these products." – Sano Shimoda, biotech industry analyst[18]

Dis-Aggregating the Food Chain

The Generation 3 strategy

The strategy behind Generation 3 is not merely to come up with something consumers will be prepared to pay for, but to *redefine* the consumers' concept of food in order to gain total control of the food system. This is not a new El Dorado. Since the sixties, food processors and retailers have struggled to shift the food focus from produce to package; off cheap garden-variety commodities and onto "value-added", branded products. While they have been successful with highly-processed and multi-ingredient items such as snack foods, confections and canned goods, they have made little headway with fresh produce. Consumer brand loyalty to the classier goods has proven to be uncomfortably price sensitive. Generation 3 will really "bring home the bacon" only if it can convince consumers to purchase identity-preserved "nutraceuticals".

The trick is to move shoppers from generic fruits, veggies, cereals, meats and dairy products to branded "enriched" produce and, from there, onto recipe regimes that sideline oranges and lemons for "citrus-plus" brands or discard coffee and teas for "caffeine-plus" revitalizers. Shoppers must be drawn to a list of prepared groceries geared to their genetic profile; or to "*morph menus"* and "*cosmo-cuisines*"

programmed to transfigure body shape and appearance.

Higher prices at the consumer end represent only one piece of the pie Generation 3 offers to food vendors. Dimming the consumers' consciousness of crops allows processors and retailers to source their raw materials more widely; to concentrate on brands rather than biology; and to weaken (though not wipe-away) climatic and seasonal constraints. High-performance "nutraceuticals" might be manufactured in goat's milk, insect bellies, yeast, or maize stalks - either in a factory fermentation process or on a molecular farm. Betting that customers want cancer-curing vegi-snacks more than cauliflower, the industry will be able to drive hard bargains with commodity producers and their governments.

Breaking free of the food chain, processors and retailers will be able to redefine food and agriculture - and the regulatory systems associated with them. The nutriceutical strategy requires tight control of every aspect of production and processing and makes it eminently reasonable (even preferable for health and environmental reasons) for regulators to allow unprecedented horizontal and vertical integration in the food / health system. In the name of biosafety -- bioserfdom!

Pipelines, Pipe Dreams and Pied Pipers:

What is being said about Generation 3?

The scope of potential Generation 3 offerings (that is, genetically modified products with perceived benefits for consumers) is enormous. The high-tech cornucopia includes the far out and whimsical such as foamier beer, cavity-fighting fruit, slow-growing grass seed, and silk-spinning goats. Other potential products aim to meet compelling human health needs such as life-saving vaccines and therapeutic proteins. (See table.)

> *"We were all once sure what food was. Now we're not sure when a food becomes functional. It's not anyone's fault. It's a reflection of the times."* - Dr.Christine Lewis, US Food and Drug Administration, Office for Special Nutritionals[19]

In the following pages, RAFI examines two major areas of Generation 3 research: nutraceuticals ("functional foods") and agriceuticals ("biopharmaceuticals" including molecular farming and other industrial products). Research in these areas demonstrates vividly that the lines between farm and pharmacy, food and medicine are blurring – and may soon become indistinguishable. With the new generation of products, observes Manfred Kroger of Pennsylvania State University, "We are witnessing the marriage of the food and pharmaceutical industries."[20]

Pharmacopia - Fictional Functional Foods and Nutraceuticals

The premiere Generation 3 products will likely be the "nutraceuticals" or "functional foods," said to contain medicinal or other beneficial properties. These foods – typically premium-priced products - will be marketed as providing health benefits beyond basic nutrition.

Functional foods are not new, and existing products are not genetically modified. In the US, functional food sales are an estimated $20 billion per annum, with growth rates of 10% per year expected well into the 21st century. Globally, sales of functional foods are currently estimated at $65 billion per annum – and that's without genetic engineering.[21] (By comparison, the worldwide market for organic food will reach an estimated $20 billion this year, and is expected to reach 15% of total food consumption by 2005.[22])

The most high-profile, functional food of the future is the highly-touted "Golden Rice" – beta-carotene-enriched, GM rice that aims to address Vitamin A deficiency in the South. Despite the fact that Golden Rice research was funded entirely by the public sector, the biotech industry has appropriated it as a potent public relations tool, and proof positive that GM foods aim to feed the hungry. (For detailed background on Golden Rice, please refer to: "Golden Rice and Trojan Trade Reps." *RAFI Communique*, September / October 2000.)

Most functional foods of the future are not likely to be found in poor farmers' fields or in their cooking pots, but on supermarket shelves and in suburban kitchens. While "rudimentary" functional foods such as orange juice fortified with calcium, or margarines designed to lower cholesterol, are now commonplace, a new generation of nutraceutical products is in the pipeline. Pharma and food giants are making modest investments in the future of functional foods. For example:

- Novartis and Quaker Oats announced in early 2000 a 50 / 50 joint venture named Altus Food Co. to focus on functional foods for the North American market.

- In February 2000 Novartis Agricultural Discovery Institute announced a multi-year deal

with SemBioSys Genetics of Canada to develop proprietary products for nutraceutical, cosmeceutical and pharmaceutical markets.

• In July 2000 Archer Daniels Midland, Aventis CropScience, SKW Trostberg and Burrill & Co. announced the formation of a new $30 million venture capital fund for nutraceuticals.

• In February, 1999 General Mills licensed exclusive rights to a UK biotechnology company's appetite suppressant, known as "Olibra" – a natural product that the company claims fools the gut into believing it is full.[23]

Researchers are identifying a host of "phyto-nutrients" – chemical compounds in plants, that could offer health benefits for specific diseases. Lycophene in tomatoes, for example, is believed to lower the risk of prostate and cervical cancer. Fish oils with omega-3 fatty acids for lowering the risk of breast cancer; sulforaphane derived from broccoli sprouts to generate cancer-blocking enzymes; lutein from kale to lower the risk of age-related blindness. Using genetic engineering, scientists are seeking to amplify and re-arrange a plant's natural ability to express phytonutrients. As a result, companies are engineering Vitamin C lettuce, maize that combats iron-poor blood, tomatoes with beta-carotene, and much more.

According to John Finley of Kraft Foods, "Biotechnology can be a powerful tool in the development of a new generation of functional foods that deliver clear health benefits."[24]

While many health experts believe that biotech can't easily improve on naturally-occurring chemicals that are readily available in whole foods, the pharmaceutical and food industry will be more interested in the value-added, profit potential of a processed food and branded product. Of course, it isn't necessary to splice genes or crack the genome to engineer new food / health products. But the biotech industry is betting that therapeutic foods touting anti-cancer, anti-aging or memory-enhancing properties will prove irresistible to the food industry and affluent consumers everywhere.

Proponents of biotech and functional foods predict that genomics research will someday revolutionize our ability to use prescription drugs and designer diets to stave off developmental deficiencies, diseases or disorders predicted by an individual's genetic profile.

"In the future, foods may be matched to an individual's risk for chronic disease. This is how food and agriculture are going to develop as we move into the next [21st] century," explains professor Bruce Watkins of Purdue University, "We'll be going beyond eliminating hunger to actually protecting individuals from specific diseases."[25]

Functional food enthusiasts envision a future where consumers will be able to shop based on individualized genetic analysis and nutritional needs. The supermarket of the future will include a health clinic offering quick blood tests and customized shopping lists based on disease risks. Individuals with a genetic pre-disposition for blood clots, for example, could be directed to food products laced with blood thinners.[26] "Eventually," writes Kathryn Brown in *Discover*, "the focus on individualized nutrition will begin before birth when an amniotic fluid from an unborn baby will allow parents to select optimal functional baby foods based on genome analysis."[27] (Issues of genetic discrimination and privacy that are raised by these futuristic scenarios, are, of course, enormous and far-reaching.)

> *"In the next 20 years, there will be revolutionary products creating new markets in areas that we only dream of today. Food will become healthier and even therapeutic. For example, your diet might comprise a meal of spaghetti where the flour for the pasta contains ingredients that lower your chance for colon cancer by 75%, the tomatoes in the tomato paste include antioxidants that will decrease aging and the iced tea that you drink will ease your anxiety…With genetic engineering and the rapid discovery pace of genomics, there is no reason why we could not provide these benefits through enhanced diet."*
> - John A. Ryals, Paradigm Genetics[28]

Dysfunctional Foods: So, consumers might wonder, if the new stuff on the shelf is a functional food, what is all that other stuff I've been eating all my life? "Functional foods are about marketing, not health" asserts Professor Marion Nestle, professor of nutrition and food studies at New York University. Nestle told *Progressive Grocer*, "My concern is that functional foods will distract people from eating healthy diets and encourage companies to market absurd products as health foods because they contain one or another single nutrient." [29]

The hype surrounding a new generation of nutritionally enhanced food products stands in stark contrast to the commercial food industry's standard, ever-popular fare: "dis-functional foods" that have promoted rampant obesity and dietary disorders among millions of people – both rich and poor -- in the industrialized world and increasingly in developing nations.

Pandora's Pipeline?

HIV Vaccine: Researchers at CropTech Corporation are genetically modifying tobacco in an effort to produce a vaccine against HIV. *AgBiotech Reporter*, June 2000, p. 29.

Therapeutic drugs in transgenic sheep: PPL Therapeutics is producing a transgenic protein in the milk of transgenic sheep, that could be used to treat cystic fibrosis. The company plans to build a $67 million plant in central Scotland to manufacture the pharmaceutical protein. *AgBiotech Reporter*, March, 2000, p. 10.

Suicide Carrots: Scientists in Australia announced in early 2000 that they have developed a "vaccine," produced in genetically modified carrots, that sterilizes possums. (In New Zealand, possums consume an estimated 20,000 tons of foliage a night.) Carrots were chosen to deliver the vaccine because scientists assert that there is no chance of carrots propagating in the wild. *AgBiotech Reporter*, March, 2000, p. 29.

Tomato Vaccine: At the University of Illinois, scientists are modifying tomatoes to express a vaccine for respiratory syncytial virus, or RSV, which causes pneumonia and bronchialitis, especially in newborns and infants.

Silk Producing Dairy Goats: Goats that are genetically altered to yield silk protein in their milk will be used to manufacture fibers known as "BioSteel." A Canadian company, Nexia Biotechnologies, will use a herd of 150 goats engineered with spider genes to manufacture super-strong silk, a fiber for making bullet-proof vests, aerospace materials, or medical sutures. Anonymous, "Goat Spider Experiment," The Associated Press, Plattsburgh, New York, June 18, 2000.

Long-lasting flowers: Senseco is extending the shelf-life of carnations through the use of biotechnology. Using anti-sense technology the company has silenced a senescence-induced lipase gene – which prevents membrane degradation. *AgBiotech Reporter*, December, 1999, p. 7.

Anti-Cancer Eggs: AviGenics has developed genetically modified chickens that produce pharmaceuticals in their eggs. The company is producing birds whose eggs contain interferon for cancer treatment. *AgBiotech Reporter*, December, 1999, p. 19.

Cavity-Fighting Fruit: Researchers at Britain's Horticulture Research International are developing GM apples or strawberries that will fight tooth decay. The fruit is designed to express a protein which protects teeth from tooth decay. *AgBiotech Reporter*, September 9, 2000.

Plastic from Maize: Construction has already begun on the first manufacturing facility to make plastics out of maize. Cargill Dow is developing a facility that will begin in 2002, requiring 40,000 bushels of maize per day. *Ag Biotech Reporter*, May, 2000, p. 6.

Non-Narcotic Poppy: Scientists at India's Central Institute of Medicinal and Aromatic Plants have developed an opium poppy with non-narcotic seeds. The protein-rich seed has a 52% oil content, and can reportedly be used to control heart disease. *AgBiotech Reporter*, January, 2000, p. 20.

Self-Lighting Xmas Tree: In the UK, graduate students entering a biotechnology contest have described a genetically modified, self-lighting, Christmas tree. The modification involves a Douglas Spruce using genes from fireflies and jellyfish. *AgBiotech Reporter*, November, 1999, p. 27-28.

Foamier Brew: German researchers are working on a genetically modified yeast which produces a superior, more reliable foam for beer. *AgBiotech Reporter*, May, 2000, p. 24

Lactose Tolerant Milk from Cows: Billions of people, especially in Asia, lack the enzyme lactase, which breaks down the lactose protein in milk. French scientists aim to overcome lactose intolerance by engineering dairy cattle that express lactase in their milk. Fumento, M. "Why 'Frankenfood' is Our Friend," *Forbes Magazine*, December 12, 2000.

"Commerciogenic malnutrition"[30] has spawned a nutrition paradox: an over-abundance of food products and calories threatens public health and promotes diseases of the affluent. Dietary, marketing and consumption trends in the US illustrate the increasingly global phenomenon:

- Americans guzzle 15 billion gallons of soft drinks annually, 585 cans per person, at a cost of $54 billion. Consumption of soft drinks has more than doubled since 1975. More soda is consumed than milk or water.[31]

- McDonald's yearly marketing budget is $1.1 billion. By contrast, the US government's National Cancer Institute spends $1 million per annum to promote the health benefits of eating fresh fruits and vegetables.[32]

- Between 1976-80 and 1988-94, the rate of obesity among US adults jumped by over one-third, from 25% to 35%.[33]

- The annual costs of direct health care and lost productivity resulting from obesity is almost 6% of total US health care expenditures, or over $52 billion per annum.[34]

In other words, if the food industry really wants to use its marketing genius to create a new generation of healthy eaters, it could do so - fast and cheaply - by jettisoning much of its current product line - or simply by 'shake 'n baking' the brand bosses or micro-waving Madison Avenue!

Pharmageddon - Fictional Agriceuticals

Genetically engineered plants and animals are potentially a cheap way to produce "agriceuticals" or "biopharmaceuticals" and industrial chemicals – ranging from plastics, enzymes, antibodies, vaccines, etc. Since the food sector is usually only after the plants' fruit or seed, that leaves the stalks, roots or leaves for the manufacture of other products. Why not use sunlight and photosynthesis to do double-duty? The estimated cost of producing recombinant proteins (vaccines, antibodies and therapeutic proteins) in plants could be 10 to 50 times lower than producing the same protein by standard fermentation methods, depending on the crop.[35] The biotech companies claim that the production of recombinant proteins in plants is safer because mammalian cell culture and animal milk can introduce harmful viruses into the drug, while plant viruses are not known to infect people.

Globally, about 20 companies are working on producing pharmaceuticals in plants, and a number of drugs are already in clinical trials. Scientists optimistically predict that recombinant pharmaceuticals from transgenic plants will be commercialized within five years.[36] Developers of edible vaccines in transgenic plants point to a number of successful clinical trials over the past year:

- In February 2000 ProdiGene (Texas, US) announced that its clinical trials have proven for the first time that an oral vaccine expressed in maize plants can protect swine from a virulent viral pathogen – transmissible gastroenteritis (TGEV).

- In July 2000 Cornell University scientists announced that human immunity to Norwalk virus had been triggered by a vaccine genetically engineered into a potato – the results of one of the first human clinical trials of a plant-based, edible vaccine. The Norwalk virus is the leading cause of food-borne illness in the industrialized world. [37]

- In November 2000 scientists reported that mice fed a transgenic potato vaccine for Hepatitis B developed an immune response. The same scientists aim to genetically modify bananas, which can be eaten raw, to contain vaccines for a range of tropical diseases.

Many other experiments are underway. At North Carolina State University, for example, researchers are attempting to engineer transgenic tobacco plants to yield a cervical cancer vaccine. The patented vaccine, now being clinically tested by SmithKline Beecham, is too expensive to produce by conventional methods. The goal is to cheaply purify large quantities of the vaccine from transgenic tobacco leaves, and to simultaneously develop a new, "life-saving" cash crop for financially-strapped tobacco farmers.[38]

SemBioSys (Calgary, Canada) has developed a proprietary oilseed technology that enables high-value pharmaceutical proteins to be readily separated and purified – a technique the company claims will make genetically engineered oilseed plants a cost-effective method for producing biopharmaceuticals. In January 2000 SemBioSys entered a multi-year product development agreement with Novartis.

No Agriceutical Protocol: Molecular farming raises a host of human health and environmental concerns,[39] particularly because "genetic drift" from GM crops cannot be easily contained or monitored. What if pollen from a drug-containing, GM plant fertilizes a nearby food crop? How will crops that are engineered to produce industrial chemicals or drugs affect soil microorganisms or beneficial insects? What if biopharmaceutical crops end up in animal feeds? Will pharmaceutical proteins be altered in unforeseen ways during plant growth, harvesting and storage? Could they cause allergies?

A variety of strategies to mitigate environmental contamination (and to lessen the regulatory burden) are already being developed. Some companies suggest that drug-producing crops could simply be harvested before they reach sexual maturity, thus preventing cross-fertilization. Another technique for plugging "gene leaks" will likely be the application of genetic seed sterilization to pharma crops – the controversial Terminator technology, which is being actively promoted by the US Department of Agriculture as an environmentally-friendly technology to control unwanted gene flow. CropTech (Virginia, USA) is using genetic trait control technology so that the expression of pharmaceutical genes is induced post-harvest. CropTech points out that if the biopharmaceutical compound becomes active only *after* the crop has been removed from the field, it will eliminate many regulatory hurdles.[40] Others have suggested that companies could prevent drug-producing plants from entering the food supply by engineering color-coded genes, so that a brightly colored pharma crop could be visibly traced.[41]

Gen 3's Non-GM Strategy: As the industry recoils from its disasters, there is growing commercial interest in the potential for non-GM seeds and products. Two genetic facts are stirring interest and optimism among companies that would like to avoid the stigma associated with genetically-modified products. First, as we were reminded earlier this year with the announcement of the first preliminary map of the human genome, we share half our genes with a banana. Many very different species actually share DNA sequences that may or may not be expressed. Second, the vast majority of DNA in any modern species may not actually be used - material set aside over the long process of evolution. The commercial point is that scientists might often be able to replicate a genetic trait they have identified in one species within their target species without having to transfer genes between species. Only gene expression would change. By employing *intra-genics* rather than transgenics, industry would sidestep regulators and the Biosafety Protocol; silence those with religious and moral objections to "unnatural" manipulations; and spread confusion among biotech's critics who have staked their opposition on "transgenics" rather than on the wider risks and social implications.

Biotech companies are already spinning a "non-transgenic" message to woo consumer acceptance. Consider the following example: The developers of a genetically modified salmon, engineered to grow to full size in half the usual time, seek to squelch GM critics by asserting that their fast-growing salmon represents "the first all-natural transgene." The President of Aqua Bounty (Massachusetts, USA) asserts, "All we've done is change one gene in the salmon to allow it to utilize its own growth hormone more efficiently. It should appeal to organic farmers – it's the marriage of biotechnology and the principles of organic farming."[42]

In its later stages, Generation 3 will be non-transgenic. This does not mean that it will be environmentally safer or socially beneficial, it is simply a new strategic maneuver.

Who will control Generation 3?

Life Industry: Doomed or Dormant?

Will the Gene Giants lose out to "All-Mart" and the Big Bio-Boxes?

Since 1996 RAFI has prepared annual updates on the life industry – the giant corporations that control ever-increasing market share in the integrated areas of drugs, pesticides, seeds and veterinary medicines. The consumer backlash against GM foods, combined with lower profit margins for agribusiness, has prompted some observers to declare the life industry model obsolete. Drug-makers, fretting that their pharmaceutical sales would be tainted by association with GM foods, began to restructure in late 1999. When Pharmacia acquired Monsanto in November 1999 it quickly spun off the ag biotech company as a detached agribusiness unit. However, Pharmacia retains 86% control of the new, independent entity. In December 1999 Novartis and AstraZeneca announced that they would merge their seed and agrochemical businesses under the newly created "Syngenta."

But Novartis shareholders retain 61% of the newly formed company, and AstraZeneca shareholders receive 39%.[43]

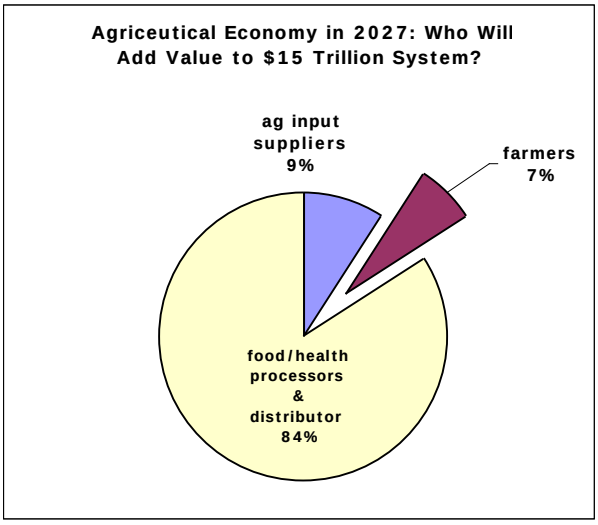
Claiming "modest synergies" between healthcare and agribusiness, Aventis is the first Gene Giant to jettison its agricultural assets.[44] Plagued by the StarLink maize scandal, the company announced on 15 November that it would divest its agribusiness division, valued at US$5,100 million. "We do not have to stick to the life science concept," said one Aventis spokesman.[45]

While some corporations are attempting to sever the agbiotech connection, others are embracing a GM future. In March, 2000 the German agrochemical company BASF boldly announced that it would invest US$680 million in agricultural biotechnology – with the clearly stated goal to: "develop plants with improved ingredients that have an obvious benefit for consumers." (emphasis added). Dow recently boosted its seed industry and biotech investments by acquiring Cargill's US and Canadian hybrid seed business. Combined with its Mycogen business, Dow will have estimated seed revenues of $350-$400 million per annum[46] – making it one of the world's top 10 seed corporations for the first time.

"Agriceutical" System of the Future: Ray Goldberg, the Harvard Professor who coined the term "agribusiness" back in 1957, would argue that the life industry concept is not dead – just dormant. In the longer term, Goldberg foresees the creation of a global "agriceutical system" that will employ over half the world's population, utilize half the assets of the world, and supply over half of the consumer expenditures in the world by the year 2027.[47] The combination of health, science, and agribusiness is almost double the size of the agribusiness sector alone at over $15 trillion.

Goldberg envisions the integration of health care, food products and services at every level in the agriceutical chain, from the most fundamental research and development to the consumer. Genomics -- biochemical and genetic information -- is the common research tool that will feed the agriceutical chain. Gene discovery and function analysis in plants, animals and humans will identify common traits, as well as interactions between the genomes of different species. Genomics will become especially important in elucidating individual responses to diseases, drugs and foods.

As corporations consolidate and the science becomes more complex, it will be difficult for any one agriceutical firm to rely only on its internal resources. Goldberg estimates that at least 20-30% of a firm's research and development will come from outside the agriceutical firms. Joint venturing and cross licensing will become more important than ever. Goldberg notes that supermarkets ("no longer just glorified grocers") will play a key role in the agriceutical system because "they represent the consumer in all ways." He cites examples of supermarkets working closely with hospitals, physicians, and disease management companies to provide counseling, services and other goods to manage specific diseases. In the US, supermarkets already account for a substantial fraction of the retail prescription sales of pharmaceuticals.[48]



Fifty years ago, the farmer contributed roughly 32% of the value added to the food chain and the food processor and distributor accounted for 50%. By the year 2028, Goldberg estimates that farmers will account for only 7% of the value-added to a consumer product in the global agriceutical system. Not surprisingly, food/health processing and distribution will account for a whopping 84% of the value-added.

The Consumer Cuddle Crunch

Processors versus Retailers

In 1981, the now-defunct United Nations Centre on Transnational Corporations published a 242-page report on the food and beverage processing industry, including a 1976 ranking of the world's largest food and beverage corporations.

RAFI's comparison of the 200 largest food and beverage companies in 1976 with today's top 200 reveals that over half (54% or 108 companies) are gone, either through merger or acquisition (99), or diversification away from food (9). Today, consolidation in the food sector is accelerating dramatically. In the first six months of 2000 alone, there were close to $150 billion in food industry consolidations and the still greater mergers are in the making.[49]

Appetite for Acquisitions

Sample Takeovers in the Food & Beverage Industry - 2000

Buyer/Bidder	Acquisition	Value – US millions
Unilever	Ben & Jerry's ice cream	$326
Unilever	Slim-Fast	$2,600
Unilever	Bestfoods	$20, 300
Philip Morris	Nabisco Holdings	$14,900
General Mills	Pillsbury	$5,400
ConAgra	International Home Foods	$1,600
Cadbury Schweppes	Snapple	$1,500
Kelloggs	Keebler	$3,860
Heinz	Beech-Nut ((pending)	$185
Interbrew	Bass	$3,450
Scottish & Newcastle	Kronenbourg	$2,700
Smithfield Foods (bid)	IBP (pending offer)	$2,700
Tyson Foods (bid)	IBP (pending offer)	$2,800
PepsiCo	Quaker	$13,400
Diageo & Pernod (bid)	Seagram's	$8,150

According to industry analysts, the current feeding frenzy in the food & beverage industry is driven by the need to counter the colossal purchasing power created by supermarket mega-mergers.[50] With giant retailers such as Wal-Mart moving aggressively into food sales, traditional retail grocers are forced to bulk up their purchasing clout, brand names and distribution channels.[51] The giant supermarket chains typically cut costs by dealing with fewer suppliers, and that means fierce competition for shelf space. Food giants like Unilever, Philip Morris and Nestle (the mega-brand holders) are snatching up popular, global brand names in an attempt to lock-in their place on the shelf. Analysts predict that "second-tier" food companies will continue to exist only if they can continue to drive innovation. As a result, mid-size companies like Campbell Soup and Sara Lee are irresistible takeover targets and will continue to fuel corporate consolidation.

Mega-food retailers (Wal-Mart, Carrefour, Ahold) are increasingly calling the shots in the food & beverage industry. It is widely predicted that only half a dozen global food retailers will ultimately survive current consolidation trends.[52] One analyst believes that *five* global food retailers will mop up the competition by 2002.[53] In the US alone, the top 5 food retailers now control 52% of all commodity volume.[54] (Just five years ago 10 companies controlled 40% of grocery sales.[55])

> *"The branded food industry has been in a very rare position over the last 10 years. It has gained around 2 billion new consumers and in emerging countries, as soon as per capita income exceeds $3,000, that money tends to be spent on branded food. World demographics would dispel any doubts about the future of the industry. We are not at all pessimistic about the prospects for the future."* – Francois Peroud, Nestlé[56]

From farm to fork, food retailers and manufacturers are now diversifying across the food chain – with far-reaching impacts on farmers and agricultural economies. ConAgra boasts that each of its branded foods has annual retail sales exceeding $100 million, and its food service subsidiary is the largest provider of products for restaurants, fast-food chains and other food service customers in the US.[57] Dutch supermarket giant, Royal Ahold, one of the first retailers to have supermarkets on three continents, paid $3.6 billion earlier this year to acquire U.S. Foodservice – a company that provides over 43,000 food and related products to restaurants and institutions (hospitals, schools, etc.). One month later, Ahold invested $73 million in PeaPod, a leading on-line grocer. "No other food

retailer is in the position we're in," boasts Royal Ahold, "Our customers now have three options: go to the physical store, eat out, or order over the Internet. Whether it's at a restaurant, sports stadium or a hospital, we have a strong presence."[58] Mergers in food retailing and manufacturing are giving mega-retailers unprecedented purchasing power, with the ability to make or break distant agricultural economies. For example, all Royal Ahold companies in 23 countries buy coffee from a single source: Colombia.[59]

There's little doubt that a rapidly decreasing number of food industry giants (both retailers and manufacturers) are locking up vital links across the food chain. But will these companies ultimately embrace and invest in GM technology? The corporate food industry won't openly embrace biotech until consumer confidence is restored and consumer benefits are visible. In reality, there's no compelling need to splice genes when you can use alternative processes and achieve almost the same results. Industry insiders told RAFI that mega-food retailers are not innovators, and they won't go down the biotech path until the rest of the industry (food processors / manufacturers) take them there.

Wal-Mart is already merging groceries, consumer goods, drugs and retail financial services within its 'Super-Centres' and, with US$156 billion in retail sales in 1999, Wal-Mart already controls an astonishing 5 per cent of the total US$3 trillion US retail market.

Today, the top five grain trading enterprises control more than 75 per cent of the world market for cereals[60] and similar levels of concentration exist for most internationally traded commodities. According to one recent study, a handful of transnationals control about 90 per cent of the global trade in wheat, maize, coffee, cocoa and pineapple; about 80 per cent of the tea trade; 70 per cent of the global banana and rice markets; and more than 60 per cent of the world trade in sugar.[61] One Mexican-based transnational commands 40 per cent of the US vegetable seed market and 25 per cent of the commercial vegetable seed business worldwide. Remarkable levels of concentration are also developing at the retail end of the food chain in both OECD and Southern countries. Half of the national vegetable business in Costa Rica is dominated by one enterprise. One company controls 40 per cent of the same market in Honduras. Five retailers control 50 per cent or more of all food purchases in France, Germany and the UK.[62]

Top 10 Global Food & Beverage Corporations

Company	1999 food revenue US$ millions	1999 revenues US$ millions
Nestle	34,900	49,400
Unilever + Best	32,400	55,300
Philip Morris	27,800	78,600
Cargill	21,000	48,000
Pepsico	20,367	20,367
Diageo	19,540	19,540
Con Agra	19,000	24,600
Coca Cola	19,000	19,000
Mars Inc.	15,300	15,300
Archer Daniels Midland	14,300	14,300

Sources: *Prepared Foods, NYT* 6/7/00

How long before we see a Nestlé or Conagra make major investments in genomics and GM technology? When Pharmacia puts Monsanto up for sale in the near future (widely rumoured), will Unilever or Archer Daniels Midland be bold

Top 10 Global Food Retailers

Company	1999 revenues US$ millions
Wal-Mart*	164,900
Carrefour*	80,000
Kroger	45,400
Metro Ag	39,800
Royal Ahold	33,800
Tesco	30,352
Safeway	28,860
Ito-Yokado	28,671
J. Sainsbury	26,218
Groupe Auchan	23,493

* Total store sales, not just food.
**Estimated revenue for supercenter stores which sell groceries and other goods. Sources: *Washington Post*, November 19, 2000.

enough to make a public bid? Probably not. It is more likely that food & beverage companies will continue to make low-key, strategic alliances with junior biotech firms like Paradigm Genetics, Prodigene and SymBioSis before they acquire a Gene Giant. But what about the year 2020? As food and pharma products merge and morph, the biotech synergies will continue to grow. In the medium to long term, it's more likely that food giants will "grow into biotech" through the acquisition of major drug companies. DuPont and Nestle already have pharmaceutical subsidiaries, for example. Will Wal-Mart gobble a Glaxo, or will Nestlé devour a DuPont? What may seem silly today, may prove common sense in the post-gene sequencing era.

Identity-Preserved Customers

A New Leach on Life Insurance?

> *"Consumers are linked now by one common interest. Everyone wants to live longer but nobody wants to grow older."* - John P. Troup, Novartis[63]

In a world in which "e-commerce" dominates the media - if not yet the market - retailers not only need to consider online grocery shopping / delivery systems but the need to consolidate "regular purchase" consumer goods into fewer and fewer convenient locations. Food, drugs, and personal care products all "fit" into one big bio-box in every way. At the manufacturing end, they involve the same technologies. At the marketing end, they meet the same broad consumer-buying pattern. In the battle between the manufacturers and the marketers (processors versus retailers) either party could dominate but it is likely the industry that wins the minds and hearts of the consumers who will take over. Retailers have the closest consumer contact. The more customer purchases can be "prescribed" at the bio-box, the more likely retailers are to win control. Processors, on the other hand, can more effectively use the media to advertise specific brands around the entire world. They are also more familiar with the technologies involved. There's a $15 trillion market up for grabs.

Given the stakes involved, other corporate interests could also become players. Designer diets and nutraceuticals generate valuable "identity-preserved" customer information, too. The commercial sector most interested in that information - and most interested in maintaining wage-earning, long-living clients - is the life insurance industry. The world's dominant life insurers generate vast revenues and profits (the top global insurance firms have a turnover of $60-$80 billion per annum compared to $20-$50 billion for food majors) and have the deep pockets necessary to takeover bio-commerce. Because insurance companies invest their funds in other companies, they also have an intimate understanding of the workings of the biotech and pharmaceutical industries.

This, according to some, could be seen as the "good news." Life insurers traditionally gain the most if we live longer - a subject of considerable mutual interest. However, drug companies make the most when we are just ill enough to be repeat buyers of their products while being well enough to keep our jobs. A merger of the two sectors - along with the food system - would guarantee life insurers of profits in any or all of three ways. If you're healthy and trying to stay healthy or if you just like to eat lots, a tri-sector merged enterprise would be selling you nutraceuticals and junk food both. If you're sick and are eating to get better or in search of medicinal help, the same company's agriceuticals are at your service. If you die insured, the company probably gleaned enough data on your health and habits to still have made a tidy profit on your insurance premiums.

What of genetic privacy? It becomes a moot issue if your doctor (or your *grocerologist*!) becomes your insurance agent.

Governing Generation 3

Generation 3 meets Generation X?

Will Generation 3 offer society a new prescription for better living? Will workers gain employment security? Will farm profitability improve? Will Gen 3 create new marketing niches and cash crops? Opinions vary. In RAFI's view, Gen 3 is most likely to extend BioSerfdom (as first described by RAFI in 1997) throughout the food production / processing system to incorporate consumers as well as producers.

Generation 3 and Those Who Feed Us: The overall success of "value-added" crops and the ingredients they produce will require a failsafe "identity-preserved" infrastructure –the capacity to segregate high-tech crops (and livestock) from generic commodities and to trace them every single step from seedling to supermarket. In some cases, industry will provide marketing incentives for growers to participate. For example, when a farmer agrees to purchase a certain amount of Cargill seed, the company provides a grain bin

which is designed to preserve the identity of the value-added material on the farm.[64] The evolving system has been aptly described as a "captive acre" in which the farmer will work with a single company to acquire all inputs – germplasm, chemicals, information - needed to produce a high-value crop or livestock. [65] Typically, transgenic crops and livestock will be owned by the company and grown under contract.

Tony Laos, president of Stauffer Seeds, predicts that within 10 years 10% of the maize acreage in the US will be devoted to production of pharmaceutical and industrial proteins contracted through Stauffer Seeds and ProdiGene. "In the next few years there will be tens of thousands of acres devoted to this type of value-added production."[66] CropTech, a Virginia-based (USA) company hoping to produce human serum albumin (a blood product) in GM tobacco plants, points out that 45,000 acres would be needed to satisfy world demand.[67] But in other cases, depending on the pharmaceutical, the amount of active ingredient required to treat the entire patient population might be quite small. "Many of these pharmaceuticals will only require a small-sized farm to serve the whole market," observes Vikram A. Paradkar of Monsanto's Integrated Protein Technologies.[68]

Molecular farming will be capital-intensive and proprietary. It will require a huge investment in infrastructure and germplasm, as well as steep insurance premiums and high bio-security. For example, Nexia Biotechnologies of Montreal recently located its first herd of 150 transgenic goats in a converted weapon storage facilities on a former Air Force base! A company spokesperson reassured the public, "We feel the site is a very secure setting."[69]

The vice-president of Ifigen, a biotech company that aims to produce pharmaceutical compounds in cow's milk, points out that molecular farms and transgenic livestock will be beyond the reach of a typical farmer. "These will be million-dollar cows, so high levels of management will be required."[70]

> "GM is an unsettling exception to a rule that farmers have followed for generations: that early adopters of a new technology reap the greatest rewards." - *The Economist*, 3/25/00 "Survival Kits: How farming is reinventing itself"

Proponents of GM technology are quick to point out that genetically engineered crops have been adopted faster than any other agricultural technology in history.[71] Just three countries, the US, Canada and Argentina, accounted for 98% of the global area planted in transgenic crops in 2000.

That US farmers have embraced the technology is evidence, assert GM proponents, that transgenic crops offer benefits for farmers. The reality is far more complex. For one thing, GM crops have penetrated US agriculture during a prolonged and severe farm crisis of staggering proportions. As the *New York Times* noted earlier this year,

"While most of the American economy is going gangbusters, many rural areas are undergoing a wrenching restructuring that is impoverishing small ranchers and farmers, forcing them to sell out, depopulating large chunks of rural America and changing the way Americans get their food."[72]

Industry proponents proudly point out that genetically modified seeds accounted for almost half the US soybean harvest and 55 percent of the US cotton harvest last year, a sure sign that farmers are enthusiastically adopting and benefiting from transgenic crops. But they ignore the fact that farmers may be embracing GM technology out of economic desperation – and because they don't have a lot of other choices. According to U.S. Department of Agriculture economists, this year's price for soybeans will be the lowest in 28 years. The price of maize and wheat will be the lowest since 1986/87. Corporate oligopolies dominate American agriculture, and, in the case of seeds, US farmers may be forced to "take what you're offered."[73] For example, one company, Delta & Pine Land, controls over 70% of the US cotton seed market; and just two companies, Monsanto and DuPont, control 73% of the US seed corn market.[74] Given the lack of choice and desperate economic conditions, it's difficult to conclude that US farmers are sold on GM technology. Empirical evidence on the benefits of GM crops for US farmers remains inconclusive, at best, and highly variable.[75]

Meanwhile, Monsanto is so confident that its "RoundUp Ready" (herbicide tolerant) soybeans will increase the farmer's bottom line, the company is offering to pay qualified soybean growers up to $10,000 each if their RoundUp Ready seed doesn't provide equal or better net income than the traditional system.[76] Monsanto's promotional offer can best be understood as a marketing strategy to cope with the expiration of Monsanto's blockbuster patent on RoundUp, which expired in September, 2000. Roundup sales

of $2.5 billion accounted for 27% of the company's revenues in 1999.[77] With its reputation staked on the future of GM seed, Monsanto is literally fighting for its economic life, and will do whatever it can to secure loyal herbicide and GM seed buyers.

If you are an agricultural worker or are employed anywhere in the food, agriculture or pharmaceutical sectors, the future is intensely uncertain. The bargaining position of farmers and other workers in specific commodities - weak already - will become weaker yet.

Generation 3 and those it would feed: What of the South? The biotech industry asserts that Generation 3 products, such as edible vaccines and Vitamin A rice, offer the potential to cure disease and malnutrition in the South. In theory, Generation 3 could have positive or negative implications for poor producers and consumers. In the long-run, however, it is not genetically-modified (*intra-genic* or *transgenic*) cassava, banana vaccines, or Golden Rice or Golden Mustard that will affect the greatest number of the South's resource-poor farming communities. More substantial and sudden impacts are likely to come from the less glamorous and seemingly benign GM products which could turn traditional commodity markets (and their producer associations) upside-down.

Generation 3 products have the potential to change not only *where* our food is produced, but also *how* it is produced, and by whom. While all agricultural economies will be affected, the South is far more vulnerable to economic disruption and hardship. For example, novel production processes could alter, reduce or eliminate the need for traditional cultivation of tropical crops and commodities in the South, or could transfer production to more favorable conditions (climate, labor costs, location, etc.) for industrial processors. New, natural substitutes may eliminate tropical export markets for some high-value products. At stake are not only foreign exchange earnings, but also the livelihoods of literally millions of agricultural workers who currently produce these products. Although RAFI has been documenting these trends for 15 years, the stunning pace of technological change brings the promise and perils of Generation 3 products into sharper focus. The following are just three examples:

• Scientists at Ohio University (USA) have successfully modified tobacco plants to produce gum arabic, an ingredient that is widely used by industrial food manufacturers.[78] Gum arabic is traditionally tapped from the branches of *Acacia Senegal* trees, primarily in North Africa. In the Sudan, the world's largest supplier of gum arabic, more than 5 million people are dependent on the gum arabic harvest, which provides US$50–70 million per annum in desperately needed foreign exchange earnings.[79] If bio-industrial production of gum arabic becomes commercially viable, it will reduce or eliminate gum arabic export markets for north African producers.

• Genetic engineering of major cash crops such as coffee may dramatically alter traditional agricultural production. Coffee, the South's most valuable agricultural export commodity, is predominantly a smallholder crop. But *coffea* varieties genetically engineered for uniform flowering and longer retention of ripe fruit aim to promote large-scale, mechanically harvested coffee production. Integrated Coffee Technologies, Inc. based in Hawaii (USA) is using a patented, genetically engineered technology to suppress the ripening process in coffee plants.[80] By applying ethylene to the engineered plants, the coffee berries will ripen uniformly, making mechanical harvesting more productive.[81] Mechanical harvesting of genetically uniform coffee trees would reduce the need for harvest labor and small-scale coffee growers, and it will likely promote a shift to large-scale coffee plantations.[82]

• Mechanically-harvested, GM coffee may have little appeal for consumers. But what about decaffeinated coffee bean plants? In the US alone, food processors spend over $1 billion per annum to de-caffeinate beans using a chemical process that impairs both coffee flavour and aroma. The University of Hawaii won its second patent in June 2000 for a technique that suppresses the expression of caffeine in GM coffee plants.[83] In August 2000 Japanese scientists and researchers at the University of Glasgow announced that they have cloned one of the genes responsible for the production of caffeine in coffee and tea.[84] Integrated Coffee Technologies is field-testing caffeine-free plants. The company says it will sell decaffeinated, GM coffee plants to specialty growers for up to three times the price of conventional plants.

Generation 3 and the environment it will live in: Will the dazzling cornucopia of Generation 3 products ultimately win consumer acceptance for genetic engineering? Will these products distract

critics and dissolve societal concerns, or will they heighten civil society's resistance?

Even the most sophisticated regulatory programs will have trouble deciphering the complexities of GM products that could be categorized as food, dietary supplement or pharmaceuticals. While there is growing recognition in OECD countries that existing frameworks for regulating GM crops and foods are inadequate and under-developed, there is little attention focused on the new challenges posed by edible vaccines, nutraceuticals or biopharmaceuticals. Existing regulatory programs have proved incapable of monitoring and assessing ecological and human health risks posed by the most rudimentary GM crops – those with single or stacked gene traits. Regulators have barely even contemplated the complexities posed by Generation 3 technologies. How will national and international regulators cope with the newest generation of GM products?

The Cartagena Protocol on Biosafety, adopted in January 2000, fails to address or even understand the complexities of Generation 3 products, and especially their potential impacts on the South. The Biosafety Protocol sets minimal standards for risk assessment and safety measures for the transboundary movement of specific categories of living modified organisms (LMOs) – primarily seeds. But LMOs intended for direct use as food or feed, or for processing are barely on the radar screen for biosafety biocrats, requiring only minimal documentation. Pharmaceutical LMOs are largely excluded from the scope of the Protocol.[85] The Biosafety Protocol is thus an empty shell for huge categories of Generation 3 products – nutraceuticals, functional foods, edible vaccines. The Protocol allows countries to consider socio-economic impacts in decision-making, but only "consistent with their international obligations." In the absence of appropriate national regulations, the Biosafety Protocol offers little relevance, protection or meaning for the South in coping with Generation 3 products.

The Protocol has not even heard of - much less thought about - the risks involved in *intra-genic* GMOs. By the time biocrats get around to considering intra-genics they will be eating them.

Generation 3 vs. Governance 1

It may be Biotech's "Gen 3" but it's still the Intergovernmental world's "Gen 1"

What happens when the "irresistible forces" of Genomics and Globalization encounter the "highly-movable object" of international governance? GM governments. Here are some of the major areas where policies are needed:

Safeguarding Food Security: The FAO Commission on Genetic Resources for Food and Agriculture (CGRFA) is now 15 years in operation and has had agricultural biotechnology on its agenda for most of that time. More than a decade ago, governments asked FAO to develop a "code of conduct" on biotechnology and then immediately sidelined the work. When the Commission convenes in April 2001 it will consider a Secretariat report and survey on the possible code. Given the vast gaps in the Biosafety Protocol and the new dimensions of Gen 3 (especially the impact for the South and the implications of *intra-genics*), it is urgent that governments at FAO take their earlier discussions seriously and develop the research, monitoring and regulatory capacities necessary to protect global food security.

Safeguarding the Environment: Governments at FAO should always work consistently with the parallel - but not overlapping - work in the Convention on Biological Diversity. As painful as it might be, governments must either re-open the BioSafety Protocol or create a second protocol specifically to address Generation 3 and the new genomics it portends. In particular, governments in the CBD need to expand their consideration of Terminator technology to take Traitor technologies into proper account. This work should be on the agenda of the next SBSTTA when it meets in 2001.

Safeguarding Science: The new "*bio-technopoly*" being created with the union of agriculture with the food system, pharmaceuticals and specialty chemicals will be led by a handful of giant companies with little need for patents or Plant Breeders' Rights. They will exercise their control through government paid-for-and-enforced biosafety standards; through new monitoring technologies; and through genetic control systems. These represent "New Enclosure" strategies that must be discussed within civil society and confronted by governments and intergovernmental organizations. While bodies such as the World Intellectual Property Organization (WIPO) may have a self-interested role here, it is UN agencies such as the International Labour Organization (ILO), World Health Organization (WHO), the Food and Agriculture Organization (FAO), United Nations Industrial Development Organization (UNIDO)

and the United Naitons Conference on Trade and Development (UNCTAD) that could take the lead. In 2001, RAFI will offer a major report titled "New Enclosures" that will lay out the new technologies and their implications in detail.

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