World Resources Institute

Sustainable Enterprise Program
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The Monsanto Company: Quest for Sustainability (A)

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"Biotechnology represents a potentially sustainable solution to the issue, not only of feeding people, but of providing the economic growth that people are going to need to escape poverty…… [Biotechnology] poses the possibility of leapfrogging the industrial revolution and moving to a post-industrial society that is not only economically attractive, but also environmentally sustainable.[i] "

--Robert Shapiro, CEO, Monsanto Company

Upon his promotion to CEO of chemical giant The Monsanto Company in 1995, Robert Shapiro became a vocal champion of sustainable development and sought to redefine the firm's business strategy along principles of sustainability. Shapiro's rhetoric was compelling. He captured analysts' attention with the specter of mass hunger and environmental degradation precipitated by rapid population growth and the expansion of resource-intensive agricultural practices. Vowing to steer the company away from a legacy of environmentally damaging, petrochemical-based agrochemicals, Shapiro entranced Wall Street with the vision of a new industry -- the "life sciences." By linking the previously disparate sectors of pharmaceuticals, nutrition, and agriculture around a common platform of biotechnology, Monsanto would generate huge profits while restoring the natural environment and providing for the food, nutrition, and fiber needs of the world's poor and dispossessed. *Food * Health * Hope* became the firm's motto.

This case was prepared by Erik Simanis under the supervision of Professor Stuart Hart of the Kenan-Flagler Business School, University of North Carolina at Chapel Hill. This case is intended to serve as a basis for class discussion rather than to illustrate the effective or ineffective handling of an administrative situation. *Financial support was provided by the V. Kann Rasmussen Foundation.*

Three short years, one spin-off, and some $8 billion in acquisitions later, The Monsanto Company was a mere shell of its former self. Its fine and bulk chemicals businesses, the heart of the original company, were spun off in 1996, and the proceeds helped finance some $8 billion worth of seed and biotechnology acquisitions. By June 1998, Monsanto had emerged as a pure life sciences company and the clear frontrunner in the burgeoning agricultural biotechnology sector. Instead of pesticides, Monsanto now sold seeds genetically engineered to produce a naturally occurring insect toxin.

Shapiro's gamble on life sciences appeared to have paid off. Global acreage of all genetically engineered crops soared to some 70 million in 1998, and Monsanto's varieties accounted for over 70 percent of the total. Analysts predicted that transgenic (genetically engineered) crops would represent a $3 billion market by 2000, rising to $20 billion by 2010. Operationally, Monsanto's Earnings before Interest, Taxes, Depreciation, and Amortization (EBITDA) had grown at a compound annual rate of 15.5 percent since 1993. Total return to shareholders had increased 285 percent when adjusted for life sciences only, and market capitalization hovered around $38 billion, up from some $15 billion in 1995. A recently announced merger with American Home Products (AHP) would create a firm with combined sales of some $23 billion, eclipsing Novartis as the world's largest life sciences company.

Yet during this period of transformation and growth, questions emerged in Europe about the potential human health side effects and environmental consequences of biotechnology and the genetic engineering of seeds. "Frankenfoods," as genetically modified (GM) foods had come to be known in the United Kingdom and the rest of Europe, were under attack by consumer groups, retailers, and nongovernmental organizations (NGOs). Monsanto, by virtue of its leadership position in the agricultural biotech race and its aggressive promotion of GM products, had become synonymous with genetic engineering and was the focus of antibiotech protestors. The backlash also began to manifest itself in the developing countries, spurred on by the recent discovery of a gene sterilization technology patented by Monsanto's latest acquisition target, Delta & Pine Land.

Thus, on most accounts, Shapiro's sustainability-driven entry into the life sciences industry had indeed paid off, with a soaring stock price reflecting the market's support. Shapiro had seemingly demonstrated that profits and sustainability were not mutually exclusive. Yet growing consumer resistance and pressure on food processors to separate GM from conventional crops created some uncertainty about the future growth and profitability of genetic engineering. In this regard, Monsanto presented a dilemma to investors: Would Monsanto's stock continue to demonstrate the strong growth of the previous three years, or was there reason to believe that Shapiro's strategy would eventually backfire?

Agriculture: Sustainability Drivers in the 21st Century

In the second half of the 20th Century, the development of high-yielding cereal hybrids, irrigation technologies and infrastructure, and synthetic agricultural chemicals (i.e., pesticides and fertilizers) led to the adoption of a resource-intensive industrial model for agriculture throughout the developed world. The subsequent gains in agricultural output during the second half of the 20th Century were significant: Global cereal production doubled, per capita food availability increased 37 percent, per capita daily calories rose 35 percent, and real food prices fell 50 percent.[2]

Yet worldwide, the number of undernourished fell only 80 million to 840 million over this period, and some 40,000 died from hunger-related causes *daily*.[3] In sub-Saharan Africa, falling agricultural productivity and continuing high population growth rates resulted in a decrease in per capita food and calorie availability. The number suffering from a deficiency in at least one micronutrient doubled. Globally, more than 2 billion people were anemic owing to an iron deficiency, and 180 million children died each year from diseases linked to a vitamin A deficiency.

The complexity of global food security was increasing because of four primary factors: falling yields of major grains, rapid growth in population and consumption, mass urbanization, and diminishing and degraded environmental resources.

Decreasing Yields

A "yield plateau" or "yield stagnation" had occurred in many of the world's major crops, especially for cereals, the crops that supported most of the world's population. From 1961 to 1979, yield growth rates for wheat and maize fell from 2.92 percent per year to 1.78 percent and from 2.88 percent to 1.29 percent, respectively.[4] At the same time, most of the world's high-quality agricultural land was already in production, and the conversion of remaining forest, grassland, and wetland habitats to cropland would carry high environmental costs.

Population and Income Growth

The world's population was expected to increase by over 2 billion in the coming 25 years, with 95 percent of the increase in developing countries. On average, 90 percent of the world's food consumption took place in the country where the food was produced.[5] Rising global incomes compounded the dilemma further, for as incomes rose, people generally consumed more meat, a far more resource-intensive source of protein. Typically, one unit of meat-based protein required 16 times the grain needed to produce one unit of vegetable-based protein.

Urbanization

Within the coming 25 years, urban populations were expected to increase by 2 billion, doubling the current number. Unlike rural populations, which obtained most of their food from subsistence agriculture and/or local markets, urban populations obtained approximately 90 percent of their food from the marketplace. Yet in India and China, countries with a total population of more than 2 billion, less than 40 percent of rice and wheat left the local zone of production.

Environment

Clean, fresh water was becoming increasingly scarce. A 1997 United Nations study reported that one third of the world's population lived in countries experiencing moderate to high water stress, and this number could rise to two thirds within the next 30 years.[6] Agriculture consumed about two thirds of all water drawn from the world's rivers, lakes, and aquifers, although only 16 percent of the earth's croplands were irrigated. Three fourths of all irrigated land was in industrialized countries.[7]

By 1990, poor agricultural practices (i.e., overapplication of agricultural chemicals, intensive monocropping [large tracts of single-species crops], heavy plowing) had contributed to the degradation of 1.4 billion acres of farmland, some 38 percent of the world total.[8] Moderate to extreme degradation affected approximately 3 billion acres (roughly the size of India and China combined), four fifths of them in developing countries.[9] Soil erosion, the principal form of degradation, was caused primarily by the washing away of topsoil, a process accelerated by intensive cultivation and the clearing of forests and vegetation. Topsoil replenishment was slow by almost any measure: 200-1,000 years are needed to generate approximately 2.5 centimeters (one inch) of soil. In addition, poor irrigation and drainage caused salinization (the accumulation of salts), affecting more than one tenth of all irrigated cropland.

Yet the impacts of agriculture extended beyond the boundaries of the farms themselves. Leaching pesticide residues (the movement of pesticides through soil and into watersheds) made agriculture the worst polluting industry in the United States,[10] while nitrogen runoff (from fertilizers) into streams and waterways caused eutrophication and toxic algal blooms. In response to declining soil quality, the industrialized countries applied ever-greater quantities of fertilizers, pesticides, and herbicides to maintain or increase crop yields. In the United States, ammonium fertilizer was used at a rate of 160 pounds *per person per year,* and 2.2 billion pounds of pesticides were applied to U.S. crops annually.[11] Although pesticide use in the U.S. had risen 3,300 percent since 1945, crop losses to pests had not decreased. Overall crop losses had actually *increased* 20 percent, and more than 500 pests had developed resistance to pesticides.[12]

The Life Sciences: An Industry in Transition

The emergence of the life sciences industry in 1996[13] — commonly defined as the convergence of agribusiness (agbiotech), pharmaceuticals, and nutrition around a common platform of biotechnology — blurred the boundaries among these traditionally distinct sectors and unleashed a flurry of mergers, acquisitions, and strategic partnerships by a motley crew of aspiring entrants. Seed growers, commodity and agricultural chemical manufacturers, boutique-genomics research houses, pharmaceutical firms, grain handlers, and food processors quite suddenly occupied a shared competitive landscape and recognized that their future success was closely intertwined (see *Exhibit 1*).

The application of biotechnology to each of the three branches of life sciences promised the creation of radically novel products. In agriculture, for example, biotech-derived plant varieties could be designed to generate their own natural pesticides and to bear fruit or grains with enhanced nutritional composition (see "The Agbiotech Pipeline," below). A biotech-based soybean plant from which plastics could be manufactured was also under development, as was a genetically engineered bacterium whose excrement would be used to fashion a lycra-like fabric. Nutrition-related businesses envisioned the next generation of "nutriceuticals" or "functional foods," foods that incorporated medications and/or nutrition-enhanced properties. Planned products included corn flakes that incorporated chemicals to reduce cancer risks and spaghetti that contained soy compounds to combat osteoporosis. The potential market for such foods was considerable — in the United States alone, retail sales totaled almost $5 billion in 1997. In pharmaceuticals, biotechnology and genomics could significantly accelerate the discovery of new drugs and possibly the development of patient-specific medications. Further, plants and bacteria could be engineered to manufacture various drugs and medications. Life sciences firms sought to leverage these apparent synergies.

Chemical companies were among the most active in embracing this new paradigm for two basic reasons. First, chronic overcapacity within the chemicals sector and the commodity-based nature of their products presented little opportunity to attain real growth rates in excess of real Gross Domestic Product (GDP) growth. Second, biotech-based solutions to pesticide management and to materials production threatened to make many of the sector's products obsolete (see "Agrochemicals," below). In the United States, Monsanto was by far the most aggressive in restructuring its business portfolio (see "The Transition to Life Sciences," below). DuPont and Dow were actively repositioning themselves as well. In 1997, DuPont purchased a 20 percent stake worth $1.7 billion in Pioneer Hi-Bred, the world's largest seed company, as well as Merck's 50 percent share (valued at $2.6 billion) of a pharmaceutical joint venture. DuPont also acquired Protein Technologies International, a supplier and manufacturer of organic soy proteins. DowElanco, an affiliate of Dow Chemical, acquired Illinois Foundation Seeds and a 65 percent share of Mycogen, the fourth largest seed corn producer in the United States, for $126 million. Dow also spent $1.2 billion to purchase Eli Lilly's 40 percent share of a pharmaceutical joint venture. A number of European chemical and pharmaceutical concerns, including BASF AG, Bayer AG, Zeneca, Rhone-Poulenc, and Hoechst, were building life sciences architectures. Novartis, a company formed through the 1996 merger of Ciba-Geigy and Sandoz, two Swiss companies with global chemicals and pharmaceuticals businesses, remained the industry leader with 1997 sales in excess of $23 billion. Novartis was the world's second largest healthcare company, the largest agribusiness company, and the third largest nutritional products and supplements company.[14]

As expected, given the relative newness of the industry and the diverse backgrounds of the entrants, firms falling under the rubric of life sciences were quite varied. However, two basic structural strategies had emerged: 1) "pure plays" — firms that divested themselves of any nonlife sciences divisions (e.g., Monsanto and Novartis) and 2) "mixed strategy" — firms that maintained significant industrial and fine chemicals operations while increasing their focus on life sciences (e.g., DuPont, Dow, Bayer, and BASF).[15] The relative financial contribution of each of the three life sciences branches varied significantly among the firms. Monsanto's financials were dominated by its agbiotech businesses. Agricultural products accounted for 42 percent of total revenues, pharmaceuticals 32 percent, nutrition and consumer products 20 percent and other products 6 percent. By contrast, pharmaceuticals remained the dominant business unit for 8 of the top 10 life sciences firms. Novartis, for example, generated 60 percent of revenues from its healthcare division, 27 percent from agribusiness, and 13 percent from nutrition. The two remaining firms, DuPont and Dow, were predominantly chemical and materials companies and received 6 percent ($2.5 billion) and 13 percent ($2.6 billion) of their 1997 revenues, respectively, from their agbiotech units.[16]

Although the industry's ultimate structure remained indeterminate, most analysts agreed that the life sciences was poised for explosive growth. In Monsanto's 1997 annual report, Robert Shapiro borrowed a page from Intel CEO Gordon Moore by comparing the industry's growth potential to that of the computer industry, declaring that "the amount of genetic information used in practical applications will double every year or two,"[17] the so-called "Monsanto's Law."

Agbiotech/Agribusiness: A Sector Overview

The agbiotech/agribusiness market, valued at approximately $45 billion, could be further subdivided into two segments: 1) agrochemical products such as herbicides, fungicides, and insecticides and 2) seeds or germplasm, the delivery mechanism of genes. The introduction of biotechnology had transformed these historically low-growth sectors into high-growth, high-tech industries. A majority of the first-generation biotechnology applications in the life sciences were to arise from this sector.

Agrochemicals

The agrochemical industry, representing approximately 65 percent of agbiotech/agribusiness sales, was highly concentrated, with the top 10 companies controlling 81 percent of the global market (see *Exhibit 2*). The power of individual firms was more apparent when one disaggregated the agchem market by crop variety. In 1997, for example, American Cyanamid controlled some 65 percent of the soybean herbicide market while Monsanto retained approximately 30 percent. In corn herbicides, Novartis was the dominant force, having captured 30 percent of the market. Monsanto, DuPont, and BASF held between 10-20 percent each.[18]

Historically, the high fixed capital needs of chemical manufacturers posed a barrier to entry. Yet the advent of biotechnology and "green chemistry" had shifted the investment from fixed assets into a firm's research and development centers. The high costs of biotechnology and genomics research was pushing R&D spending to levels associated with pharmaceuticals (10-15 percent of sales), an investment far above the 3.5 percent average of the basic chemicals industry.

The agrochemical market was expected to grow at an overall rate of 1-2 percent per year. The sector's future profitability was threatened by three primary factors: 1) government restrictions (per The Food Quality Protection Act) on the use of traditional agrochemicals, 2) growing concern about the environmental impacts of agrochemicals, and 3) an agrochemical oversupply in developed countries.

The Global Seed Market

The global seed market was valued at approximately $15 billion in 1998. The sector had undergone significant consolidation and was led by a handful of national/international suppliers, with DuPont, Monsanto, and Novartis the dominant players. Through its subsidiary Pioneer Hi-Bred,[19] DuPont generated sales of $1.8 billion in 1998 and controlled 34 percent and 17 percent of the corn hybrid seed and soybean seed market, respectively. Monsanto, through its acquisitions (both completed and announced) of DeKalb, Asgrow, Holden's Foundation Seeds, and Delta & Pine Land, forecasted seed revenues of $1.8 billion for 1998.[20] Novartis generated revenues of some $1 billion in 1998 from its seed operations. Other leading firms included Cargill North America, the French firm Groupe Limagrain (1998 revenues of $733 million), AstraZeneca[21] (1998 revenues of $412 million), and Savia S.A. de C.V. of Mexico (1998 revenues of $428 million).[22]

Like the agrochemical industry, many seed firms dominated a specific crop market. For example, Monsanto's acquisition target, Delta & Pine Land, controlled 71 percent of the North American cotton seed market in 1998. Similarly, Monsanto (via DeKalb) and DuPont (via Pioneer Hi-Bred) together represented 52 percent of the North American corn seed market in 1997.[23]

The Agbiotech Pipeline

Agbiotech products may be classified as those that have input traits, those that have output traits, and those that function as biofactories. Monsanto characterized the evolution of agbiotech as a three-wave sequence, from input to biofactories.

Genetically engineered crops with input, or agronomic, traits created value for farmers by increasing production or reducing the need for pesticides or fertilizers. Most of Monsanto's initial R&D was concentrated in this area. Monsanto's *Roundup Ready* line of crops was resistant to Monsanto's *Roundup* herbicide, allowing farmers to delay herbicide application until after crop germination, thus reducing the frequency and volume of herbicide applications. *YieldGard* corn was one of Monsanto's insect-resistant crops that contained a gene from a naturally occurring soil bacterium, *Bacillus thuringiensis (Bt),* an organism used by organic growers to kill insect pests. Once inserted into a crop's genome, the *Bt* gene stimulated the production of a protein toxic to specific insect pests. Other trait characteristics were also inserted into a single crop variety, or "stacked." Monsanto, for example, offered a cotton seed with bollworm/budworm insect protection as well as *Roundup* tolerance.

Crops with output, or quality, traits created value for consumers by enhancing the plant's food and fiber quality. Crops could be designed to integrate medicinal properties and increase vitamin and mineral content, for example. DuPont had focused its primary attention on output traits, a market with an estimated value of $500 billion.[24] Optimum Quality Grains, DuPont's joint venture with Pioneer Hi-Bred, marketed a high-oil corn seed for the animal feed market. Similarly, Monsanto was establishing Renessen, a joint venture entity with Cargill, Inc. Renessen would develop and market biotech-enhanced products for the grain processing and animal feed markets.

Biofactories were genetically engineered crops that produced outputs such as plastics with less energy use and environmental impact than traditional means. Dow-Cargill Polymers, a joint venture between Dow Agrosciences and Cargill, had succeeded in creating a plastic derived from corn, although commercialization was not planned until 2000.

Biotechnology and the Agricultural Supply Chain

Many industry leaders believed that biotechnology would effect a fundamental restructuring of the commodity-based agricultural value chain. Modern agriculture consisted of growing large quantities of homogeneous crops for universal use, which would be transported in bulk. Yet Shapiro and others foresaw a future in which farmers would grow specialized crops destined for a handful of manufacturers or consumers, thus requiring a new infrastructure to preserve the identity of these specialized crops throughout the value chain (see *Exhibit 3*).

The Monsanto Company: From Chemicals to Life Sciences

The Beginning: Founding to 1972

Founded in 1901 by John Queeny as Monsanto Chemical Works, Monsanto's initial products included such food additives as saccharin, caffeine, and vanillin. By 1917, the company began producing phenol (an antiseptic) and aspirin, for which it was the largest manufacturer until the 1980s. Under the leadership of John Queeny's son Edgar, the company diversified into rubber additives, plastics, and synthetic resins, the firm's primary focus through the 1970s. Acrilan, AstroTurf, urethane foam, and other synthetic products were among its best known product lines. However, Monsanto was perhaps most often associated with the infamous chemical, Agent Orange, which it produced to government specifications, and with its dominant position in polychlorinated biphenyls (PCBs), a product Monsanto voluntarily phased out prior to the 1976 ban.

An Agricultural Division was established in 1960. Acquisitions of insecticide and fertilizer manufacturers complemented Monsanto's internal development of herbicides. In the early 1970s, the company developed the blockbuster herbicide *Roundup*, a broad-spectrum herbicide (effective against a wide variety of plants, including the crop itself) with the active ingredient, glyphosate. Glyphosate possessed a favorable environmental profile: it was nonpersistent (it biodegraded over time), it did not bioaccumulate in the food chain (its relative concentration did not increase within the food chain), it biodegraded into substances such as carbon dioxide and nitrogen by naturally occurring soil organisms, it was non-toxic to animals (glyphosate interfered with the production of a protein that was found only in plants and was necessary for their survival), and it bound tightly to soil organisms, making the potential for movement into groundwater extremely unlikely. As well, unlike most other herbicides, because glyphosate dissipated rapidly from surface waters, it was one of the few products registered for direct application to aquatic weeds. *Roundup* quickly became the world's best-selling herbicide and was granted patents worldwide. An extensive family of products that used glyphosate as their active ingredient was developed by Monsanto and sold under the brand names of *Roundup, Rodeo*, *Azural*, *Accord*, *Polaris*, and *Roundup Bioforce*.

Setting the Stage for Life Sciences

During the 1970s, Monsanto experienced eroding profitability of its petroleum-based chemical products, the firm's core focus. The low-growth cyclical nature of the chemical industry spurred the company to rethink its processes and strategy. Jack Hanley, who became Monsanto's president and chief executive in 1972, began his tenure by surveying leading scientists around the country about technology's future. "The answer, time and again, was molecular biology and genetics, and the emphasis, said the experts, should be human health."[25]

By 1975, Monsanto had established a biology research program in its Agricultural Division. A team of leading scientists from the fields of gene-cloning, microbial genetics, plant-cell and tissue culture, and DNA transfer was assembled, and Monsanto's foray into genetic engineering was firmly established. In 1982, Monsanto scientists genetically modified a plant cell for the first time in history, receiving front-page recognition in the *Wall Street Journal*. By February 1986, tomatoes immune to *Roundup*, insects, and disease were growing in Monsanto's Chesterfield, Missouri, greenhouses. Only 16 months later, on June 2, 1987, the U.S. Department of Agriculture gave permission for Monsanto to plant the GM tomatoes in its newly plowed research fields in Jerseyville, Illinois — the first GM plants ever to be planted and to flower outdoors.

As of 1986, Monsanto had committed $2.7 billion to the purchase of G.D. Searle & Co, a Chicago-based pharmaceutical company; $23 million to a research agreement with Washington University in St. Louis, Missouri; and $150 million to the construction of a world-class life sciences research center in Chesterfield.

Robert Shapiro and the Life Sciences: The Path to Sustainability

Robert Shapiro: A Vision of Sustainability

In 1995, Robert Shapiro, a graduate of Harvard College and Columbia University School of Law, assumed the helm of the 95-year-old chemical company. Shapiro's career with Monsanto began in 1985 when, as president of the NutraSweet Group for the pharmaceutical firm Searle, his company was acquired by Monsanto. Following the acquisition, Shapiro was named president of Monsanto's NutraSweet Company subsidiary. In 1990, he was tapped as executive vice president of The Monsanto Company and president of The Agricultural Group, an operating unit of Monsanto. Three years later, Shapiro was named Monsanto's president and chief operating officer. Before joining Searle, Shapiro's career included his being a law professor at Northwestern University and the University of Wisconsin at Madison, an attorney with the New York law firm Poletti, Freidin, Prashker, Feldman, and Gartner, and vice president and general counsel for General Instrument Corporation.

Shapiro's easy-going, approachable manner was coupled with a deep belief in employee empowerment and flat management hierarchies. Characteristic of his style, Shapiro converted an executive parking deck at Monsanto's St. Louis corporate headquarters into an employee wellness center, and he dismantled the exclusive private offices of top executives, creating open working spaces to encourage interaction.

In 1994, shortly before his official ascension to CEO, Shapiro sought to refocus Monsanto's strategic direction in light of what he believed was an emerging discontinuity between demographic trends and the limits implied by the earth's closed systems:

> What we thought was boundless has limits, and we're beginning to hit them. That's going to change a lot of today's fundamental economics, it's going to change prices, and it's going to change what's socially acceptable.[26]

To clarify and articulate this new vision, Shapiro assembled a 25-member cross-functional team of up-and-coming leaders within Monsanto and sent them off to consider the company's role in the unfolding world. Architect Bill McDonough, business sustainability guru Paul Hawken, and other nontraditional outsiders were brought in to challenge the group's core assumptions. From this exercise, the company's focus on sustainable development became obvious.

With the support of a now energized and emotionally charged cadre of internal change agents, Shapiro voiced a compelling new direction for Monsanto that blended no-nonsense business logic with a keen awareness of the global environmental and social challenges that lay ahead:

> We think that the reality of a more sustainable economy — one that satisfies people's needs in ways that also provide for a spiritually and aesthetically pleasant environment that can continue to sustain life — is a need that can be expressed in the marketplace. . . . What we fundamentally are is a technology company. Our role has to be to use good science to try to create products and services that are consistent with what we think will be an emerging and increasing need for sustainable development.[27]

Shapiro publicly committed the firm to solving the food and fiber needs of a burgeoning population by using environmentally sustainable technologies. A transition away from the materials-based science of chemistry to the information-based discipline of biotechnology, the platform upon which the life sciences concept rested, was requisite in fulfilling this vision.

Biotechnology and Sustainability

Biotechnology, or genetic engineering (see *Exhibit 4A & 4B*), professed to offer both social and environmental benefits: improved nutritional quality of staple crops, increased drought resistance, reduction in post-harvest losses attributable to rapid ripening, and increased transportability. Theoretically, plants could be engineered to grow in marginal climates and poor soils, decreasing pressure on the conversion of environmentally sensitive areas to agricultural use. Genes bestowing insect resistance and accelerated plant growth could eliminate the need for pesticides and other agricultural inputs, thus removing one of the world's major sources of pollution and reducing agriculture's net environmental burden. *Exhibit 5* illustrates the potential net environmental benefits from Monsanto's *NewLeaf* potatoes, a variety genetically engineered to defend itself against the destructive Colorado potato beetle. And compared to traditional plant breeding methods, which depended on trial and error, genetic engineering techniques greatly reduced the time necessary to identify and isolate favorable traits.

The private sector was not alone in recognizing these potential benefits. Scientists at research institutions worldwide were engaged in plant biotechnology research, in many cases focused on the needs of developing countries. Scientists at the Swiss Federal Institute of Technology were modifying rice to produce high levels of the micronutrients iron and beta-carotene, a substance converted to Vitamin A in humans. This "golden rice," so named because of its yellow color, could potentially alleviate millions of cases of blindness and death caused by persistent Vitamin A deficiency in Asian countries and aid some 3 billion people worldwide suffering from iron deficiency. The Rockefeller Foundation, a global foundation with a mandate and commitment to enrich and sustain the lives of the poor, was a leading proponent of biotechnology, and it actively funded research in Asia, Latin America, and Africa. In Mexico, a Rockefeller grantee had added genes to rice and corn that allowed the plants to tolerate high concentrations of aluminum, a soil toxicity problem that constrained cereal production over vast areas of the tropics. In India, another grantee had added genes to rice that appeared to help the plant tolerate submergence, a common problem in parts of Asia.

Operationalizing Sustainability

To operationalize its sustainable development strategy, Shapiro relied on the energy and initiative of the original visioning team to guide the formation of a grassroots effort. Within four months, some 80 individuals had converged around the sustainability effort, often volunteering their participation after learning of the project. At its first meeting in October 1995, the group decided to form seven teams, focusing on eco-efficiency, full-cost accounting, sustainability benchmarks, new products and businesses, water, global hunger, and company-wide training in principles of sustainability.[28]

Monsanto launched a Sustainable Development Business Sector in addition to its three existing global businesses (agricultural, pharmaceutical and nutrition). An Agriculture Sustainability Team undertook initiatives to commercialize technologies that enhanced agriculture's sustainability. A Precision Agriculture Team researched application of the Global Positioning Satellite (GPS) and other technologies for determining nutrient and input needs at precise locations on a farm. Additionally, a Smallholder Team was charged with developing products, services, and partnerships to meet the needs of small-scale rural farmers in developing countries. In Africa and Southeast Asia, partnerships were established with Winrock, Sasakawa Global 2000, and other leading international agriculture-based NGOs to further understanding of the smallholder farmers' needs.

Monsanto also sought to integrate microcredit into its developing country strategy, becoming a financial sponsor of and active participant in the World Microcredit Summit, a global network of microcredit practitioners founded in 1997. Microcredit sought to alleviate poverty by extending uncollateralized small-scale loans (often as low as $25) to an individual or community group wanting to begin a small commercial venture. In June 1998, leaders of the Monsanto Company and the Grameen family of organizations, the internationally recognized microcredit pioneers, were prepared to unveil a unique partnership. The Grameen-Monsanto Technology Center, to be located in Bangladesh, would help smallholder farmers attain environmentally sustainable self-sufficiency with loans and access to modern agricultural tools and technologies.

Collaborative R&D efforts were established with research institutes in Kenya, Mexico, India, and Southeast Asia, and proprietary technologies conferring disease resistance to local plant varieties were donated. In Mexico, for example, resistance to potato virus X, potato virus Y, and potato leaf roll virus was transferred to local potato varieties, and in Kenya, local sweet potato varieties were made resistant to the sweet potato feathery mottle virus (SPFMV). Each season, SPFMV destroyed some 50-80 percent of this subsistence crop.

Transition to the Life Sciences

Yet transforming a 95-year-old chemical giant into a sustainability-driven life sciences company required radical changes to Monsanto's structure.

> The problem with having businesses as divergent as our chemical business on one hand, and what has become our life sciences businesses on the other, was that we ended up making cultural compromises that suboptimized both. . . . For example, the kinds of people who are important to a life sciences business are very different from the kinds of people who are who are important to our chemical business. Not only do they have different educational backgrounds, but they also think differently. One group thinks more about creating blockbuster new products, the other more about operational excellence and customer focus.[29]

In 1997, Monsanto's fine and bulk chemicals businesses and the heart of the original company were spun off as Solutia. The chemical division had projected revenues of $2.6 billion and an operating income of $265 million for 1996; life science sales were estimated at $6 billion.

Bill Young of Donaldson, Lufkin and Jenrette voiced concern that Monsanto's proportional dependence on *Roundup* (Monsanto maintained agricultural herbicides as part of the life sciences company) would increase following the divestiture.[30] Since its introduction some 25 years earlier, sales of *Roundup* had grown 20 percent annually, with much of the growth outside the United States, the only country where *Roundup* enjoyed patent protection (the patent was to expire in 2000). Two main factors supported this sustained growth: 1) Monsanto's ability to exploit the market's elastic demand for *Roundup* by continued reductions in unit costs through improved manufacturing technology and operating efficiency and 2) the global expansion of conservation tillage, a farming practice that reduces soil erosion and enhances soil quality by using herbicides instead of plowing to control weeds. Because of its efficacy and highly favorable environmental profile, *Roundup* was the herbicide of choice for conservation tillage. In 1996, *Roundup* accounted for approximately 25 percent of sales and 40-50 percent of the firm's operating profit; all other chemicals generated 24 percent of profits.[31]

Concurrently, Shapiro moved aggressively to acquire firms with technological competencies and assets deemed critical to the firm's success. In 1996 alone, he spent $750 million buying ownership and interests in a number of seed/biotech companies: Calgene (54 percent), DeKalb Genetics (40 percent), Ecogen (10 percent), and Agracetus (100 percent).

In February 1997, Monsanto offered to buy the rest of Calgene for $217 million and completed its acquisition of Asgrow Agronomics, a global leader in soybean research and seeds. Monsanto then bid $1.02 billion for the privately held Holden's Foundation Seeds and two of its Des Moines-based sales agents (Corn States Hybrid Service and Corn States International). Holden's supplied 35 percent of the U.S. corn seed market and generated revenues of approximately $45 million per year. A $218 million alliance with Millenium (named Cereon Genomics), a leader in genomics research, was cemented in November 1997. At the end of 1997, Monsanto also acquired control of Agroceres, a leading Brazilian seed corn company, for $160 million.

In May 1998, Monsanto again outbid rivals, offering $2.5 billion in cash for the remaining 60 percent of DeKalb. A $1.8 billion stock swap for Delta & Pine Land, the leading supplier of cotton seed to the U.S. market with a 71 percent market share, was announced shortly thereafter. The firm acquired Cargill's international seed and distribution operations in Central and Latin America, Europe, Asia, and Africa in June 1998 for $1.4 billion. All told, Monsanto spent approximately $8 billion on acquisitions in the 3-year period.

Exhibits 6 and *7* list key products in Monsanto's life sciences triumvirate of pharmaceuticals, agriculture, and nutrition and the financial contribution of each division.

A Merger of Equals

In June 1998, Monsanto announced a merger with American Home Products (AHP), catapulting the combined company to the dominant position in life sciences with expected 1998 sales of approximately $23 billion. AHP was one of the world's largest research-based pharmaceutical and healthcare products companies and a leader in the discovery, development, manufacturing, and marketing of prescription drugs and over-the-counter medications. AHP was also a leader in vaccines, biotechnology, agricultural products, and animal health care. The new company would have a market capitalization in excess of $96 billion, based on then-current market prices, and the new board would consist of 22 members, with representation equally divided between AHP and Monsanto. Monsanto chairman and CEO Robert Shapiro and AHP chairman, president, and CEO John Stafford would become co-chairmen and co-CEOs.

Monsanto: The Launch of Genetic Engineering

The AgbiotechTimeline

Monsanto launched its first biotech product, Posilac, in 1994. Posilac was a genetically engineered version of bovine somatotropin (bST), a hormone produced in a cow's pituitary gland that stimulates milk production. Injecting recombinant (genetically engineered) bST would increase a cow's milk production by 10-15 percent.[32] Because bST did not affect the nutritional quality of milk and was virtually identical to milk from untreated cows, the FDA did not require that manufacturers label foods from bST-treated cows.

In Europe, the mad cow disease scare and the resulting loss in confidence in government regulatory agencies initially hampered sales of bST. Mad cow disease, or bovine spongiform encephalopathy (BSE), a terminal disease that caused degenerative changes in the brains of cattle, had recently appeared in the United Kingdom and triggered near hysteria when it was linked to a similar disease (Creutzfeldt-Jacob disease) detected in humans. European government officials had previously claimed that BSE could not be transmitted to humans if they ate the meat of infected animals.

Monsanto's first biotech crop products, *Roundup Ready* soybeans and *YieldGard* corn, were commercialized in the United States in 1996. *Roundup Ready* crops contained a gene that made the plants immune to glyphosate, the active ingredient in Monsanto's popular *Roundup* family of broad-spectrum herbicides. *Roundup*, because it was toxic to all plants, including the crop itself, was typically used as a pre-emergent herbicide (i.e., applied before the crop germinated). With *Roundup Ready* crops, the farmer could better target herbicide applications (and thereby reduce the amount of herbicide used) because applications could be delayed until after the crops had germinated and the weeds had appeared. *Roundup Ready* crops also made it easier to use the increasingly popular (and vitally important) soil-preserving farming technique known as conservation tillage. Prior to planting, farmers often tilled the soil to eradicate and control weeds (turning soil over the exposed weed seeds to prevent their germination). Tilling, however, greatly increased soil erosion and pesticide runoff. With *Roundup Ready* crops, tilling could be greatly reduced, even eliminated, because weeds could now be controlled during the growing season with glyphosate-based herbicides.

YieldGard corn contained a gene from the soil bacterium *Bacillus thuringiensis* (*Bt*) (see "The Agbiotech Pipeline," above), which protected against the European corn borer (ECB). Approximately 37 million acres were planted to corn in the United States, with the annual crop valued at some $24.3 billion, and approximately 5 million acres of land were planted to corn in the European Union (EU) countries. The ECB is an insect whose larvae had destroyed up to 20 percent of the crop in some regions of Europe and the United States. Attempts to control it with traditional crop breeding methods and biological controls (i.e., insects that prey on the ECB) had been largely unsuccessful. In addition, although chemical insecticides were effective, only a small percentage of corn fields were treated because of the precise timing requirements of insecticide applications and the difficulties of scouting (visually inspecting crops) for the pest.[33]

Between 1996 and 1998, Monsanto diversified its offering. The *Roundup Ready* trait was added to canola, cotton, and corn, and insect resistance was inserted into potatoes (*NewLeaf* potatoes) and cotton (*Bollgard* cotton). *NewLeaf* potatoes offered protection against the destructive Colorado potato beetle (see *Exhibit 5*). *Bollgard* cotton contained the *Bt* gene and protected against budworms and bollworms. Conventional cotton production accounted for some 25 percent of the world's insecticide use, with more than 600,000 pounds of pesticides and chemical fertilizers applied in the six largest cotton-growing states in the United States alone. Approximately three quarters of a pound of pesticides and synthetic fertilizers was required to produce the cotton for a typical pair of jeans.[34]

Crops containing stacked traits were also commercialized. These included *Bollgard* and *Roundup* resistant cotton and *NewLeaf Plus* and *NewLeaf Y* potatoes, potatoes resistant to insects and to two viruses (potato leafroll virus and potato virus Y, respectively).

Agbiotech and Farmer Acceptance

Monsanto's crop biotech products were not sold but were licensed to farmers. Under Monsanto's "seed as software" licensing arrangement, farmers were not allowed to use glyphosate herbicides other than Monsanto's *Roundup*. In addition, farmers were not allowed to save or reuse seed, and they had to allow field inspectors to review the progress of their crops, a practice later discontinued. Monsanto was criticized at times for its aggressive defense of its patents, culminating with the revelation that Pinkerton's (a private detective agency) was being employed in Canada.

Yet the novel marketing of agbiotech products appeared not to hinder their adoption. Plantings of Monsanto biotechnology crops skyrocketed from approximately 3 million acres in 1996 to 18 million acres in 1997 and to 57 million acres in 1998. Total transgenic crop sales by all agbiotech firms grew about 6-fold, from $235 million in 1996 to $1.2-$1.5 billion in 1998.[35] Analysts projected sales to increase to $3 billion or more in the year 2000, to $6 billion in 2005,[36] and to $20 billion in 2010.[37]

Approximately one third (some 25 million acres) of all the U.S. soybean acreage was planted to Monsanto's *Roundup Ready* variety in 1998. Of the nearly 70 million acres planted to GM crops worldwide, Monsanto varieties accounted for over 70 percent.[38] *Exhibit 8* summarizes the acreage and geographic location of some of Monsanto's agbiotech products.

Geographically, the United States alone accounted for 74 percent of the area planted to transgenics; Canada accounted for 10 percent of the global total. Argentina, with 15 percent of total acreage, was the only developing country with any significant transgenic plantings. However, several developing countries had either approved commercialization of transgenic crops or were conducting field tests phase. China commercialized transgenic crops in 1997, including Mosanto's *Bollgard* cotton. South Africa approved commercialization (also of *Bollgard* cotton) in 1998: several years of field tests in the KwaZulu-Natal province demonstrated a 20 percent yield increase.[39] Trials and field tests were also underway in India, the world's third largest producer of cotton, with some 22 million acres under production.

A 1997 U.S. Department of Agriculture Agricultural Resource Management study indicated that farmers' primary reasons for adopting genetically engineered crops with pest management traits were to "increase yields through pest control" (54-76 percent of adopters) and to "decrease pesticide costs" (19-42 percent of adopters). Exhibit 9 summarizes the findings of this study.

Agbiotech and Consumer Acceptance

Although U.S. farmers endorsed GM products, consumers and NGOs remained in strong opposition, particularly in Europe, and raised concerns about human health side effects and their environmental consequences. Rebecca Goldburg, a senior scientist at the Environmental Defense Fund, pointed out that the addition of proteins to foods through genetic engineering could cause individuals to become allergic to foods they had previously been able to eat. Other scientists believed that genes that conferred herbicide resistance to crops could cross over to closely related grass species, creating "super weeds." Organic farmers who relied on the soil bacterium *Bacillus thuringiensis* (*Bt*) as a natural pest control worried that inclusion of *Bt* genes into millions of acres of monocultures (land with a single crop species) would accelerate insect resistance to this valuable biological control. Others challenged the ethical premise of genetic manipulation.

Developing country activists raised additional concerns. In 1998, activists revealed that a seed sterilization patent had been awarded jointly to the U.S. Department of Agriculture and Monsanto's recently announced acquisition target, Delta & Pine Land. The technology, coined "The Terminator" by antibiotech activists, would protect a firm's intellectual property by rendering the seeds of a GM crop sterile, thus preventing farmers from planting saved seed. In many developing countries, seed saving was a centuries-long tradition. Activists and NGOs also voiced concern that the expansion of proprietary research and the increasing power of multinational corporations would result in technologies that only resource-rich farmers could afford, further extending the gap between rich and poor countries.[40] Corporate monopoly over seeds and crop varieties could possibly lead to increased genetic homogeneity and monocultures, thereby displacing local varieties and leading to a loss of biodiversity. Thus, a nation's food supply could become even more vulnerable to diseases and pests. In addition, patenting life forms as permitted by western government intellectual property rights presented an affront to the cultural traditions of many developing countries and raised questions of equity.

European consumers, retailers, and NGOs campaigned for labeling all foods containing GM ingredients. In opposing this request, Monsanto cited a 1992 Food and Drug Administration (FDA) policy that stated that GM foods were "substantially equivalent" to conventionally grown foods.[41] Further, it was unnecessarily costly, perhaps physically impossible, to separate GM from non-GM throughout the commodity distribution network. Trade representatives from Canada and Argentina, countries with significant soybean exports, concurred, arguing that handling, storage, and transport costs would increase as much as 20 percent.[42]

Monsanto also extended the FDA's substantial equivalence designation for GM foods into the realm of international trade, asserting that countries should not be able to prevent the importation of GM products on the basis of the precautionary principle. Under the precautionary principle, "lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."[43] The agbiotech industry and U.S. trade representatives were concerned that countries would use the precautionary principle as a pretext for protecting their domestic agricultural industry from imports.

Antibiotech Campaigns

A Greenpeace-led campaign in Europe (whose origins could, somewhat ironically, be traced to an antibiotech effort begun in the early 1980s by Jeremy Rifkin and his U.S. organization, the Foundation on Economic Trends) had proven extremely effective in generating intense media coverage and had brought scientist and consumer concerns to the forefront.

The images were powerful: activists in an inflatable raft blocking grain-filled vessels as they attempted to dock in Belgium and the United Kingdom; huge banners trumpeting the hazards of genetically modified organisms (GMOs) unfurled from the national offices of food producers Nestle, Unilever, and Danone; activists clad in white decontamination suits destroying GM test plots; a truckload of GM soy being dumped at the doorstep of Europa BIO's London office (the European life sciences trade association); and GM protesters at the Cologne Cathedral hanging a banner declaring "Man is not God — down with Genetic Manipulation."

Daily media coverage of "Frankenfoods" spawned additional action by consumer and environmental organizations. In September 1997, 31 groups — including Greenpeace International, the Sierra Club, the International Federation of Organic Agriculture Movement, the Centre for International Technology Assessment in Washington D.C., and the Institute for Agriculture and Trade Policy in Minneapolis, Minnesota — filed a petition against the U.S. Environmental Protection Agency, charging it with negligence for its approval of genetically engineered crops. The petition was the first step in filing litigation against a U.S. government agency. Organizations from the British Medical Association and the U.K. Soil Association to more radical groups such as Friends of the Earth urged varying degrees of caution with respect to genetic modification. Celebrity figures Paul McCartney and the Prince of Wales also publicly voiced strong opinions against GM foods.

Monsanto: Stakeholder Management

Government Approval

In the United States and abroad, government regulatory approval was necessary for commercializing genetically engineered crops. Three agencies participated in the regulatory process in the United States: the Food and Drug Administration (FDA), the U.S. Department of Agriculture (USDA), and the Environmental Protection Agency (EPA). The FDA maintained authority over GM processes and products. Among others, the FDA reviewed nutritional composition, animal feed performance, processing, wildlife safety, disease susceptibility, and allergenicity. Developers of bioengineered foods were expected to consult with the agency before marketing to ensure that all safety and regulatory questions had been fully addressed (see *Exhibit 10*). The USDA oversaw three areas of interest: 1) whether the plant or related species could become a plant pest, 2) whether a plant could outcross or breed with weeds or other species and 3) whether the new trait changed the plant's susceptibility to insects. A USDA permit was required to field-test a GM plant. EPA's primary responsibility was to review and approve applications for GM pesticides or crop plants containing pesticidal properties prior to their field tests.

The GM approval process in the European Union (EU) was less transparent. As late as 1997, European legislation governing genetically modified crops was either incomplete or nonexistent, and the registration approval process for GM crops was decidedly slower. For example, an insect-protected corn developed by Novartis won U.S. approval in roughly a year, but EU approval took nearly twice as long. Furthermore, EU approval did not necessarily speak for all countries within the common market: Austria's health minister banned imports of genetically modified corn in December 1997, arguing that the strain had not been sufficiently tested.[44]

Monsanto managed regulatory and trade complexities through a robust government affairs office in Washington, D.C. that employed a number of former high-ranking government officials (see *Exhibit 11*). As one author suggested, "few companies of its size are as well connected in Washington, D.C. as Monsanto."[45]

Consumers and Civil Society

Monsanto sought to alleviate consumer doubt and concerns about the GM safety, as well as to communicate its commitment to sustainable development through a multimillion dollar European media campaign. In August 1997, Monsanto selected Bartle Bogel Hegarty in the United Kingdom to design the ads. The campaign was set to launch during summer 1998.

In October 1997, Monsanto also appointed a former consumer champion and critic of the genetically modified food industry to manage its U.K. public affairs. Ann Foster, the director of the Scottish Consumer Council and member of several U.K. government advisory committees, including the Committee on Medical Aspects of Food and Nutrition, became Monsanto's U.K. director of public and government affairs beginning in January 1998.

Monsanto: Financial and Operating Performance

Throughout this tumultuous period, Monsanto's operating and financial performance remained solid (see *Exhibit 12)*. *Exhibit 13* contains Monsanto's 1997 financial statements and key financial ratios.

Shapiro, in his 1997 letter to shareholders, suggested that Monsanto's results should be viewed in the context of two basic trends: a substantial increase in income from continuing operations and a larger rate of increase in growth spending (which includes technology, infrastructure costs, and the income effects of acquisitions). Excluding unusual items, income from continuing operations would have grown at a compound rate of 25 percent per year.[46] By March 1998, Monsanto's market capitalization had risen to $34.5 billion, a $5.8 billion increase over the previous quarter.

A 20 percent increase in sales of *Roundup* and strong sales of biotech products boosted agricultural revenues; five pharmaceutical product lines delivered a 21 percent increase in Searle's sales (Monsanto's pharmaceutical division). The nutrition sector, however, declined 3 percent from sales in 1996, primarily because of lower sales volumes in tabletop sweeteners.

Both the agriculture and pharmaceutical sectors maintained robust pipelines. Among the agbiotech pipeline's 30 new products, 14 had output and biofactory traits, including improved plant oils and colored cotton. Searle's pipeline was poised with three potential blockbusters (a drug with annual sales in excess of $750 million), including its much anticipated *Celebrex*, a COX-2 inhibitor for the treatment of arthritic pain and inflammation without gastrointestinal side effects.

Monsanto and Life Sciences: Staying on Top or Staying Alive?

Thus in three short years and some $8 billion in acquisitions later, Robert Shapiro had transformed a 95-year-old chemical giant into the world's leading agbiotech firm, competing in the high-growth, high-stakes life sciences industry. Judging by farmers' rapid adoption of Monsanto's technologies and the financial market's soaring valuation of the firm's stock, Shapiro's life sciences gamble appeared to have paid off and the years of growth spending were about to reward shareholders handsomely.

Yet NGOs and European consumers remained intransigent in their anti-GMO stance, and negative media coverage continued to hamstring Monsanto's efforts to communicate the benefits of genetic engineering. Food processors were also experiencing pressure from consumers to separate and label foods containing GM ingredients.

Would Monsanto's media campaign help allay consumer fears? Or would consumer opinion change once products containing consumer-beneficial output traits were commercialized? Given the rapid adoption rate of GM crops by farmers during the last three years, one had to question whether consumer approval was even requisite for continued expansion.

In any event, Robert Shapiro's sustainability-driven strategy was a radical departure from business as usual. A new business paradigm linking global sustainability with corporate profitability had been born. But its longevity remained to be seen.

Notes

[1] Robert Shapiro, Speech before the Biotechnology Industry Organization (BIO '98), New York, June 17, 1998.
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[3] Ismael Serageldin. "The Challenge of Poverty in the 21st Century: The Role of Science," p. 26. Online at: http://cgiar.org/biotech/rep0100/serageld.pdf. Accessed January 2000.
[4] World Resources Institute. "Food Production: Have Yields Stopped Rising?" Online at: http://www.wri.org/trends/foodprod.html. Accessed February 2000.
[5] McCalla and Brown, "Feeding the Developing World," p. 33.
[6] World Resources Institute. "Water: Critical Shortages Ahead?" Online at: http://www.wri.org/trends/water.html. Accessed February 2000.
[7] Paul Hawken, Amory Lovins, and Hunter Lovins, *Natural Capitalism* (Boston: Little, Brown and Co., 1999), p. 193.
[8] World Resources Institute. "Disappearing Land: Soil Degradation." Online at: http://www.wri.org/trends/soilloss.html. Accessed February 2000.
[9] Hawken, Lovins, and Lovins, 1999, *Natural Capitalism*, p. 193.
[10] Janine Benyus, *Biomimicry: Innovation Inspired by Nature* (New York: Morrow, 1997), p. 19.
[11] Ibid., p. 18.
[12] Ibid.
[13] The life sciences moniker was apparently first used by Novartis, a company formed through the 1996 merger of Ciba-Geigy and Sandoz, two Swiss companies with global chemicals and pharmaceuticals businesses.
[14] Srinivas Ramdas Sunder, "Novartis: Betting on Life Sciences," (Harvard Business School case study, 1998).
[15] Tim Stevens, "Sowing Seeds of Success," *Industry Week* (September 6, 1999): 68.
[16] Patricia Van Arnum, "Are the Life Sciences the Way to Grow?" *Chemical Market Reporter* (May 10, 1999): FR3-FR4.
[17] The Monsanto Company, *1997 Annual Report*.
[18] Martin Hayenga. 1998. "Structural Change in the Biotech Seed and Chemical Industrial Complex," *AgBioforum* 1(no. 2): 43-55. Online at: http://agbioforum.missouri.edu. Accessed March 2000.
[19] DuPont officially acquired the remaining 80 percent of Pioneer Hi-Bred in October 1999 for $7.8 billion.
[20] Rural Advancement Foundation International (RAFI). September 1999. "World Seed Conference: Shrinking Club of Industry Giants Gather for Wake or Pep Rally." Online at: http://64.6.69.14/web/cgibin/commander4.cgi through http://www.rafi.org. Accessed January 2000.
[21] The Astra AB and Zeneca merger was not officially announced until December 1998.
[22] RAFI, 1999, "World Seed Conference."
[23] Hayenga, 1998, "Structural Change."
[24] Jim Papanikolaw, "AgBiotech Arena Enters Period of Rapid Change," *Chemical Market Reporter* (July 6, 1998): 20.
[25] The Monsanto Company, "Fields of Promise," n.d. (company brochure), p. 4.
[26] Joan Magretta, "Growth Through Global Sustainability: An Interview with Monsanto's CEO, Robert B Shapiro," *The Harvard Business Review* (January-February 1997): 78.
[27] "The Sustainable CEO: International Finance Corporation Interviews Bob Shapiro," *Impact Magazine* (Spring 1998). Online at: http://www.monsanto.com/monsanto/mediacenter/background/98spring_SustainableCEO.html. Accessed: March 2000.
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[30] Peter Chapman, "Monsanto Bets on Life Sciences with Chemical Business Spinoff," *Chemical Market Reporter* (December 16, 1996).
[31] Robert Lenzner and Bruce Upbin, "Monsanto versus Malthus," *Forbes* (March 10, 1997): 58.
[32] "FDA Backgrounder: New Animal Drug for Increasing Milk Production," *Food Insight Media Guide on Food Safety and Nutrition* (International Food Information Council, 1996-1997).
[33] Leonard P. Gianessi and Janet E.Carpenter, "Agricultural Biotechnology: Insect Control Benefits," (National Center for Food and Agriculture Policy, July 1999).
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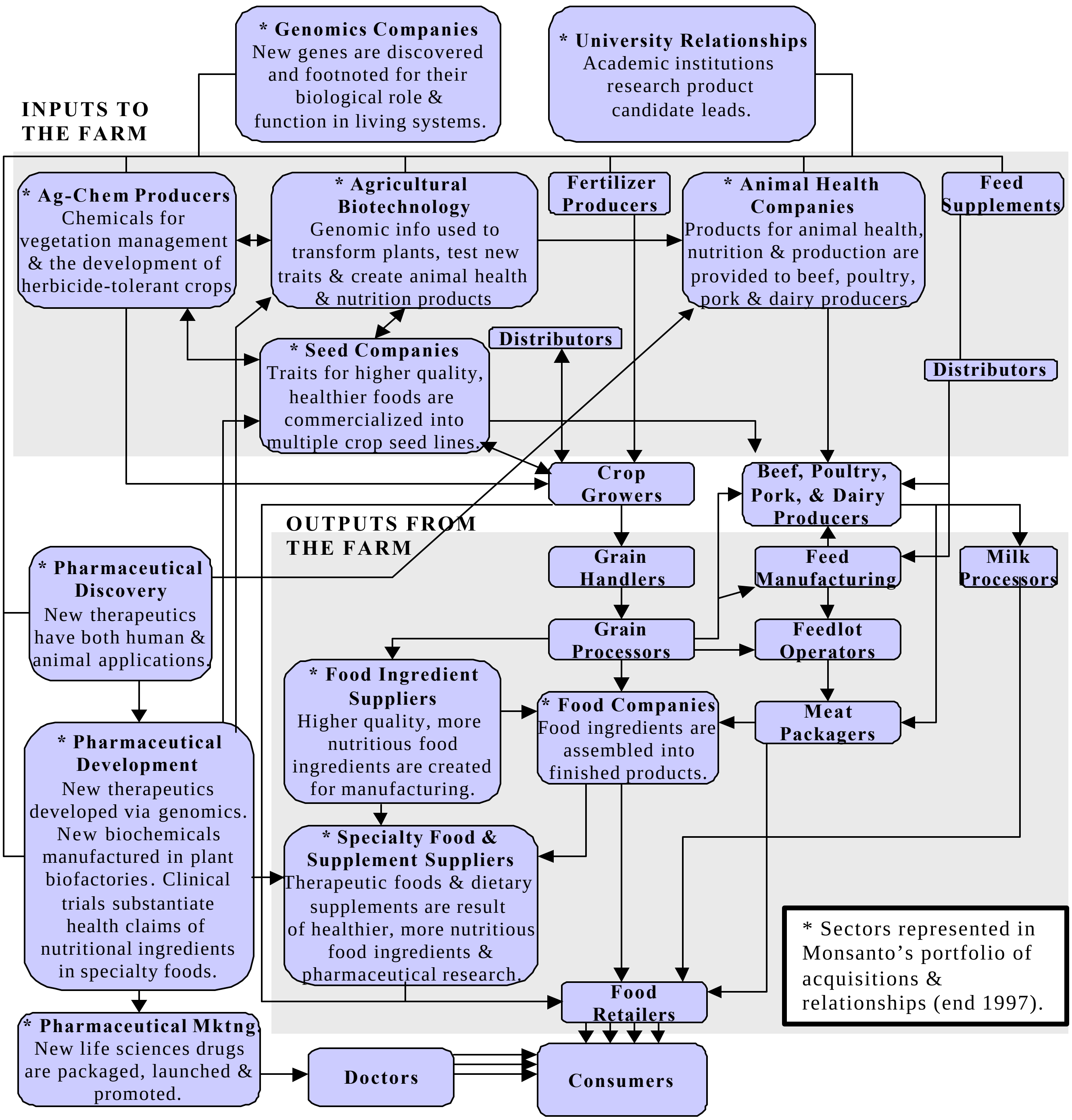
[35] Ismael Serageldin, "Biotechnology and Food Security in the 21st Century," *Science* (July 16, 1999): 388.
[36] Judy Stringer, "Monsanto: Poised to Reap Biotech Harvest," *Chemical Week* (November 6, 1996).
[37] Karen Coaldrake, "Trait Enthusiasm Does Not Guarantee On-Farm Products," *AgBioForum* (Spring 1999).

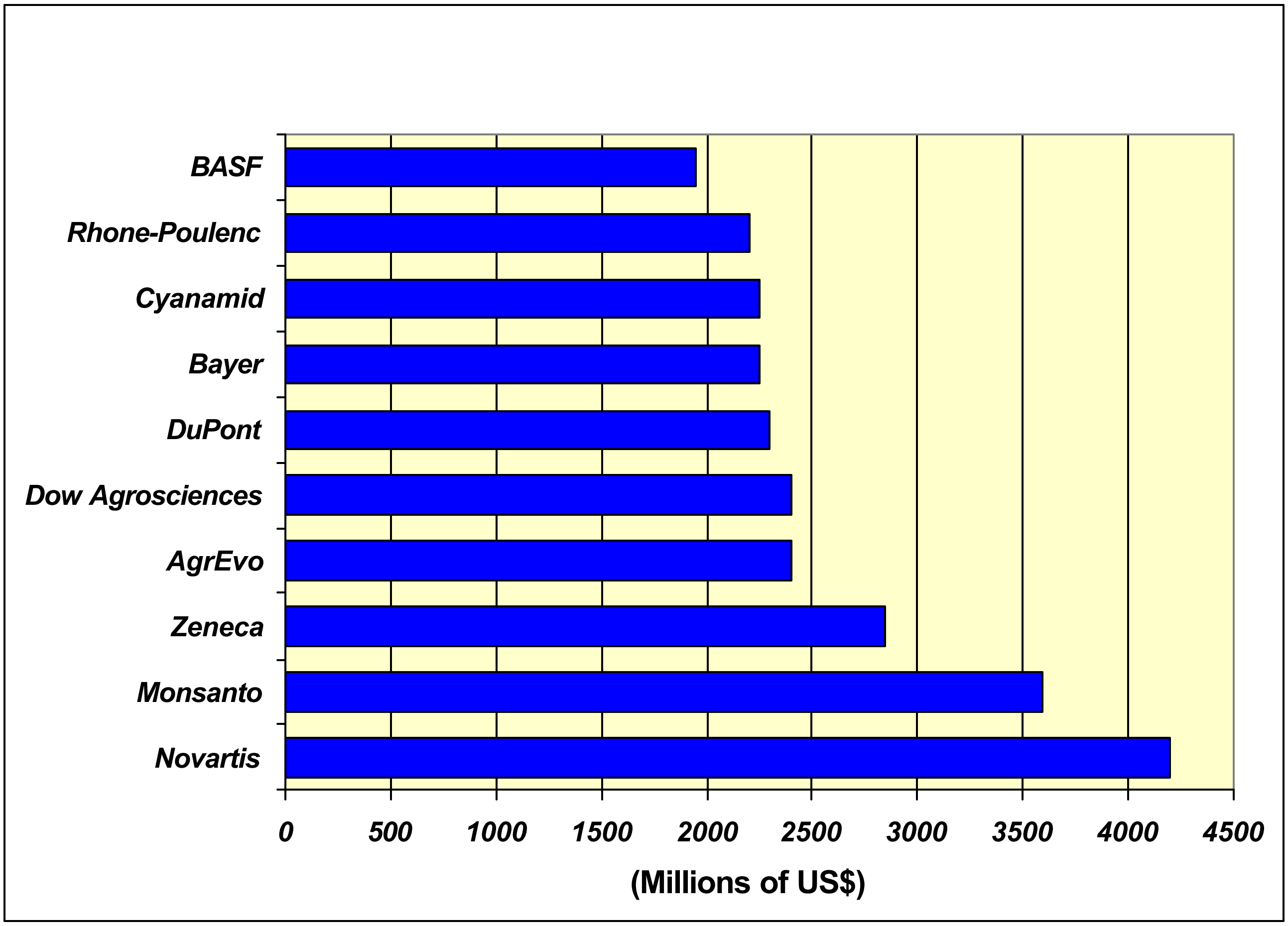
[38] Robert Service, "Chemical Industry Rushes to Greener Pastures," *Science* (October 23, 1998): 608.
[39] Jennifer A.Thompson, "Poor Nations Can't Afford Debate on Gene-Altered Crop," *The Christian Science Monitor* (November 13, 2000).
[40] M.S. Swaminathan. "Genetic Engineering and Food Security: Ecological and Livelihood Issues." Online at: http://www.cgiar.org/biotech/rep0100/swarminat.pdf. Accessed January 2000.
[41] The Food and Drug Administration's landmark 1992 policy governing GMOs (*"Statement of Policy: Foods Derived from New Plant Varieties"*) stated that genetically engineered foods were considered "substantially equivalent" to products created through traditional plant breeding techniques and were, therefore, "generally recognized as safe." Under this designation, labeling was not required for biotech products unless the modified product contained a substance known to cause allergic reactions, the product contained material from a source not currently in the food supply, or the product's nutritional value changed after the addition or subtraction of genetic material.
[42] "Genetically Modified Free Trade," *The Economist* (February 20, 1999).
[43] As stated in the 1992 Rio Declaration on Environment and Development.
[44] Julie Wolf, "Europe Turns Nose up at Biotech Foods — Lacking EU Rules for Modified Crops, Farm Sector Could Suffer," *The Wall Street Journal* (January 2, 1997).
[45] Jon Luoma, "Pandora's Pantry," *Mother Jones* (February 2000): 58.
[46] The Monsanto Company, *1997 Annual Report,* p. 4.

Exhibit 1
The Life Sciences: A Complex Web of Connections



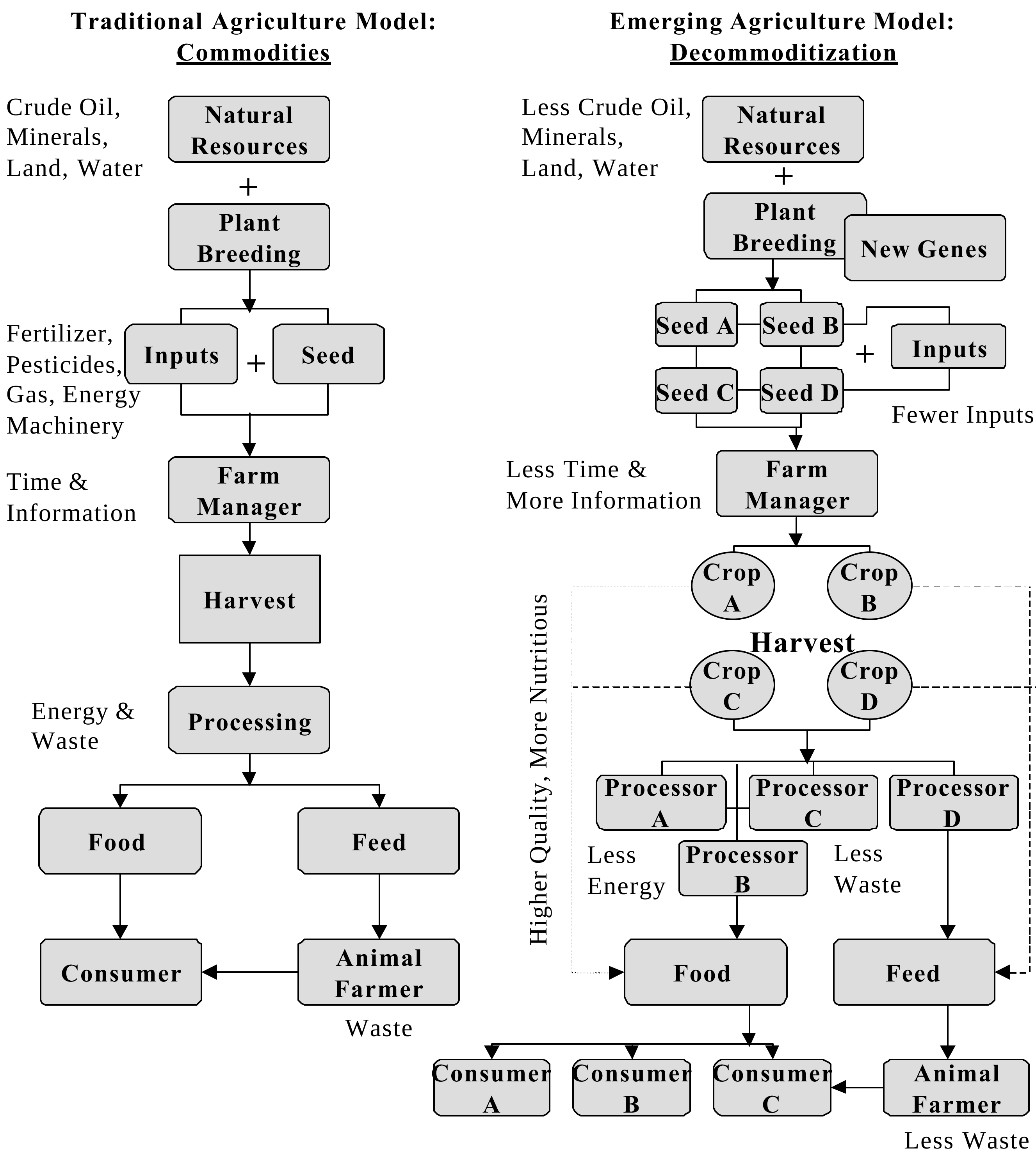
Source: The Monsanto Company, 1997 Annual Report*, p. 23. Accessed March 2000.*

Exhibit 2
Worldwide Agrochemical Sales (1998)



Source: The Monsanto Company, "AgriBasics," n.d. (mimeographed company manual).

Exhibit 3
Biotechnology & the Agricultural Supply Chain



Source: The Monsanto Company, 1997 Annual Report*, p.10.*

Exhibit 4 (a)
Genetic Engineering Techniques

There are a number of techniques for moving genes artificially into recipient organisms. The oldest of these is called *recombinant DNA*, a technique that relies on biological vectors like plasmids or viruses. Other newer gene transfer techniques are *electro- and chemical poration*, *microinjection*, and *bioballistics*.

Recombinant DNA

Recombinant DNA techniques use biological vectors like plasmids and viruses to carry foreign genes into cells. Plasmids are small circular pieces of genetic material found in bacteria that have the ability to cross species boundaries. The circles can be broken and new genetic material added to them. Plasmids augmented with new genetic material can move across microbial cell boundaries and place the new genetic material next to the bacterium's own genes. Often the bacteria will take up the gene and begin to produce the protein for which the gene codes. Where the new gene codes for insulin, for example, the bacterium will begin to produce insulin along with its other gene products. A large vat of bacteria engineered to produce insulin can then become a sort of pharmaceutical factory.

Viruses can also act as vectors in genetic engineering. Viruses are infectious particles that contain genetic material to which a new gene can be added. The virus can carry the new gene into a recipient cell in the process of infecting that cell. The virus can also be disabled so that while it can carry a new gene into a cell, it cannot redirect the cell's genetic machines to make thousands of copies of itself.

Microinjection

Other methods do not rely on biological vectors like plasmids and viruses. One of these is called microinjection and involves simply injecting genetic material containing the new gene into the recipient cell. Where the cell is large enough, as many plant and animal cells are, the injection can be done with a fine-tipped glass needle. Somehow the injected genes find the host cell genes and incorporate themselves among them.

Electro- and Chemical Poration

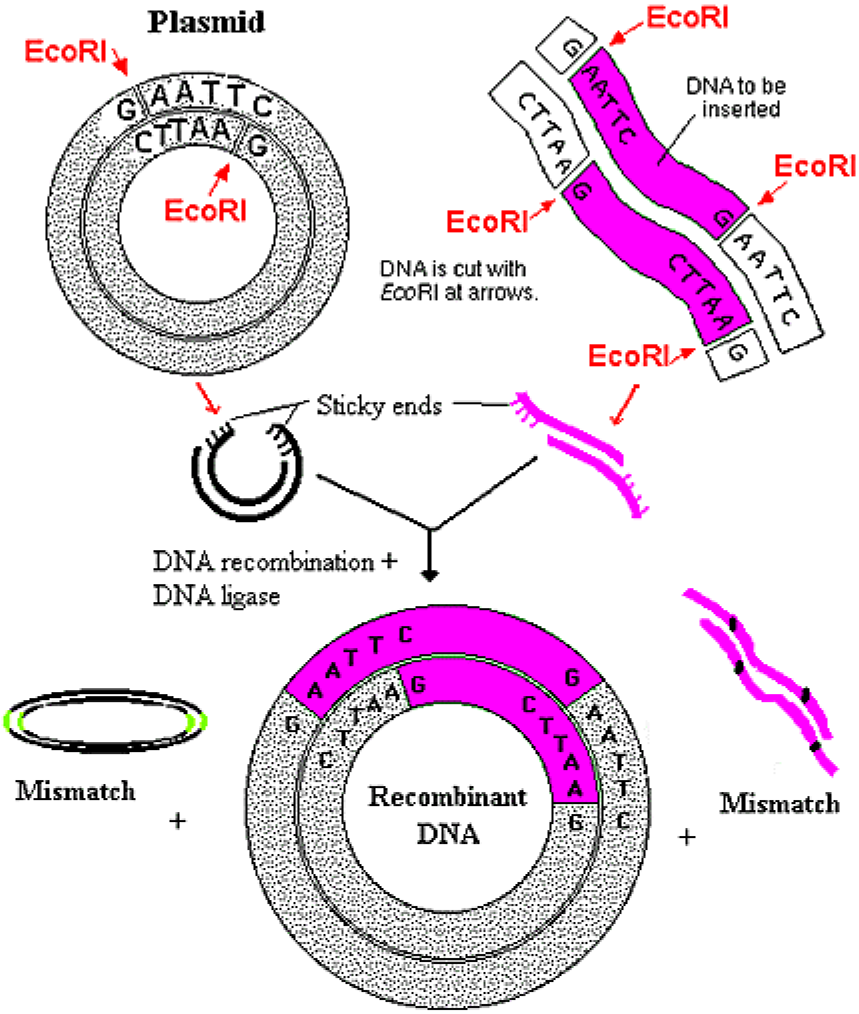
Other methods for direct gene transfer involve creating pores or holes in the cell membrane to allow entry of the new genes. This can be done by bathing cells in solutions of special chemicals--so-called chemical poration--or subjecting cells to a weak electric current--so-called electroporation.

Bioballistics

Finally, there are so-called projectile methods that use metal slivers to deliver the genetic material to the interior of the cell. The small slivers (much smaller than the diameter of the target cell) are coated with genetic material. One projectile method, called bioballistics, propels the coated slivers into the cell using a shot gun. A perforated metal plate stops the shell cartridge, but allows the slivers to pass through and into the living cells on the other side. Once in the cell, the genetic material is transported to the nucleus where it is incorporated among the host genes.

Source: Union of Concerned Scientists. 2000. Online at: http://www.ucsusa.org/agriculture/gen.techniques.html. *Accessed March 2000.*

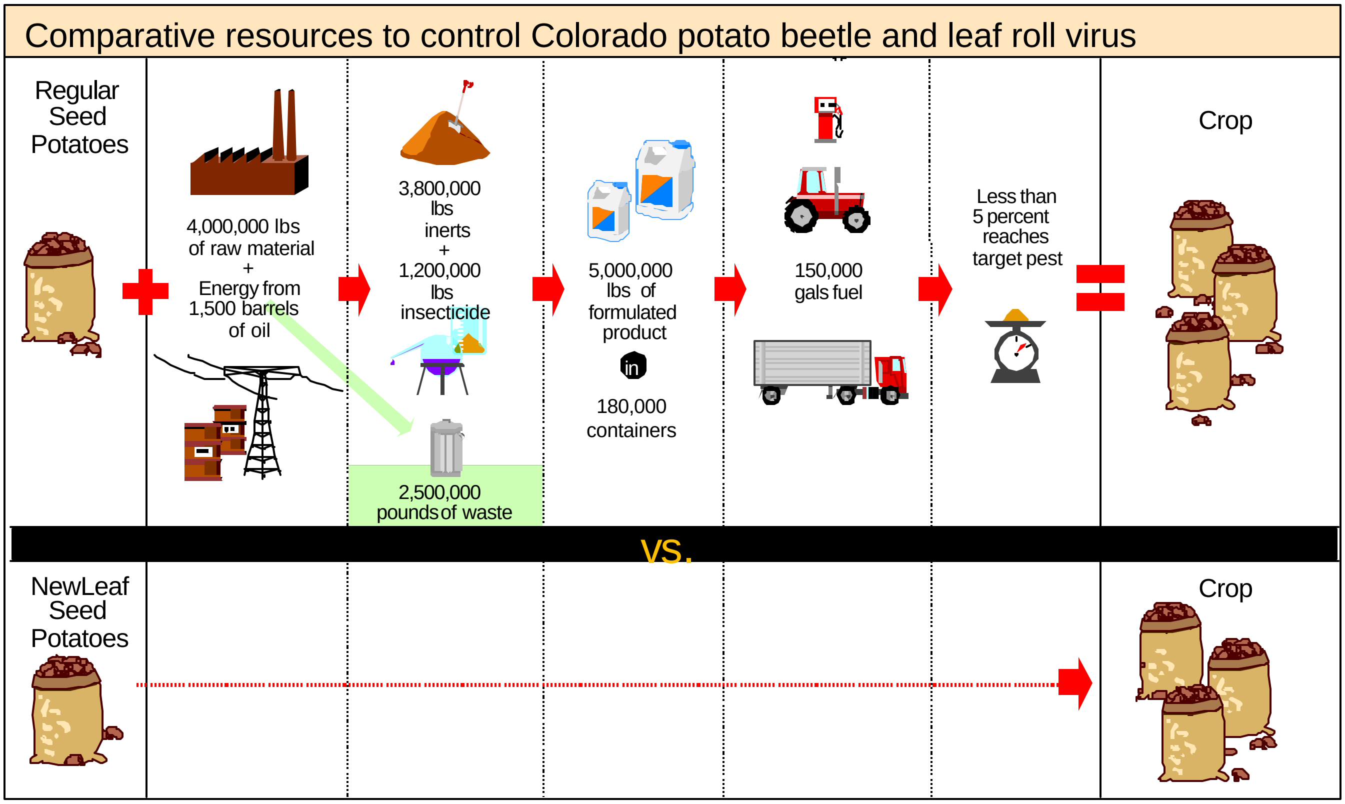
Exhibit 4(b)
Inserting a DNA Sample into a Plasmid



Plasmid vectors are small circular molecules of double stranded DNA derived from natural plasmids that occur in bacterial cells. The plasmid and the foreign DNA are cut (by EcoRI in this example) producing intermediates with sticky and complementary ends. Those two intermediates recombine by base-pairing. A new plasmid containing the foreign DNA as an insert is obtained, though mismatches do occur, producing an undesirable recombinant. The new plasmid can be introduced into bacterial cells that can produce many copies of the inserted DNA. This technique is called DNA cloning.

Source: The National Health Museum. 2000. Online at: http://www.accessexcellence.org/AB/GG/inserting.html. *Accessed March 2000.*

Exhibit 5
Agbiotechnology and Sustainability:
System Effects of Monsanto's *NewLeaf* Potato



Source: The Monsanto Company. 2000. Online at: http://www.Biotechbasics.com/newleaf.html. *Accessed March 2000.*

Exhibit 6

The Monsanto Company: Key Products (End 1997)

Division	Product	Description
Pharmaceuticals	*Ambien* Short-Term Treatment for Insomnia	Leader in the U.S. hypnotic market with a 50% market share in total prescriptions.
	Arthrotec Arthritis Treatment	Treatment for arthritis which combines a non-steroidal anti-inflammatory drug (NSAID) with an ulcer preventive drug. Already sold in many countries and recently received approval from the U.S. Food & Drug Administration.
	Calan & *Covera-HS* Long-Acting Calcium Channel Blockers	Used to treat chest pain and hypertension. First anti-hypertensive medication with unique delivery system that provides 24 hours of blood pressure control.
	Cytotec Ulcer Preventative Drug	Helps prevent gastric ulcers caused by use of NSAIDs.
	Daypro Arthritis Treatment	Once-a-day NSAID treatment for osteoarthritis and rheumatoid arthritis.
	Demulen & *Tri-Norinyl* Oral Contraceptives	Oral contraceptives used in some 70 countries around the world.
Agriculture	*Avadex BW* & *Far-Go* Herbicides	Herbicides used to control wild oats in wheat, peas and lentil crops.
	Bollgard Insect-Protected Cotton	Cotton developed through biotechnology to protect itself from several insect pests.
	Harness & *Lasso* Herbicides	Herbicides used with corn. *Lasso* is also used for weed control in soybean, peanut and sorghum crops.
	New-Leaf Insect-Protected Potatoes	Potatoes developed through biotechnology to protect itself from the Colorado potato beetle.
	Posilac Bovine Somatotropin	Animal health product which increases milk production in cows and helps decrease farmers' costs.
	Roundup Herbicide	World's leading nonselective agricultural and industrial herbicide.
	Roundup Ready Canola, Cotton & Soybeans	Products developed through biotechnology that tolerate *Roundup* herbicide.
	YieldGard Insect-Protected Corn	Corn developed through biotechnology to protect itself from the corn borer, one of the most destructive corn pests.
Nutrition	*Equal* Brand Sweetener	Popular tabletop sweetener made with *Nutrasweet* brand sweetener.
	NutraSweet Brand Sweetener	Leading brand of high-intensity sweetener used in beverages and food products worldwide.
	Xanthum Gums, Alginates & Gellan Gums	Food ingredients used to improve the bulk, texture and processing of soups, sauces, beverages, bakery goods and other products.

Source: The Monsanto Company, 1997 Annual Report*, p. 24.*

Exhibit 7

Monsanto 1997 Annual Report

Segment Data

	Net Sales			Operating Contribution[1]			Operating Income (Loss)[2]		
	1997	1996	1995	1997	1996	1995	1997	1996	1995
Agricultural Products	$3,126	$2,555	$2,134	$ 762	$ 639	$ 508	$ 112	$ 520	$ 478
Nutrition and Consumer Products	1,535	1,581	1,371	304	338	294	211	193	186
Pharmaceuticals	2,407	1,995	1,711	340	223	144	318	79	132
Corporate and Other	446	217	194	(142)	(124)	(84)	(142)	(197)	(98)
Total	***$7,514***	***$6,348***	***$5,410***	***$1,264***	***$1,076***	***$ 862***	***$ 499***	***$ 595***	***$698***

	Total Assets			Capital Expenditures			Depreciation & Amortization		
	1997	1996	1995	1997	1996	1995	1997	1996	1995
Agricultural Products	$4,520	$3,007	$2,329	$ 341	$ 280	$ 135	$ 208	$ 153	$ 142
Nutrition and Consumer Products	2,646	2,635	2,653	82	98	72	118	125	119
Pharmaceuticals	2,865	2,391	2,619	190	89	78	136	130	127
Corporate and Other	752	581	375	31	33	16	25	15	17
Discontinued Operations		2,623	2,755						
Total	***$10,774***	***$11,237***	***$10,731***	***$644***	***$500***	***$301***	***$487***	***$423***	***$405***

(1) Operating contribution is operating income excluding goodwill amortization and the effect of restructuring and other unusual items.

(2) Operating income was affected by research and development write-offs in 1997 and by restructuring and other unusual items in 1996 and 1995.

Source: The Monsanto Company, 1997 Annual Report*, p. 35*.

Exhibit 8
Monsanto GM Crop Acreage (1998)

Monsanto Biotechnology Product	Current Acres Planted (1998)	Location
Roundup Ready Soybeans	25,000,000 100,000 2,500	United States Canada Mexico
Bollgard/Ingard Cotton (*Bt*)	200,000 130,000 100,000 30,000 20,000	Australia China Mexico South Africa Argentina
Roundup Ready Cotton and stacked *Roundup Ready* and *Bollgard* Cotton *(combined total)*	5,000,000 *(of this total, 950,000 acres were planted in Roundup Ready Cotton the first year of introduction.)*	United States
Roundup Ready Corn	950,000	United States*
YieldGard Corn (Bt)	11,000,000+ 300,000 42,000	United States Canada Argentina*
Roundup Ready Canola	2,000,000	Canada
NewLeaf Potatoes	50,000 10,000	United States Canada
Laurate Canola (oil modification)	50,000	United States
BXN Cotton (herbicide resistant)	1,000,000	United States

** Denotes first year of commercialization.*

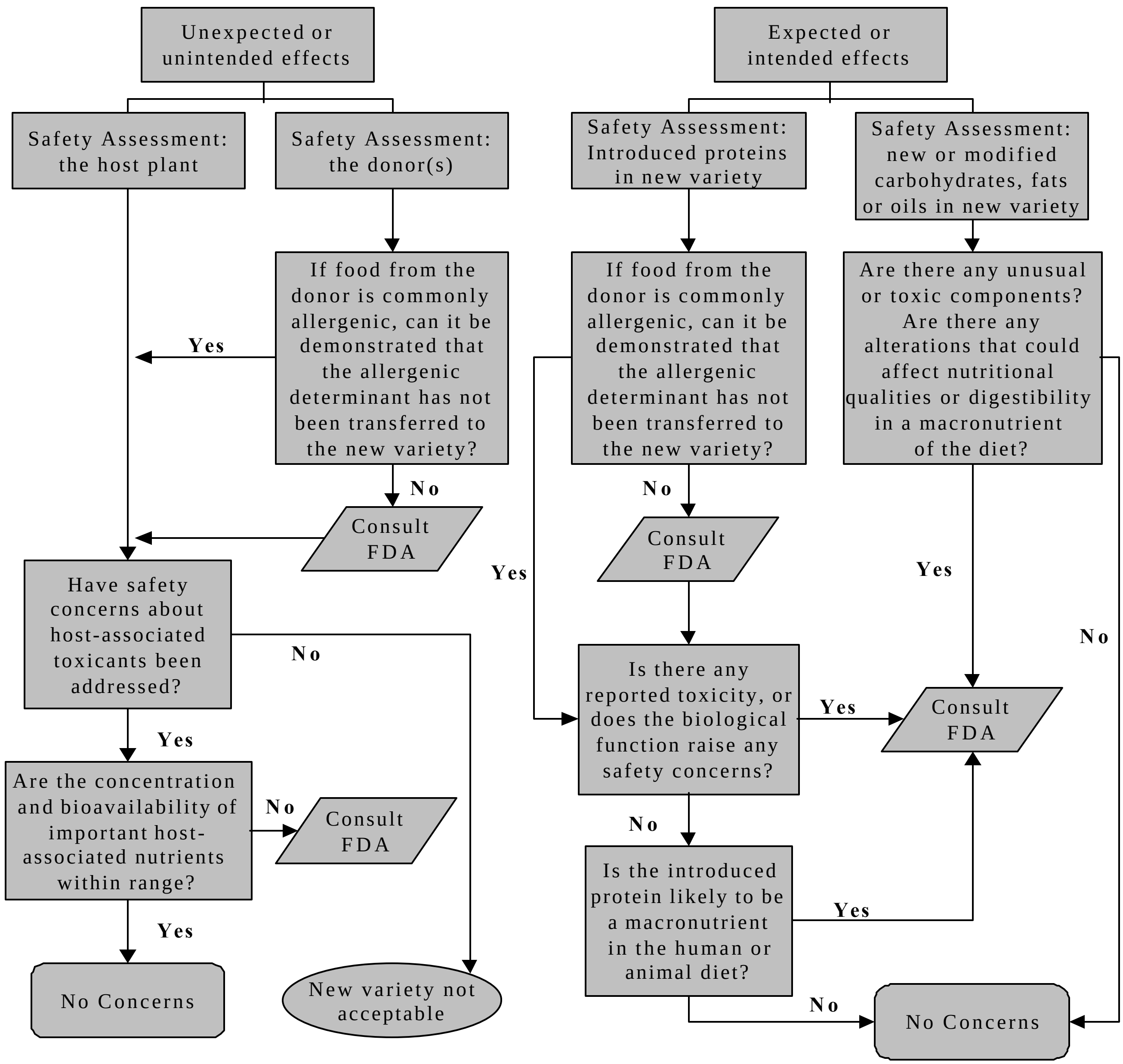
Source: The Monsanto Company, 1998 Sustainable Development Report*. Online at:* http://www.monsanto.com/monsanto/about_us/environmental_information/sustain_98/siteindex/index.html *Accessed March 2000.*

Exhibit 9
Farmer Adoption of GM Crops

	Percentage of Acreage Among Adopters		
Stated Reason for Adoption	**Herbicide-Tolerant Soybeans**	**Herbicide-Tolerant Cotton**	**Bt Cotton**
Increase yields through improved pest control.	65.2	76.3	54.4
Decrease pesticide input costs.	19.6	18.9	42.2
Increased planting flexibility (e.g., use reduced tillage or no-till systems, easier to rotate crops).	6.4	1.8	2.2
Adopt more environmentally friendly practices.	2.0	0.9	0.0
Some other reason(s).	6.8	2.3	1.2

Source: Economic Research Service, United States Department of Agriculture, "Adoption of Genetically Engineered Crops," Genetically Engineered Crops for Pest Management/ AER-786.

Exhibit 10
FDA Review and Approval Process Flow for Genetically Modified Foods



Source: FDA Statement of Policy: Foods Derived from New Plant Varieties, May 29, 1992, as cited in Pam Anderson, Heather Lair, and Kara Rubin, "Fooling Nature, Feeding the World: Genetic Modification, Monsanto and the Future of the World," University of Michigan Business School, December 1998 (mimeograph).

Exhibit 11
The Monsanto Company:
Key Employees with Previous Government Experience

- ***Michael R. Taylor -*** Monsanto's Vice President of Public Policy (as of September 1998). Former executive assistant to the commissioner of the Food and Drug Administration (FDA), Taylor was also the agency's deputy commissioner for policy when the government's 1992 policy on GE food safety was drafted.

- ***Mickey Cantor -*** Member of Monsanto's Board of Directors since 1997. Personal attorney to President Clinton and former U.S. commerce secretary and US trade representative.

- ***Marcia Hale -*** Monsanto's Director of U.K. Government Affairs. Former assistant to President Clinton for intergovernmental affairs.

- ***William D. Ruckelshaus -*** Member of Monsanto's Board of Directors. Former chief administrator to the EPA under Nixon and Reagan.

- ***Jack Watson -*** Chief legal strategist for Monsanto. Former White House Chief of Staff in the Carter administration.

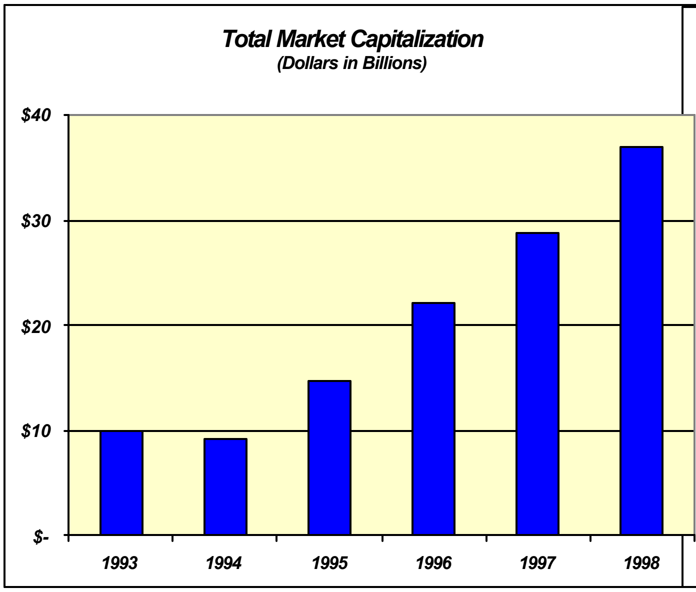
- ***Linda J. Fisher -*** Vice President of Public Affairs for Monsanto. Former assistant administrator of the EPA's Office of Prevention, Pesticides and Toxic Substances.

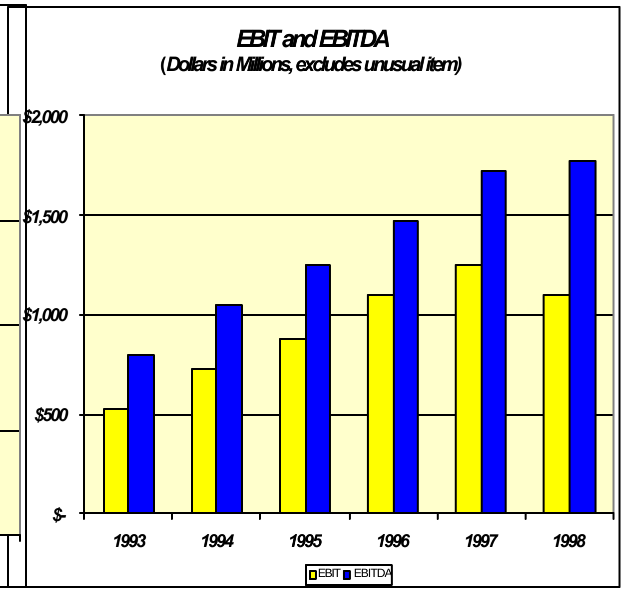
- ***Michael A. Friedman, M.D. -*** Senior Vice President of Clinical Affairs for G.D. Searle (Monsanto's pharmaceutical division). Former acting FDA commissioner.

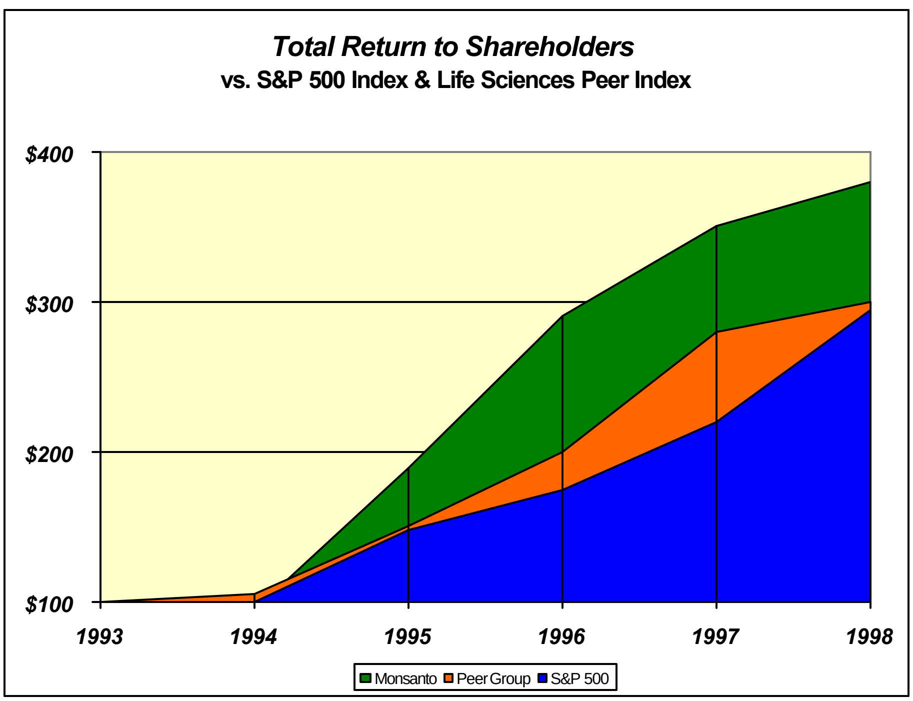
- ***Toby Moffett -*** Vice President of Public and Government Affairs for Monsanto. Former Democratic Congressman from Connecticut.

Source: Jon Luoma, "Pandora's Pantry," Mother Jones *(February 2000): 58.*

Exhibit 12
The Monsanto Company:
Operating & Financial Performance







Source: The Monsanto Company, 1998 Annual Report, *p. 2.*

Exhibit 13
Balance Sheet:
Statement of Consolidated Financial Position

AS OF DEC. 31 (Dollars in millions, except per share)

ASSETS	1997	1996
CURRENT ASSETS:		
Cash and cash equivalents	$ 134	$ 166
Trade receivables, net of allowances of $63 in 1997 and $47 in 1996	1,823	1,515
Miscellaneous receivables and prepaid expenses	692	286
Deferred income tax benefit	243	282
Inventories	1,374	1,183
Discontinued operations		908
TOTAL CURRENT ASSETS	4,266	4,340
PROPERTY, PLANT AND EQUIPMENT:		
Land	99	118
Buildings	914	848
Machinery and equipment	3,359	3,162
Construction in progress	329	300
Total property, plant and equipment	4,701	4,428
Less accumulated depreciation	2,301	2,333
NET PROPERTY, PLANT AND EQUIPMENT	2,400	2,095
INVESTMENTS IN AFFILIATES	329	257
INTANGIBLE ASSETS, net of accumulated amortization of $853 in 1997 and $769 in 1996	2,837	2,166
OTHER ASSETS	942	664
NONCURRENT ASSETS — DISCONTD. OPERATIONS		1,715
TOTAL ASSETS	$10,774	$11,237

LIABILITIES		
CURRENT LIABILITIES:		
Accounts payable	$ 480	$ 479
Wages and benefits	251	456
Restructuring Reserves	176	247
Miscellaneous accruals	906	728
Short-term debt	1,726	654
Discontinued operations		837
TOTAL CURRENT LIABILITIES	3,539	3,401
LONG-TERM DEBT	1,979	1,608
DEFERRED INCOME TAXES	97	102
POSTRETIREMENT LIABILITIES	735	594
OTHER LIABILITIES	320	509
NON-CURRENT LIABILITIES — DISCTD. OPERATIONS		1,333

Exhibit 13 (Con't)
Balance Sheet, page 2:
Statement of Consolidated Financial Position

SHAREOWNERS' EQUITY:		
Common stock (authorized: 1,000,000,000 shares, par value $2)		
Issued: 821,970,970 shares in 1997 and 1996	1,644	1,664
Additional contributed capital	321	65
Treasury stock, at cost	(2,570)	(2,661)
(226,686,302 shares in 1997 and 237,594,831 shares in 1996)		
Reinvested earnings	4,973	4,795
Reserve for ESOP debt retirement	(123)	(174)
Accumulated currency adjustment	(128)	10
Other	(13)	11
TOTAL SHAREOWNERS' EQUITY	4,104	3,690
TOTAL LIABILITIES AND SHAREOWNERS' EQUITY	$10,774	$11,237

Source: The Monsanto Company, 1997 Annual Report*, p. 30.*

Key Financial Statistics

	1997	1996	1995
Current Ratio (Current assets divided by current liabilities)	1.2	1.3	1.5
Trade Receivables Outstanding — Days Sales Outstanding (Fourth-quarter trade receivables divided by fourth-quarter net sales times 30 days)	95	99	80
Inventory Turnover Ratio (COGS/Inventory)	2.2	2.3	2.2
Interest Coverage (Income from continuing operations before interest expense and income taxes divided by total interest cost)	2.9	5.3	5.7
Cash Provided By Continuing Operations/Total Debt	10%	42%	26%
Total Debt/Total Capitalization	47%	38%	35%

Source: The Monsanto Company, 1997 Annual Report*, p.45.*

Exhibit 13 (Con't)
Statement of Consolidated Income

(Dollars in millions, except per share)	1997	1996	1995
NET SALES	$7,514	$6,348	$5,410
Costs and expenses:			
Cost of goods sold	3,091	2,684	2,357
Selling, general and administrative expenses	2,023	1,860	1,521
Technological expenses	1,044	702	601
Acquired in-process research and development	684		
Amortization of intangible assets	173	151	119
Restructuring expenses	356	114	
OPERATING INCOME	499	595	698
Interest expense	(170)	(119)	(132)
Interest income	45	51	57
Other income (expense) — net	(8)	26	22
INC.CONTINUING OPERATIONS (PRE-TAX)	366	553	645
Income taxes	72	140	184
INCOME FROM CONTINUING OPERATIONS	294	413	461
DISCONTINUED OPERATIONS:			
Income (Loss) from discontinued operations	176	(28)	162
Gain on sale of styrenics plastics business			116
INCOME (LOSS) FROM DISCONTINUED OPERATIONS	176	(28)	278
NET INCOME	$ 470	$ 385	$ 739
BASIC EARNINGS (LOSS) PER SHARE:			
Continuing operations	$ 0.50	$ 0.71	$ 0.81
Discontinued operations	0.30	(0.05)	0.49
NET INCOME	$ 0.80	$ 0.66	$ 1.30
DILUTED EARNINGS (LOSS) PER SHARE:			
Continuing operations	$ 0.48	$ 0.69	$ 0.79
Discontinued operations	0.29	(0.05)	0.48
NET INCOME	$ 0.77	$ 0.64	$ 1.27

Source: The Monsanto Company, 1997 Annual Report*, p.44.*

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