



good ideas are growing

PLANT BIOTECHNOLOGY



Plant biotechnology: good ideas are growing

Plant biotechnology is helping today to provide people with more and better food and holds even greater promise for the future.

Whether cotton farmers in China, India and South Africa, canola farmers in Canada, soybean farmers in Argentina or corn farmers in Spain and the United States, millions of farmers around the world are using biotech seeds to boost yields, improve their livelihoods and preserve the environment.

That's why organizations including the United Nations, American Medical Association, International Society of African Scientists and the Organization for Economic Cooperation and Development,¹ have voiced their support for plant biotechnology.

Yes, there are questions and concerns — just as there are with any new technology. But for nearly 300 years, plant breeders have worked to create better crops — a process that actually began thousands of years ago with the domestication of wild plants. Plant biotechnology is the next stage in the evolution of our continuing efforts to improve the food we eat.

What is plant biotechnology?

Plant biotechnology is a process in which genetic information and techniques are used to develop useful and beneficial plants.

“It is important to recognize that we have been genetically modifying the food supply for thousands of years,” wrote food scientist Susan Harlander.²

TEOSINTE⁵

Modern corn, for example, bears little resemblance to its early ancestor, teosinte. Those early cobs were just one to two inches long with a few tiny kernels.³ Ancient varieties of potatoes and tomatoes were also vastly different from their modern relatives — and barely edible, if at all.⁴ It was only after centuries of careful breeding that corn, potatoes and tomatoes were developed into the tasty, nutritious foods we know and enjoy today.



MODERN CORN

Austrian monk Gregor Mendel was the first to begin understanding genetics, as he said, “just what it is that gives the colors and the shapes to the different trees and fruits and flowers.”

In 1866 Mendel speculated that certain unseen particles passed traits from one generation to the next. It wasn’t until nearly 100 years later that researchers discovered that these unseen particles are genes. Genes carry the code that tell a plant what color it will be or how it will taste.⁶

In 1973, researchers Stanley Cohen and Herbert Boyer actually took a gene from one organism and inserted it into another, launching the modern biotechnology era.⁷ Their work led to the very first commercial biotech product — human insulin.

Modern plant biotechnology is a much more precise tool than traditional plant breeding. It allows researchers to select a gene with a specific trait — such as taste or hardiness — in one plant and move it to another. With traditional plant breeding, many genes are transferred to create a new plant variety. Some of these genes carry desired traits, others carry unwanted traits that must be removed with still more breeding. Getting it right is often difficult.

But with organisms modified with advanced biotechnology, “We are in a better, if not perfect, position to predict the [resulting traits],” said the National Research Council in a 1989 report.⁸ The NRC advises the U.S. government on science issues.



Products approved for market

To date, more than 50 biotech crops have been approved for sale in the United States and Canada, and three have been approved in Mexico. The list includes enhanced soybeans, cotton, corn, canola, cantaloupe, papaya, potato, squash, sugar beets and tomatoes.

Most of these crops have been enhanced in one or more of the following ways:

- **Herbicide tolerant** crops are immune to certain herbicides that are effective against harmful weeds but have no effect on the crop. Globally, about three-fourths of the biotech crops planted in 2002 were herbicide tolerant.⁹
- **Pest resistant** crops usually contain a protein from *Bacillus thuringiensis* or *Bt*, a naturally occurring soil bacterium that wards off the European corn borer.
- **Virus resistant** crops are shielded from plant viruses in a similar way that humans are protected from disease with vaccines: by being “inoculated” and thus building a natural defense.
- **Stacked trait** crops combine these and other traits.

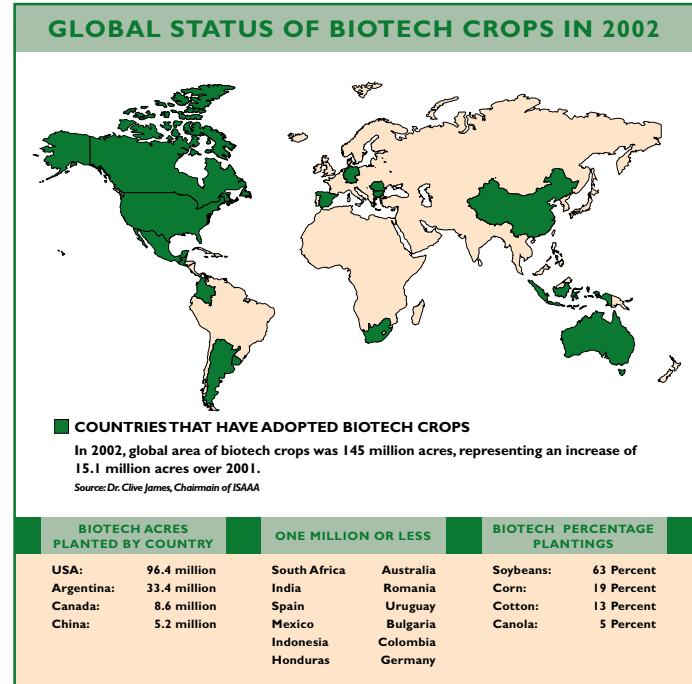
While four countries — the United States, Argentina, Canada and China — accounted for 99 percent of the global biotech acreage in 2002,¹⁰ the adoption of biotech crops has actually been faster in developing countries than in developed countries.¹¹ Between 5.5 million and 6 million farmers in 16 countries planted biotech seeds in 2002, according to the International Service for the Acquisition

of Agri-biotech Applications (ISAAA). More than three-quarters were farmers in developing countries — primarily in China and South Africa.¹²

“Normally, at the end of the year, I would ask my wife how we are going to pay our bills,” says South African cotton farmer T.J. Buthelezi, who now plants *Bt* cotton. “Now I ask her, how are we going to spend this money?”

Farmers have embraced the technology so quickly for very simple reasons: Biotech crops improve yields, cut costs, reduce spraying and save time.¹³

“Biotechnology continues to be the most rapidly adopted technology in agricultural history due to the social and economic benefits the crops offer farmers and society, particularly the 5 million resource-poor farmers in developing countries,” says Clive James of ISAAA. “Biotech crops can significantly alter the lives of these farmers, limiting the time they must spend in the field and helping alleviate poverty.”



4000 BC – 1600 AD



Early farmers — like those in Egypt and the Americas — saved seeds from plants that produced the best crops and planted them the next year to grow even better crops.

1700 – 1720



Thomas Fairchild, the forgotten father of the flower garden, creates Europe’s first hybrid plant.¹

1866



Austrian monk Gregor Johann Mendel publishes a study on heredity that describes how plant characteristics are passed from generation to generation.²

1870 – 1890

Plant researchers crossbreed cotton to develop hundreds of new varieties with superior qualities.³



“For the first time in 20 years, we’re seeing a return of ladybugs, quail and red foxes to our farm. It’s the healthier, cleaner environment. Biotechnology helps me be a more successful farmer and a better steward of my land.”

Donna Winters, farmer, Lake Providence, Louisiana

Benefits of biotechnology

More and more studies are documenting the economic and environmental benefits of biotech crops.

A 2002 study of biotech crops by the National Center for Food and Agricultural Policy (NCFAP) found that six biotech crops planted in the United States — soybeans, corn, cotton, papaya, squash and canola — produced an additional 4 billion pounds of food and fiber on the same acreage, improved farm income by \$1.5 billion and reduced pesticide use by 46 million pounds.¹⁴

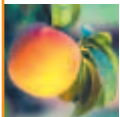
Other global studies have confirmed the economic benefits of biotech crops:

- Yield increases for *Bt* cotton ranged from 5 to 10 percent in China, 10 percent or more in the United States and Mexico, and 25 percent in South Africa — reaping global cotton farmers an additional \$1.7 billion in income between 1998 and 2001, according to ISAAA.¹⁵
- *Bt* corn in Spain produced yield increases of between 10 and 15 percent — and an average income gain of 12.9 percent — in areas with high levels of insect infestations in 2001-02, according to a study funded by Agricultural Biotechnology in Europe.¹⁶

- Biotech canola in Canada produced 10 percent yield increases in 2000, generating an average earnings increase of \$5.80 per acre compared with conventional canola, according to a Canola Council of Canada study.¹⁷
- Biotech soybean yields in Argentina were 10 percent higher than yields for conventional soybeans, according to ISAAA.¹⁸

While biotech cotton has led the way in developing countries like China and South Africa, there's even more excitement about the benefits this new technology can bring to staple food crops grown in developing regions of the world. The reason is very simple: The developing world, home to 800 million hungry people, has the most at stake and potentially the most to gain through plant biotechnology.

1871 – Early 1900s



Researcher Luther Burbank developed the Russet Burbank Potato, and later went on to develop several new hybrid fruits, including plums, berries, prunes and peaches.⁴

1908

First U.S. hybrid corn produced by G.H. Shull of Carnegie Institute through self-pollination.⁵

1919

Word “biotechnology” coined by Hungarian immigrant Karl Ereky.⁶

1930



Inspired by writings of Luther Burbank, U.S. Congress passes the Plant Patent Act, enabling the products of plant breeding to be patented.⁷



“Agribiotechnology matters to Kenya, as to most other African countries, for the most basic reasons: Our people do not have enough to eat.”

Florence Wambugu, African scientist and founder,
A Harvest Biotech Foundation, Nairobi, Kenya

More food

With the world population projected to top 8 billion by 2030, there will be another 2 billion mouths to feed — most of them in developing regions.¹⁹ With income growth also fueling demand for better diets, farmers will need to at least double their production over the next 25 years to satisfy these appetites, according to the United Nations.²⁰ But annual increases in agricultural yields in recent years are holding at just 1.3 percent a year — less than half of the gains of 30 years ago.²¹

C.S. Prakash, founder of the AgBioWorld Foundation, says an additional 4 billion acres will need to come under the plow by 2050 to feed all of these people if there are no increases in farm productivity.²² That's more than twice the size of the continental United States.

Getting the most production from existing land is important because more than a fourth of the world's 21.5 billion acres of agricultural land, pastures and woodlands have already been degraded from overuse or misuse,²³ such as over-irrigation or erosion. Biologists fear that up to half of the world's remaining 6 billion acres of tropical forests will be lost to agricultural expansion, and some are warning

that as many as 20 percent of all tropical forest species could be extinct within 30 years if forests continue to disappear at the current rate.²⁴

Biotechnology is not the single solution for feeding a growing population. But it is a tool that can help grow more food in a sustainable way that does not deplete existing farmland or force more remaining wilderness areas to go under the plow.

Researchers are busy developing hardier crops that can produce greater yields on existing land, or even thrive on marginal land:

- A biotech rice that can better withstand droughts and thrive in marginal soil is being developed by Cornell University researchers.
- A biotech sweet potato²⁵ that can produce twice the yields of conventional varieties is midway through field trials in Kenya. Sweet potatoes are a staple crop for millions in the developing world.
- A biotech papaya — credited with saving the papaya industry in Hawaii — is now being brought to farmers in Southeast Asia, the Caribbean and several other developing areas where papaya is a staple food.

1933



Hybrid corn becomes available commercially⁸ in the United States, causing corn yields to triple over the next 50 years.⁹

1953

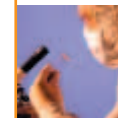
Watson and Crick describe the double helix structure of DNA, providing more insight into how DNA carries genetic information.¹⁰

1960s



After decades of work, Norman Borlaug creates dwarf wheat that increases yields by 70 percent, launching the Green Revolution that helped save millions of lives.¹¹

1973



Cohen and Boyer successfully splice a gene from one organism and move it into another, launching the modern biotechnology era.¹²



“We face many other fascinating possibilities. How about genetically modifying foods to contain higher levels of cancer-fighting compounds... Or developing fresh fruits and vegetables with improved shelf lives?”

Joe Schwarcz, Office for Science and Society,
McGill University, Montreal, Canada

Better food

Not only is biotechnology being used to produce more food, it is also developing better food — food that is healthier, more nutritious and better tasting.

For the developing world, researchers are working to create:

- Golden rice, which is fortified with beta carotene that stimulates the production of vitamin A in the human body. Every year, between 250,000 and 500,000 children go blind because of vitamin A deficiency, according to the World Health Organization. And about half of these children die within a year of losing their sight.²⁶
- Cassava, a staple food in many poorer parts of the world, is being enhanced so it contains 35 to 45 percent more protein and essential amino acids.²⁷
- Plant-based vaccines — made from crops such as banana or potato — which are then pulverized and administered in pill form. Researchers have developed a vaccine for hepatitis B that is similar to a traditional vaccine but can be produced by a banana for a fraction of the cost.

It's reasons like these that have led organizations like the United Nations to call biotechnology a “breakthrough technology for

developing countries”²⁸ and the International Society of African Scientists to say that “Africa and the Caribbean cannot afford to be left further behind in acquiring the uses and benefits of this new agricultural revolution.”²⁹

Biotechnology is also being used to develop better food for people in the industrialized world. Researchers are working to develop:

- A cancer-fighting tomato with three times more beneficial lycopene than conventional varieties. Lycopene protects human tissue and could help prevent breast and prostate cancers as well as heart disease.
- New cooking oils made from canola, corn and soybeans that contain up to 10 times more healthful vitamin E. Researchers believe vitamin E can lower the risk of cardiovascular disease and some cancers.
- Food with fewer allergens. Researchers are working to reduce the allergens in rice, wheat, peanuts and other crops so more of the estimated 50 million people who suffer from allergies worldwide can enjoy the food most people eat everyday.

1978

Boyer's lab created a synthetic version of the human insulin gene.¹³



1982

The first biotech plant is produced — a tobacco plant resistant to an antibiotic. The breakthrough paved the way for beneficial traits, such as insect resistance, to be transferred to plants.¹⁴

1985



Field trials for biotech plants that are resistant to insects, viruses and bacteria are held in the United States.¹⁵

1986

The EPA approves the release of the first crop produced through biotechnology — tobacco plants.¹⁶ A coordinated framework for the regulation of products derived from biotechnology is established.¹⁷



MONARCH BUTTERFLY

While a 1999 Cornell University study suggested that large amounts of *Bt* corn pollen — when fed to monarch larvae in the laboratory — could pose a threat, several studies have since concluded that biotech corn does not harm monarchs.

In a comprehensive study that has been described as a model for assessing the risks of biotech crops, a team of federal, university and industry scientists concluded that the impact of *Bt* corn — enhanced with a naturally occurring soil bacterium that wards off insect pests — on monarch populations is “negligible.”³⁰ Other groups concur. “The weather seems to be by far the largest influence on monarch butterfly populations,” said a report on the butterfly issue by the nonprofit Pew Initiative on Food and Biotechnology.³¹

As wilderness, including monarch habitat, shrinks from agricultural expansion, biodiversity is lost. Biotech crops can make existing farmland more productive, reducing pressure to put wilderness areas under the plow.

Because *Bt* corn is not considered a threat, the U.S. Environmental Protection Agency (EPA) in October 2001 approved the planting of *Bt* corn for another seven years and one year later the European Congress of Entomology issued a statement supporting the use of *Bt* corn.³²

Better for the environment

Biotech crops are also helping protect the environment. A recent report confirmed their benefits.

“The results clearly show that soil, air and water quality are enhanced through the responsible use of current biotechnology-derived soybean, corn and other crops,” said Teresa Gruber, executive director of the Council for Agricultural Science and Technology.³³

Biotech crops also make it easier for farmers to use environmentally friendly conservation tillage practices, where more residue from the previous crop is left on the field rather than plowed under.

No-till conservation practices — the best for the environment because soil is left virtually undisturbed from harvest to planting — have increased 35 percent since biotech crops came on the market in 1996, according to a study by the Conservation Technology Information Center in Indiana.³⁴

“There is a clear association between sustainable tillage practices and biotech crops,” said the study, noting that nearly three-fourths of no-till soybean acres — and 86 percent of no-till cotton acres — were planted with biotech varieties.

Conservation tillage in the United States has:

- Saved nearly 1 billion tons of soil per year.
- Resulted in a projected \$3.5 billion savings by lowering maintenance costs for activities such as dredging rivers, cleaning road ditches and treating drinking water.
- Created better habitat for birds and mammals, which thrive in the protective residue of no-till fields.
- Reduced levels of phosphorous and nitrogen in lakes, streams and the Gulf of Mexico.
- Saved 306 million gallons of fuel in 2002 by reducing the number of tractor passes needed to control weeds. On average, no-till saves about 3.9 gallons of fuel per acre, according to the study.

In Canada, studies by George Morris Centre and the Canola Council of Canada have reached similar conclusions about the environmental benefits of biotech crops.

1991

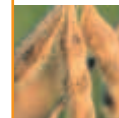
The USDA's Animal and Plant Health Inspection Service publishes guidelines for field trials of biotech crops.

1994



The biotech FlavSavr® tomato is approved by the FDA for U.S. grocery stores. It was developed to have more flavor and to have a longer shelf-life than conventionally grown tomatoes.

1995-1996



Biotech soybeans and corn are approved for sale, and biotech cotton is commercialized in the United States.¹⁸ Biotech crops become the most rapidly adopted technology in the history of agriculture.

1996

In total, farmers in six countries plant biotech crops on 4.2 million acres.¹⁹



REGULATION

Before foods developed with biotechnology can be marketed in the United States, there are nine separate steps in the regulatory process that typically take seven to 10 years to complete — a far more rigorous process than is required for conventional foods, says Bruce Chassy, a professor of food microbiology at the University of Illinois.

“Crops produced through biotechnology have proven to be as safe or safer than crops produced by conventional breeding,” he says.³⁵

In Canada, there are six steps that must be taken before foods developed with biotechnology are approved.³⁶

After studying biotechnology issues for two years, the Canadian Biotechnology Advisory Committee said that although the regulatory process could be improved, biotech foods currently on the market are safe.

“GM foods currently in the marketplace have arguably undergone greater regulatory scrutiny than their conventional counterparts,” said the report.³⁷ “We conclude that no scientific evidence exists to suggest that GM plants and foods currently in the market pose any greater health or environmental risk than other foods.”³⁸

Safety

Perhaps the most telling fact about the safety of plant biotechnology is that there isn't a single documented case of an illness caused by foods developed with biotechnology since they first came on the market in the mid-1990s.³⁹

Even a report from the European Commission, whose member states are more skeptical about biotech products, concluded that “the use of more precise technology and the greater regulatory scrutiny [over biotech foods] probably make them even safer than conventional plants and foods.”⁴⁰

That report, validating the safety of biotech crops, summarized more than 15 years of research by 400 research teams funded by European governments. A host of other organizations have also attested to the safety of foods developed with biotechnology.

- The American College of Nutrition “supports the use of biotechnology to develop food crops that contribute to global food security and enhance the safety and nutritional value of the food supply.”
- The American Medical Association recognized the “many potential benefits offered by genetically modified crops and

foods... and encourages ongoing research developments in food biotechnology.”⁴¹

- The International Society of Toxicology says “there is no reason to suppose that the process of food production through biotechnology leads to risks of a different nature than those... created by conventional breeding.”
- The General Accounting Office — the investigative arm of the U.S. Congress — says “biotechnology experts believe that the current regimen of tests has been adequate for ensuring that GM foods marketed to consumers are as safe as conventional foods.”
- And the World Health Organization said, “The benefits of biotechnology are many,” including improved production and reduced pesticide use, and promise “major improvements in both food quality and nutrition.”⁴²

Regulatory agencies in the United States:

Food and Drug Administration, Department of Agriculture, Environmental Protection Agency

Regulatory agencies in Canada:

Canadian Food Inspection Agency, Health Canada, Environment Canada

Regulatory agencies in Mexico:

CIBIOGEM, which includes six ministries (Agricultura, Salud, Medio Ambiente, Educacion, Economia, Hacienda y Credito Publico) and the National Council of Science and Technology (CONACYT)

1999



German and Swiss scientists develop golden rice, fortified with beta carotene, which stimulates production of vitamin A that can prevent some forms of blindness.²⁰

2000



The first entire plant genome is sequenced, *Arabidopsis thaliana*, which provides researchers with greater insight into the genes that control specific traits in many other agricultural plants.²¹

2000

Farmers in 13 countries plant biotech crops on 109.2 million acres, a 25-fold increase over 1996.²²

2001



U.S. and Canadian scientists develop a biotech tomato that thrives in salty conditions, a discovery with the potential to create tomatoes and other crops that can grow in marginal conditions.²³



“Biotechnology is the greatest thing since hybrid corn.”

Rod Gangwish, farmer, Shelton, Nebraska

Support grows

More organizations and leaders are voicing their support for the many benefits of biotechnology.

“We are increasingly encouraged that the advantages of genetic engineering of plants and animals are greater than the risks,” said Catholic Bishop Elio Sgreccia. “We cannot agree with the position of some groups that say it is against the will of God to meddle with the genetic make-up of plants and animals.”⁴³

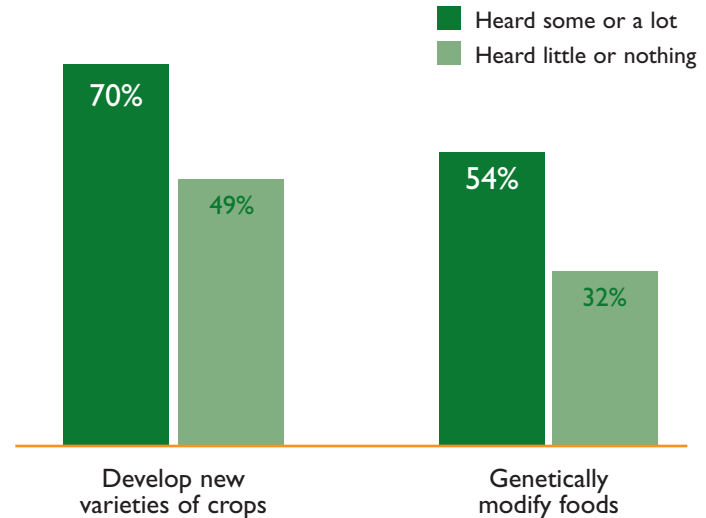
Opinion polls show that a majority of people believe plant biotechnology will be good for society in the long term. Julia Child, the master chef and cookbook author, says she’s fascinated by the potential benefits of biotechnology.

“If they can give us a better tomato, I’m for it,” she once said.

Biotechnology is just beginning to deliver the benefits that can improve lives all over the world. Yes, there are questions. But they are being answered by studies that are documenting the benefits these crops have delivered over the past few years. And that is just the beginning of the potential for biotechnology to provide more and better food in years ahead.

SUPPORT GROWS WITH KNOWLEDGE

Percent who support biotech to...



Council for Biotechnology Information, November 2002

2001

The European Commission releases a 15-year, \$64 million study that involved more than 400 research teams on 81 projects. It found that biotech products pose no more risk to human health or the environment than conventional crops.²⁴

2001

EPA renews registration for Bt corn²⁵ and cotton²⁶, citing that they do not pose any health or environmental risks.

2002



A National Center for Food and Agricultural Policy study found that six biotech crops planted in the United States — soybeans, corn, cotton, papaya, squash and canola — produced an additional 4 billion pounds of food and fiber on the same acreage, improved farm income by \$1.5 billion and reduced pesticide use by 46 million pounds.²⁷

Sources

- ¹ “Communiqué of the G8 Heads of Government meeting at Genova,” Organization for Economic Cooperation and Development, July 2001, Communiqué of the G8 Heads of Government meeting at Genova, July 2001, www.oecd.org/EN/document/0,,EN-document-528-14-no-21-9800-528,00.html.
- ² Harlander, Susan K. “The Evolution of Modern Agriculture and its Future with Biotechnology,” Journal of the American College of Nutrition, June 2002, p. 161S, www.jacn.org/cgi/reprint/21/suppl_3/161S.pdf.
- ³ “Considering the Nature and Issues of Food Biotechnology,” North Carolina Biotechnology Center, www.ncbiotech.org.
- ⁴ McGloughlin, Martina. “Harvest of Fear” interview, Nova/Frontline documentary, www.pbs.org/wgbh/harvest/interviews/mcgloughlin.html.
- ⁵ Photo by Hugh Iltis. www.eisc.edu/eosint/Images.htm.
- ⁶ “Agricultural Biotechnology: What Are the Issues,” University of California at Davis, College of Agricultural and Environmental Sciences.
- ⁷ About Biotech, Overview and History, Access Excellence, The National Health Museum, www.accessexcellence.org/AB/BC/1953-1976.html.
- ⁸ “Field Testing Genetically Modified Organisms: Framework for Decisions,” National Academy Press, 1989, p. 13-14.
- ⁹ James, Clive. “Preview: Global Status of Commercialized Transgenic Crops: 2002,” International Service for the Acquisition of Agri-biotech Applications, ISAAA Briefs, No. 27.
- ¹⁰ James, Clive. “Preview: Global Status of Commercialized Transgenic Crops: 2002,” International Service for the Acquisition of Agri-biotech Applications, ISAAA Briefs, No. 27, p. 7.
- ¹¹ James, Clive. “Preview: Global Status of Commercialized Transgenic Crops: 2002,” International Service for the Acquisition of Agri-biotech Applications, ISAAA Briefs, No. 27, p. iii.
- ¹² James, Clive. “Preview: Global Status of Commercialized Transgenic Crops: 2002,” International Service for the Acquisition of Agri-biotech Applications, ISAAA Briefs, No. 27, p. 19.
- ¹³ James, Clive. “Preview: Global Status of Commercialized Transgenic Crops: 2002,” International Service for the Acquisition of Agri-biotech Applications, ISAAA Briefs, No. 27.
- ¹⁴ Gianessi, Leonard P. “Plant Biotechnology: Current and Potential Impact for Improving Pest Management in U.S. Agriculture, An Analysis of 40 Case Studies,” June 2002, p. 1, www.ncfap.org/40CaseStudies/NCFAB_Exec_Sum.pdf.
- ¹⁵ James, Clive. “Global Review of Commercialized Transgenic Crops: 2001. Feature: Cotton,” International Service for the Acquisition of Agri-biotech Applications, Dec. 13, 2002, www.isaaa.org/ke/CBTNews/ISAAA_PR/briefs26_exeng.htm.
- ¹⁶ Brookes, Graham. “The Farm Level Impact of Using Bt Maize in Spain,” Sept. 16, 2002, www.euroabio.org/upload/documents/gb_press_release/EuropaBio_btmaizeinspainreport_FINAL.pdf.
- ¹⁷ “Impact of Transgenic Canola on Growers, Industry and Environment,” Canola Council of Canada, www.canola-council.org/production/impactsurvey.pdf.
- ¹⁸ James, Clive. “Preview: Global Status of Commercialized Transgenic Crops: 2002,” International Service for the Acquisition of Agri-biotech Applications, ISAAA Briefs, No. 27, p. 17.
- ¹⁹ “Population Numbers and Trends: World Population Still Growing,” United Nations Population Fund, www.unfpa.org/modules/briefkit/05.htm.
- ²⁰ “State of World Population 2001: Chapter 2, Environment Trends, Moving Towards Food Security” United Nations Population Fund, November 7, 2001, www.unfpa.org/step/2001/english/ch02.html#2d.
- ²¹ Hautea, Randy A., James, Clive. “The Road to Global Sustainable Agriculture: A View and Experience from ISAAA,” multimedia presentation, slide 3.
- ²² Prakash, C.S. “Agricultural Biotechnology and Food Security,” PowerPoint presentation, Slide 8, www.agbioworld.org.
- ²³ “Food in the 21st Century: From Science to Sustainable Agriculture,” Consultative Group on International Agricultural Research (CGIAR), p. 21, www.worldbank.org/html/cgiar/publications/shahbook/shahbook.pdf.
- ²⁴ “Food in the 21st Century: From Science to Sustainable Agriculture,” Consultative Group on International Agricultural Research (CGIAR), p. 24, www.worldbank.org/html/cgiar/publications/shahbook/shahbook.pdf.
- ²⁵ “Sweet Potato,” International Service for the Acquisition of Agri-biotech Applications, www.isaaa-africenter.org/sweetpotatoes.htm.
- ²⁶ “Combating Vitamin A Deficiency: The Challenge,” World Health Organization Web site, Sept. 12, 2002, www.who.int/nut/cad.htm.
- ²⁷ “Harvest on the Horizon,” Pew Initiative on Food and Biotechnology, September 2001, pewagbiotech.org/research/harvest/harvest.pdf.
- ²⁸ “Although Controversial, Biotechnology Could Be Breakthrough Technology for Developing World,” United Nations Development Programme, July 10, 2001, www.undp.org/hdr2001/pr2.pdf.
- ²⁹ International Society of African Scientists Position Statement on Agricultural Biotechnology Applications in Africa and the Caribbean, www.monsantoafrica.com/reports/ISAS/ISAS.html.
- ³⁰ Sears, Mark et al., with the Agricultural Research Service, “Impact of Bt corn pollen on monarch butterfly populations: A risk assessment,” Proceedings of the National Academy of Sciences, Oct. 9, 2001, www.pnas.org/cgi/content/full/98/21/11937.
- ³¹ “Three Years Later: Genetically Engineered Corn and the Monarch Butterfly Controversy,” Pew Initiative on Food and Biotechnology, p. 16, <http://pewagbiotech.org/resources/issuebriefs/monarch.pdf>.
- ³² “Resolution, VII European Congress on Entomology,” October 7-13, 2002, Thessaloniki, Greece.
- ³³ “Biotech Crop Use Benefits Environment,” Council for Agricultural Science and Technology press release, July 25, 2002, www.cast-science.org/pubs/biotechcropbenefit_nr.htm.
- ³⁴ “Conservation Tillage and Plant Technology: How New Technologies Can Improve the Environment by Reducing the Need to Plow,” Conservation Technology Information Center, October 2002, www.ctic.purdue.edu/CTIC/Biotech.html.

- 35 “Food Safety Evaluation of Crops Produced Through Biotechnology,” *Journal of the American College of Nutrition*, Vol. 21, No. 90003, 166S-173S (2002), www.jacrn.org/cgi/content/full/21/suppl_3/166S.
- 36 “Plant Biotechnology in Canada,” Council for Biotechnology Information, www.hybiotech.com/html/pdf/plant_bt_in_canada.pdf.
- 37 “Improving the Regulation of Genetically Modified Foods and Other Novel Foods in Canada,” Canadian Biotechnology Advisory Committee, August 2002, p. ix, www.cbac-cccb.ca/documents/en/cbac.report.pdf.
- 38 “Improving the Regulation of Genetically Modified Foods and Other Novel Foods in Canada,” Canadian Biotechnology Advisory Committee, August 2002, p. xii, www.cbac-cccb.ca/documents/en/cbac.report.pdf.
- 39 Aaron, David, former undersecretary of Commerce and Trade. “In Support of Biotechnology (Expert Views).” The Alliance for Better Foods, www.betterfoods.org/Expert/Expert.htm.
- 40 “Commission Launches Roundtable on GMO Safety Research,” European Commission, Sept. 10, 2001, europa.eu.int/rapid/start/cgi/guesten.ksh?p_action.gettxt=gt&doc=IP/01/139110/RAPID&lg=E N&display.
- 41 “Genetically Modified Crops and Foods,” American Medical Association (AMA), Recommendation #6, www.ama-assn.org/ama/pub/article/2036-3604.html.
- 42 “Report of a Joint Consultation of the U.N. Food and Agriculture Organization and the World Health Organization” 1996, www.who.int.
- 43 “Vatican Experts OK Plant, Animal Genetic Engineering,” *St. Louis Review*, Oct. 22, 1999, www.bio.org/food&ag/vatican.html.
- 9 Hybrid Corn History, Development, National Corn Handbook, www.inform.umd.edu/EdRes/Topic/AgrEnv/nddl/agronomy/HYBRID_CORN_HISTORY%2C_DEVELOPMENT.html.
- 10 “Watson and Crick Describe Structure of DNA,” *A Science Odyssey, People and Discoveries*, PBS, www.pbs.org/wgbh/aso/databank/entries/do53dn.html.
- 11 Billions Served, Reason Online, April 2000, reason.com/0004/fe.rb.billions.shtml.
- 12 About Biotech, Access Excellence, The National Health Museum, www.accessexcellence.org/AB/BC/1977-Present.html.
- 13 About Biotech, Access Excellence, The National Health Museum, www.accessexcellence.org/AB/BC/1977-Present.html.
- 14 About Biotech, Access Excellence, The National Health Museum, www.accessexcellence.org/AB/BC/1977-Present.html.
- 15 About Biotech, Access Excellence, The National Health Museum, www.accessexcellence.org/AB/BC/1977-Present.html.
- 16 About Biotech, Access Excellence, The National Health Museum, www.accessexcellence.org/AB/BC/1977-Present.html.
- 17 “Milestones in Molecular Biology and U.S. Agricultural Biotechnology,” *Economic Issues in Agricultural Biotechnology/AIB-762*, USDA-ERS.
- 18 “Biotech Basics, A Brief Biotech Timeline,” Monsanto, www.biotechknowledge.monsanto.com/biotech/bbasics.nsf/timeline.html?OpenPage.
- 19 International Service for the Acquisition of Agri-biotech Applications, www.isaaa.org.
- 20 “Biotech Basics, A Brief Biotech Timeline,” Monsanto, www.biotechknowledge.monsanto.com/biotech/bbasics.nsf/timeline.html?OpenPage.
- 21 “Little Weed in Science Landmark,” *BBC News*, Dec. 13, 2000, news.bbc.co.uk/1/hi/sci/tech/1068848.stm.
- 22 International Service for the Acquisition of Agri-biotech Applications, www.isaaa.org.
- 23 Travis, John. “Gene Makes Tomatoes Tolerant of Salt,” *Science News Online*, Aug. 4, 2000, www.sciencenews.org/20010804/job1.asp.
- 24 “EC-sponsored Research on Safety of Genetically Modified Organisms: A Review of Results,” European Commission Web site, europa.eu.int/comm/research/quality-of-life/gmo/index.html.
- 25 “Biotech Corn Approved for Continued Use,” Environmental Protection Agency, Oct. 16, 2001, yosemite1.epa.gov/opa/admpress.nsf/b1ab9f485b098972852562e7004dc686/8db7a83e66e0f7d085256ae7005d6ec2?OpenDocument.
- 26 “Conditional Registration of Bt Cotton Reaffirmed,” Environmental Protection Agency, Oct. 2, 2001, yosemite1.epa.gov/opa/admpress.nsf/b1ab9f485b098972852562e7004dc686/e9220c40c6e547de85256ad90063699b?OpenDocument.
- 27 Gianessi, Leonard P. “Plant Biotechnology: Current and Potential Impact for Improving Pest Management in U.S. Agriculture, An Analysis of 40 Case Studies, Executive Summary,” June 2002, p. 1, www.ncfap.org/40CaseStudies/NCFAB_Exec_Sum.pdf.

Timeline Sources

- 1 Leapman, Michael. *The Ingenious Mr. Fairchild*. St. Martin's Press. New York, 2001.
- 2 “Mendel, Gregor Johann,” Microsoft® Encarta® Online Encyclopedia 2002, encarta.msn.com/encnet/refpages/RefArticle.aspx?refid=761562358.
- 3 Biotechnology Industry Organization timeline, www.bio.org/er/timeline2.asp.
- 4 “Luther Burbank: The Idaho Potato,” The Lemelson-MIT Award's Program's Invention Dimension, web.mit.edu/invent/www/inventors-A-H/burbank.html.
- 5 Hybrid Corn History, Development, National Corn Handbook, www.inform.umd.edu/EdRes/Topic/AgrEnv/nddl/agronomy/HYBRID_CORN_HISTORY%2C_DEVELOPMENT.html.
- 6 About Biotech, Overview and History, Access Excellence, The National Health Museum, www.accessexcellence.org/AB/BC/Overview_and_Brief_History.html.
- 7 “Luther Burbank: The Idaho Potato,” The Lemelson-MIT Award's Program's Invention Dimension, web.mit.edu/invent/www/inventors-A-H/burbank.html.
- 8 Biotechnology Industry Organization Timeline, www.bio.org/er/timeline2.asp.

