AGRICULTURE BIOTECHNOLOGY REFERENCE GUIDE

AGRICULTURE BIOTECHNOLOGY REFERENCE GUIDE

is brought to you by

NATIONAL CORN GROWERS ASSOCIATION

and

U.S. GRAINS COUNCIL

FOREWORD

Welcome to the Agriculture Biotechnology Reference Guide. Published by the National Corn Growers Association and sponsored in part by the U.S. Grains Council, this comprehensive resource is intended to provide readers with an update on the latest events surrounding biotechnology in agriculture.

As you'll see when you read through the guide, biotechnology holds great promise for farmers and consumers around the globe. Biotechnology has not only assisted today's producers in meeting increased demand for a safe and abundant grain supply, it has also benefited rural economies and the environment.

More growers are introduced to the benefits of biotechnology each year and the use of biotech crops continues to increase significantly. In 2004, corn producers planted 45 percent of their acreage to biotech hybrids, up 19 percentage points from just three years earlier. But much work remains to be done. Further advancements in biotechnology are necessary to ensure the world can continue to rely on U.S. growers to provide high quality food, feed, fiber and fuel.

As demonstrated by the rapid adoption of biotechnology in the U.S. agriculture sector, farmers understand the advantages the technology offers. Yet, as is often the case with emerging technologies, some consumers do not fully understand the potential of biotechnology. NCGA's goal is to continue to inform consumers about biotechnology through educational outreach and awareness efforts.

This guide provides a contemporary science-based approach to biotechnology and addresses many of the issues surrounding the escalating use of this technology. We hope the publication heightens your understanding of biotechnology and answers any questions you may have.

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ABOUT NCGA

National Corn Growers Association (NCGA) is a national commodity organization founded in 1957 that represents nearly 33,000 dues-paying corn growers from 48 states and the interests of over 300,000 farmers who contribute to corn checkoff programs in 20 states.

ABOUT U.S. GRAINS COUNCIL

Founded in 1960, U.S. Grains Council is a private, non-profit corporation with 10 international offices and programs in over 80 countries. Its unique membership includes producer organizations and agribusinesses with a common interest in developing export markets.

INTRODUCTION

Why does the world need biotechnology? What does it mean to our world? In short, agricultural plant biotechnology is needed to feed the world of the future. In 1900, the global population was approximately 1.6 billion people. Today our population has surged to 6 billion people and is estimated by the United Nations to surpass 8 billion by the year 2030. Biotechnology allows farmers around the world to help feed a growing population. It helps increase yields while decreasing the need for inputs such as water and fertilizer. It provides improved pest control methods that are more compatible with the environment, including drastic reductions in the need for pesticides. And it helps to produce more with less – less land use, less labor and less risk of total crop loss, a key issue in many parts of the world. Agricultural biotechnology provides extraordinary benefits but it is not without its opponents. Outside of the United States, the introduction of food products derived from agricultural biotechnology has become a source of controversy in many countries. Anti-biotechnology activists concerned about the environmental and health effects of the technology have encouraged domestic legislation to prohibit or limit imports of genetically modified (GM) food. In some countries legislation will provide an opportunity to shield domestic producers from U.S. imports.

While dialogue is healthy, scientific fact and over 20 years of research are on the side of biotechnology proponents. The goal of this publication is to provide the facts behind agricultural biotechnology. What is it? Where did it come from? What are the consumer benefits? How does it benefit farmers? What is the process for approval of biotechnology and who oversees it? What's here today and coming tomorrow?

Biotechnology holds great promise for the world but U.S. grain producers understand the need and benefit of informed consumers. That's why National Corn Growers Association and U.S. Grains Council have come together to compile this collection of information from numerous respected sources. Use this book as a reference for gaining the information you need to tell the biotechnology story.

"Current internationally agreed approaches to the safety assessment of GM food crops offer a high level of safety assurance for the consumer."

European Network on Safety Assessment of Genetically Modified Food ENTRANSFOOD, 2004

"...in those countries where transgenic crops have been grown, there have been no verifiable reports of them causing any significant health or environmental harm"

Food and Agriculture Organization of the United Nations (FAO), 2004

"Biotechnology offers opportunities to increase the availability and variety of food, increasing overall agricultural productivity while reducing seasonal variations in food supplies. Through the introduction of pest-resistant and stress-tolerant crops, biotechnology could lower the risk of crop failure under difficult biological and climatic conditions. Furthermore, biotechnology could help reduce environmental damage caused by toxic agricultural chemicals."

Food and Agriculture Organization of the United Nations (FAO), 2004

"This is probably the first time a dominant human allergen has been knocked out of a major food crop using biotechnology."

Elliot M. Herman, USDA plant pathologist, on a 2003 report that the USDA's Agricultural Research Service is one step closer to removing the allergen in soybeans that impact 6-8% of children and 1-2% of adults.

"The responsible genetic modification of plants is neither new nor dangerous. The addition of new or different genes into an organism by recombinant DNA techniques does not inherently pose new or heightened risks relative to the modification of organisms by more traditional methods, and the relative safety of marketed products is further ensured by current regulations intended to safeguard the food supply."

Statement by 20 Nobel Prize Winners and 3,200 international scientists, 2003

"GM crops have demonstrated the potential to reduce environmental degradation and to address specific health, ecological and agricultural problems which have proved less responsive to the standard tools of plant breeding and organic or conventional agricultural practices. Thus, we affirm the conclusion of our 1999 Report that there is an ethical obligation to explore these potential benefits responsibly, in order to contribute to the reduction of poverty, and to improve food security and profitable agriculture in developing countries.

Nuffield Council on Bioethics, 2003

"Biotechnology - especially genetic modification - represents an important technology option for meeting the long-term food needs of developing countries. ...The choice of technology should be driven by the determination of local needs. Many developing countries have already indicated priorities that could be addressed by using genetic modification in their agricultural development strategies."

Calestous Juma, Director, The Science, Technology and Innovation Program Center for International Development at Harvard University, Appropriate Technology for Sustainable Food Security: Modern Biotechnology, August 2001

"In addition to safer foods, biotechnology also has the potential to bring about the creation of more nutritious foods…it would be a significant loss to humanity if the many benefits of biotechnology were not realized because of concerns that have little basis in scientific fact."

Brian Larkins, Ph.D., president, American Society of Plant Physiologists and Professor, Department of Plant Science, University of AZ, in a letter to The Wall Street Journal, July 29, 1999

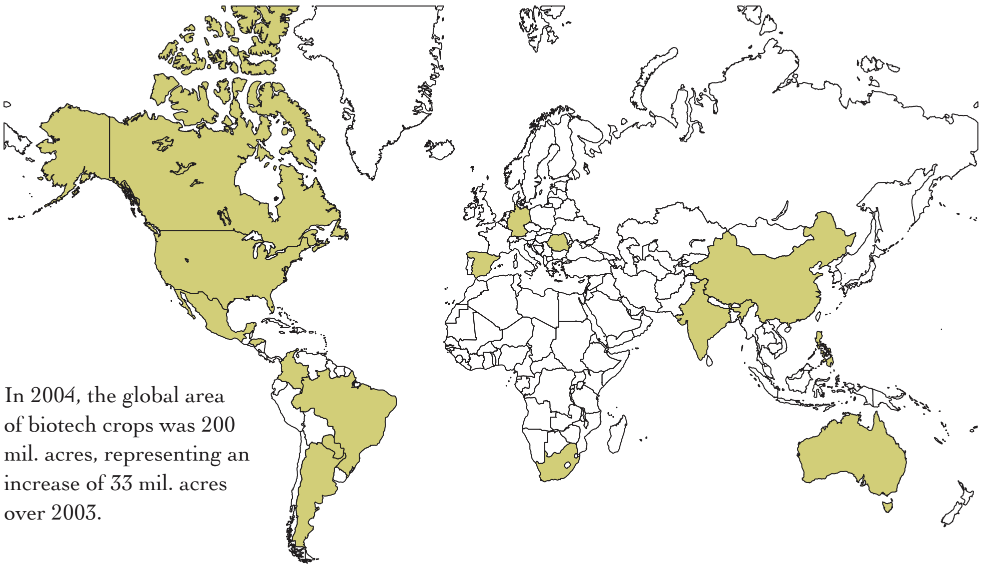
"The rate of change facing farmers today is truly incredible. Biotechnology is another tool for farmers. Bt corn is a much safer method of pest management, and has less detrimental impact on all aspects of the environment – monarchs included – than the use of broad-spectrum insecticides."

DiFonzo, C. and Bolin, P. (1999) Bt corn pollen and monarch butterflies. MI State University

"If imports like these [biotechnology crops] are regulated unnecessarily, the real losers will be the developing nations. Instead of reaping the benefits of decades of discovery and research, people from Africa and Southeast Asia will remain prisoners of outdated technology. Their countries could suffer greatly for years to come. It is crucial that they reject the propaganda of extremist groups before it is too late."

Former President Jimmy Carter in The NY Times, August 26, 1998

Global Status of Biotech Crops in 2004



Biotech acres planted by country

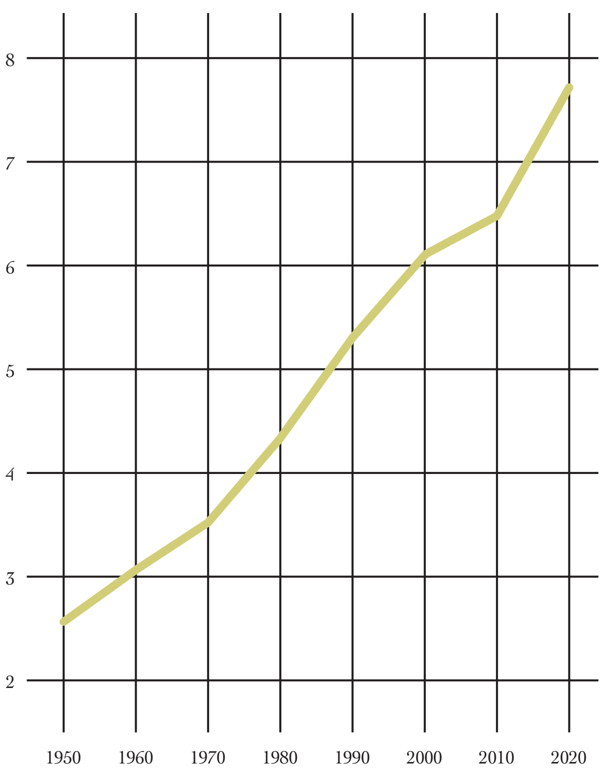
Country	*Mil. Acres*
USA	117.6
Argentina	40.0
Canada	13.3
Brazil	12.4
China	9.1
Paraguay	3.0
India	1.2
South Africa	1.2
Australia	> 1
Colombia	> 1
Germany	> 1
Honduras	> 1
Mexico	> 1
Phillipines	> 1
Romania	> 1
Spain	> 1

In 2004, the global area of biotech crops was 200 mil. acres, representing an increase of 33 mil. acres over 2003.

Sources: Council for Biotechnology Information/ISAAA

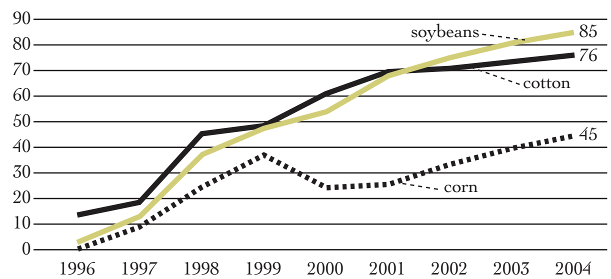
Countries who have adopted biotech

Population in Billions



Source: United Nations

Percent of Total U.S. Acreage

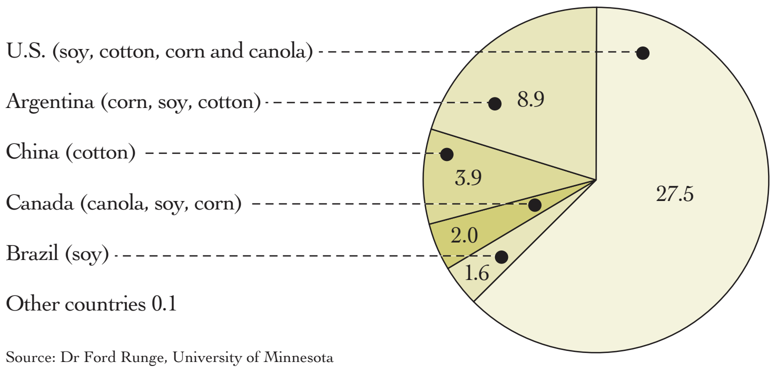


Source: Council for Biotechnology Information

Farmers need to produce **75 percent** *more food per acre by 2020 to meet the anticipated demand.*

Source: United Nations Population Fund

The value of biotech crops in 18 countries was $44 billion in 2003-04
(billions of dollars)



Source: Dr Ford Runge, University of Minnesota

Biotechnology is increasing yields for farmers

- U.S. farmers increased yields by 5.3 billion pounds in 2003 due to their use of biotech crops, such as soybeans, corn, cotton and canola
- Biotech cotton yields were 24% higher than non-biotech cotton yields in China from 1999-2001
- In India, farmers who planted Bt cotton realized 45-63% higher yields in 2002-2003 versus non-Bt cotton
- Field studies in Germany indicate average yield gains of 12-15% with Bt corn vs. non-Bt corn. Similar trials in South Africa show 10% gains.

Sources: National Center for Food and Agricultural Policy (NCFAP); Huang et al., 2003; Bennet et al., 2004; James 2004

Biotechnology is improving the environmental profile of agriculture

- NCFAP reported that U.S. farmers eliminated the use of 46 million pounds of pesticides due to their use of biotech crops
- Farmers in India who use Bt cotton have reduced pesticide applications by two-thirds
- The use of YieldGard Corn Rootworm is expected to eliminate the use of 1 million plastic containers; more than 65,000 gallons of aviation fuel; 5 million gallons of water used in insecticide formulations; 5 million pounds of insecticide active ingredient; and 5 million gallons of diesel fuel per year.
- In Australia, use of Bt cotton in 1998-99 resulted in 50% fewer pesticide applications
- In China, studies have shown a 67% decrease in pesticide applications since growers switched to Bt cotton

Sources: National Center for Food and Agricultural Policy (NCFAP); Bennet et al., 2004; Rice, 2004; Fitt, 2003; Huang, 2003

CONSUMER BENEFITS

Plant biotechnology is already helping to provide people with more and better food and holds even greater promise for the future. Dozens of organizations ranging from the United Nations, American Medical Association, and International Society of African Scientists to the Organization for Economic Cooperation and Development have voiced their support for plant biotechnology. Why? For many reasons that include everything from expanded production capacity to crops that are more environmentally friendly to foods that are enhanced to fill in gaps in nutritionally depleted diets. The following are some of the ways biotechnology benefits consumers today.

BIOTECHNOLOGY ENABLES FARMERS TO PRODUCE MORE ON LESS LAND; MEET THE NEEDS OF A GROWING POPULATION

With a world population projected to top 8 billion people by 2030, farmers need to produce enough food to feed an additional 2 billion people. In fact, according to the United Nations Population Fund, farmers will need to produce about 75 percent more food per acre by 2020 to meet the anticipated demand. Biotechnology increases crop yield, lessens the negative effects on the environment and decreases stress placed on existing cultivated land.

A recent report from the National Center for Food and Agricultural Policy (NCFAP) summarized the results from 40 case studies of 27 biotech crops. Agricultural biotechnology increased yields by 14 billion lbs., improved farm income by $2.5 billion and reduced pesticide use by 163 million lbs.

Based on increased yields and reduced production costs growers realized a net economic impact or savings of $1.9 billion. Compared with 2001, that represented a 41 percent increase in yield gain, 25 percent greater reduction in production costs, and 27 percent higher economic return in 2003.

By 2010, it is expected that 15 million farmers in 30 countries will grow more than 370 million acres of biotech crops.

Source: United Nations Population Fund

NUTRITIONALLY-ENRICHED FOOD

Not only is biotechnology helping to produce more food, it is developing better food — food that is healthier, more nutritious and better tasting. Consider the benefits of reducing undesirable saturated fats in cooking oils; the elimination of allergens; or increasing nutrients that reduce chronic disease. All of these developments are possible with plant biotechnology – and already at work. For example, researchers have developed a cassava (a staple food in many poorer regions of the world) enhanced to contain 35-45 percent more protein, which promises to aid in staving off multiple health problems. Researchers are also exploring crops with unexpected health benefits, such as a cancer-fighting tomato, which may someday help prevent breast and prostate cancers.

CONSERVATION OF NATURAL RESOURCES

Plant biotechnology is at work to create more stress-tolerant crops that allow for food production in even the harshest environments on earth – places where it is needed most. Hardier disease and pest-resistant crops allow for greater conservation of resources by requiring less fuel, labor, water and fertilizer. In large part, that's because plant biotechnology requires fewer pesticide applications and trips across the field. Of note, international researchers in the United States and Israel are exploring ways to produce cotton that can survive in semi-arid conditions, a development that could one day lead to a savings of billions of gallons of water each year.

The Conservation Technology Information Center (CTIC) reported in 2002 that increased use of conservation tillage practices such as no-tillage reduced soil erosion by nearly 1 billion tons and saved $3.5 billion in sedimentation treatment costs. Other benefits from no-tillage included significant fuel savings (3.9 gallons of fuel per acre), reduced machinery wear and tear, reduction of pesticide use in greenhouse gases due to improved carbon sequestration and improved habitat for birds and animal.

LONGER-LASTING, FRESHER PRODUCE

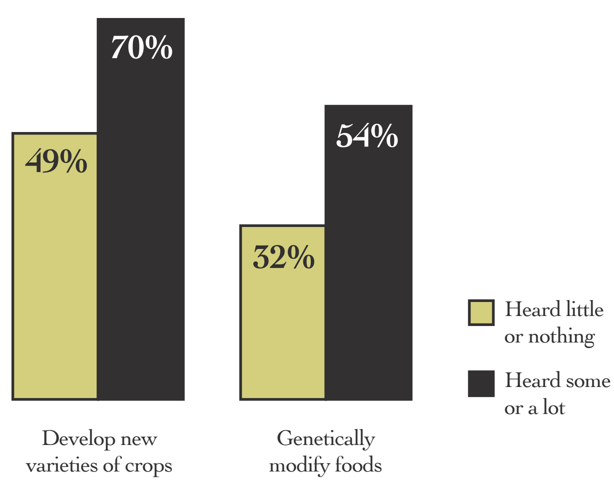
Biotech foods could one day reduce losses to spoilage in fresh produce, especially in areas with limited transportation and refrigeration capability.

FACILITATING PRODUCTION OF NEW MEDICINES

As scientists begin to better understand the genetic makeup of humans, they are simultaneously making headway in developing treatments that utilize human proteins. Compared to existing recombinant production methods, plants have a superior ability to assimilate

Support Grows With Knowledge

Percent supporting biotech to...



Source: Council for Biotechnology Information

Consumer Confidence in Biotechnology Growing

The majority of U.S. consumers favor food developed with biotechnology if it tastes better or fresher or if it means the use of fewer pesticides.

66% would likely buy fresh produce
54% would buy genetically enhanced tomatoes
59% believe biotechnology will provide their family more benefits in the next five years

Source: International Food Information Council

genetic information and produce complex proteins that can be used to make more effective therapeutics. In the near future, that could lead to an entire industry of plant-made pharmaceuticals that promise to reduce costs while using a sustainable resource.

Bt TECHNOLOGY REDUCES MYCOTOXINS IN CORN; SAFER FOR HUMANS

According to research done by Gary Munkvold, a plant pathologist at Iowa State University, Bt corn hybrids that control European Corn Borer usually have lower fumonisin concentrations, a mycotoxin that can cause illness in humans and animals. Mycotoxin build-up is directly related to certain fungal plant diseases, which can be increased by insect damage in crops. Some of these toxins, such as fumonisin, can be fatal to horses and pigs and are probable human carcinogens.

GREATER BIODIVERSITY AND SUSTAINABILITY

The greatest threat to global biodiversity is loss of wildlife habitat when it is converted to low-yield agriculture. Technologies that increase productivity on existing cultivated acreage will help meet increasing world food demand and reduce pressure to encroach further on wildlife habitat, rainforests and some of the earth's most fragile habitats.

Information Sources: Alliance for Better Foods, Council for Biotechnology Information, National Corn Growers Association, and Tomorrow's Bounty.

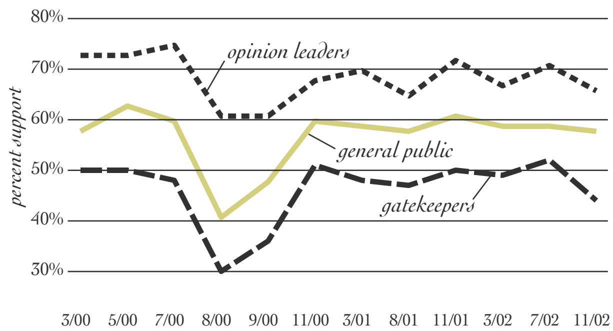
Total impact of biotechnology-derived crops by state in 2003

	Volume (thousand lbs)	Value (thousand dollars)	Costs (thousand dollars)	Total Net Value (thousand dollars)	Pesticide Use (thousand lbs/acre)
AL	9,128	4,564	-11,426	15,990	-655
AK	99,450	32,998	-97,963	130,941	-3,064
AZ	17,315	6,129	-6,579	12,704	-389
CA	10,290	5,145	-27,850	32,995	-776
CO	97,563	4,267	-249	4,613	-149
CT	728	32	-21	53	-4
DE	10,304	451	-4,241	4,692	-166
FL	4,990	2,150	-774	2,821	-205
GA	53,833	18,835	-209,988	38,574	-2,279
HI	8,980	2,960	53	2,910	0
ID	0	0	-142	142	-13
IL	452,464	19,798	-157,340	176,898	-6,502
IN	74,734	3,272	-171,531	174,592	-6,281
IA	1,079,275	47,352	-192,447	238,931	-7,481
KS	309,863	13,569	-29,708	43,217	204
KY	56,784	2,483	-7,940	10,423	433
LA	72,148	15,182	-25,789	40,896	-843
MD	60,872	2,663	-5,696	8,359	-343
MA	168	6	-8	14	-1
MI	73,419	3,214	-27,662	31,428	225
MN	525,975	23,012	-153,721	176,619	-6,594
MS	86,187	32,886	-61,816	94,555	-2,195
MO	311,369	23,017	-91,644	114,630	-4,438
NC	36,354	11,215	-40,541	51,729	-1,452
ND	58,240	2,549	-49,104	51,653	1,154
NE	743,375	32,525	-49,497	81,716	-2,781
NJ	4,200	183	-1,357	1,539	-68
NM	8,708	1,083	-739	1,822	-80
NY	4,368	192	-3,758	3,950	-204
OH	23,047	1,010	-68,586	69,585	1,254
OK	44,332	5,712	-7,940	13,652	-208
PA	37,968	1,658	-4,246	5,904	-310
SC	19,294	1,708	-8,700	10,392	-26
SD	468,639	20,503	-55,862	76,357	458
TN	72,148	21,307	-36,321	57,628	-1,580
TX	281,442	39,246	-35,338	74,584	-1,473
UT	0	0	-51	51	-5
VA	6,985	1,348	-6,307	7,651	-319
VT	2,184	96	-11	107	-7
WV	1,176	51	-151	202	-310
WI	109,796	4,805	-9,739	14,482	1,090
WY	0	0	-71	71	-7

Source: National Center for Food and Agricultural Policy

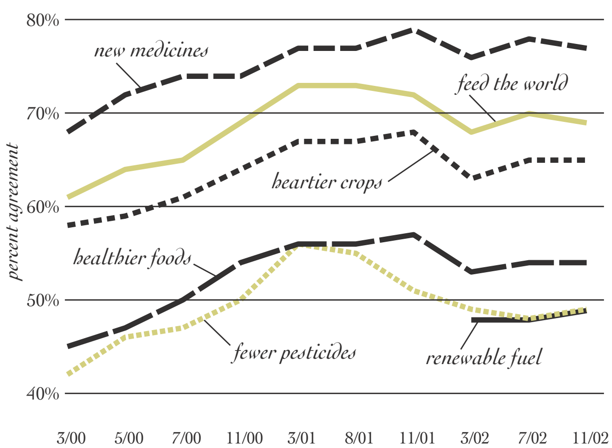
Support for biotech crops has been steady since 2000.

Question: Would you say you strongly support, somewhat support, somewhat oppose or strongly oppose...using biotechnology to develop new varieties of crops such as cotton, corn, soybeans and wheat or are you neutral?



Source: Council for Biotechnology Information

Agreement with benefits in the general public



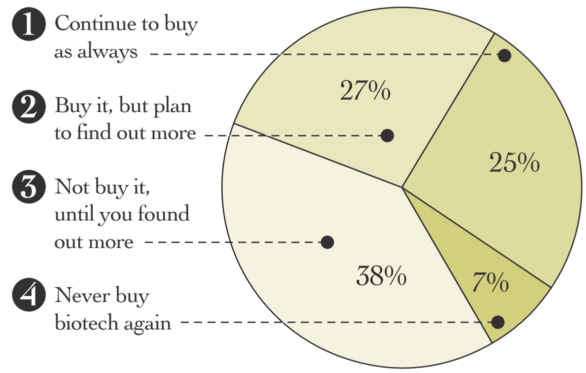
Source: Council for Biotechnology Information

Consumers find value in direct benefits

Product	*Percent who say it's valuable*
Cancer-fighting tomato	65
Virus-resistent sweet potato	61
Banana/potato vaccines	56

Source: Council for Biotechnology Information

Gender, income, education - key factors in acceptance



1. Mostly female (58%), over 50 years old, most likely to shop organic (51%)
2. Two-thirds female (61%), more likely than average to be mothers, more likely than average to shop organic (42%)
3. Demographically closely mirrors general population
4. Two-thirds male (66%), higher than average incomes, less likely to shop organic (20%)

Source: Council for Biotechnology Information

Food demand factors: population & income by 2010

Area	*Population Growth*	*Income Growth*
Former Soviet Union	0%	4%
Europe	0%	24%
North America	5%`	27%
South America	8%	9%
Africa	35%	6%
Asia	51%	32%

Source: Council for Biotechnology Information

Quality-enhanced biotech products in the pipeline

- *Nutrition:* lower saturated fat vegetable oils
- *Nutrition:* cholesterol lowering soybean oils
- *Nutrition:* heart-healthy Omega-3 crops
- *Nutrition:* vitamin A crops for developing countries
- *Health:* removing allergens

Source: Council for Biotechnology Information

"We farm near a lake which is used for community swimming, fishing and camping. During the summers, I would not spray herbicides and pesticides for fear of having some of these chemicals enter the lake. As a result, it was very difficult to protect against yield loss. With biotechnology, I can now protect my crops without using chemicals which might pose a risk to my neighbors and people enjoying the park."

-Jerry Ploehn, Ploehn Farms, Alpha Minnesota, 2005

"I would have told the assembled that the accusations of 'Frankenstein food' and 'killer tomatoes' are as much a fantasy as the Hollywood movies they are borrowed from. I would have argued that, if adding a daffodil gene to rice in order to produce agenetically modified strain of rice can prevent half a million children from going blind each year, then we should move forward carefully to develop it."

Dr. Patrick Moore, Chairman, Greenspirit Strategies, February 2004

"Risks associated with biotechnology-derived foods are not inherently different from the risks associated with conventional ones."

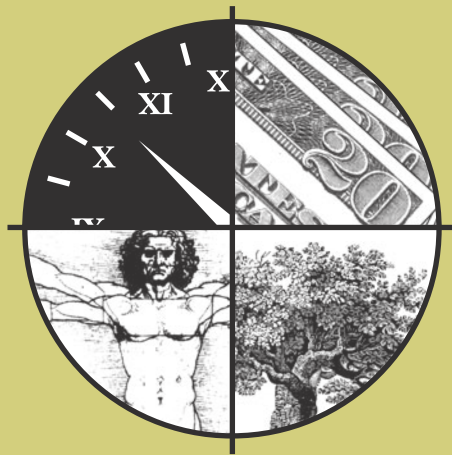
Report of the Task Force for the Safety of Novel Foods and Feeds Organization for Economic Cooperation and Development, May 17, 2002

"FAO recognizes that genetic engineering has the potential to help increase production and productivity in agriculture, forestry and fisheries. It could lead to higher yields on marginal lands in countries that today cannot grow enough food to feed their people. There are already examples where genetic engineering is helping to reduce the transmission of human and animal diseases through new vaccines. Rice has been genetically engineered to contain pro-vitamin A (beta carotene) and iron, which could improve the health of many low-income communities."

UN Food and Agriculture Organization Statement on Biotechnology, March 2000

"The results show significant, substantial and consistent benefits of adopting Bt cotton for resource-poor smallholders in the Makhathini area of South Africa over the first three significant years of adoption. Benefits were largely in the form of increased yields, reduced pesticides and labor for spraying that, despite higher seed and harvesting labor costs, resulted in substantial improvements in gross margin. Results also suggest that those benefiting most from the technology were the smaller and more intensive cotton growers."

Stephen Morse, Richard Bennett and Yousouf Ismael, University of Reading, UK



GROWER BENEFITS

Biotechnology offers farmers around the world improved efficiencies and potential profits when managed wisely and with regulatory oversight based on sound science. The improved economics begin on the farm. Already, the proliferation of biotechnology is redefining current systems of price discovery, consumer desire for information on food, and drastically changing our grain handling systems and trade management. Never before has the farmer been so involved with the entire food chain. Historically, the role of the commodity farmer ended at the farm gate; but today that position has changed. Most farmers today understand the need to address the concerns of their customers and the importance of protecting the integrity of the markets they rely on. That's why responsible and accountable management by biotechnology providers, farmers, suppliers and grain merchandisers is imperative. But it is the promise of biotechnology that has farmers more fully engaged in protecting the technology.

Documenting results: conservation tillage

- No-till acres increased 35 percent to 55 mil. acres since biotech crops introduced
- Reduces soil erosion 1 billion tons per year
- Saves $3.5 billion in water treatment and waterway maintenance
- Saves farmers 309 mil. gallons of fuel per year
- Improves wildlife habitat

Source: Council for Biotechnology Information

Biotechnology offers farmers ecological tools that help them protect crops from disease, weeds and insects. In fact, biotechnology provides farmers a wider variety of crop production options that are safer for humans, animals and the environment than conventional methods. Consider these additional ways in which biotechnology benefits the farmers of the world.

BIOTECHNOLOGY REDUCES PRODUCTION COSTS

With biotechnology, farmers are using significantly fewer pesticides and making fewer trips across the field, adding up to substantial cost savings in equipment, fuel and labor related costs. It is estimated those reduced costs alone can return a U.S. corn farmer an additional $8-$13 per acre. Much of that profitability can be attributed to reduced tillage costs made possible by the improved crop protection benefits of biotechnology.

BIOTECHNOLOGY IMPROVES A FARM'S ENVIRONMENTAL PROFILE

Biotechnology provides farmers with the means to decrease soil erosion through farming practices that protect the environment. For example, certain biotech varieties of cotton and soybeans require less tilling, preserving precious topsoil and helping to reduce sediment run-off into rivers and streams. While no-till and reduced-till crops are now being used primarily in the United States, it is hoped that subsistence farmers worldwide will also benefit from new varieties of crops with traits that similarly reduce the need for tillage.

BIOTECHNOLOGY CREATES NEW SOURCES OF ENERGY; REDUCES POLLUTION

Biotechnology will one day produce corn plants specifically created for maximizing ethanol production value and making us less dependent on non-renewable resources such as oil and natural gas. Ethanol is also a cleaner burning fuel, making it both a sustainable and environmentally favorable alternative to other fossil fuel related products.

BIOTECHNOLOGY HELPS CREATE HARDIER CROPS AND REDUCES LAND USE

Biotech scientists are working to improve farming in regions where food is difficult to grow by improving the crops' abilities to withstand natural environmental factors such as heat, drought, soil toxicity, salinity and flooding. Plants that can protect themselves from pests, diseases and environmental factors allow growers to produce more food on the same amount of land, thereby reducing pressures to clear additional acres for cultivation. Improved farm productivity could result in less impact on prairies, wetlands, forests and other fragile ecosystems that might otherwise be converted for agricultural purposes.

DISEASE-RESISTANT PLANTS REDUCE NEED FOR PESTICIDES

Through biotechnology, plants are able to protect themselves, and the need for pesticides is declining. Biotechnology is helping to make hardier strains of staple crops such as sweet potato, cassava, papaya, rice and corn that provide better protection against insects and diseases. For example, researchers are developing sweet potatoes that are resistant to the sweet potato feathery mottle virus, which can destroy between 20 to 80 percent of a sweet potato crop.

Information Sources: Alliance for Better Foods, Council for Biotechnology Information, Conservation Technology Information Center, National Corn Growers Association, Tomorrow's Bounty.

Documenting results: economic

	Yield increase	*Net economic impact*	*Pesticide reduction*
Current cultivars	4 billion lbs	$1.5 to $2.5 billion	46 mil. lbs
Potential cultivars	10 billion lbs	$1 billion	117 mil. lbs
Total	14 billion lbs	$2.5 to $3.5 billion	163 mil. lbs

Source: Council for Biotechnology Information

Approval Dates of Corn Biotechnology Products

Product Registrant	*Event Characteristic*	*Trade Name*	*Approved*
Bt176	corn borer resistance	Syngenta Knockout	EPA - Aug '95
Bt11	corn borer protection + glufosinate herbicide tolerance	Syngenta YieldGard/ Liberty Link	APHIS - Jan '96, EPA - Aug '96
Mon810	corn borer protection	Monsanto YieldGard	APHIS - Mar '96, FDA - Sep '96, EPA - Dec '96, Re-registered - Oct '01 (7 yrs)
MonGA21 SYTGA21	glyphosate herbicide tolerance	Monsanto Roundup Ready Syngenta Agrisure Advantage	APHIS - Nov '97, FDA - Feb '98
Mon810+GA21	corn borer resistance + glyphosate herbicide tolerance	Monsanto YieldGard/ Roundup Ready 2	EPA/APHIS/FDA do not require formal independent registration of events created by stacking previously registered events
Mon863	corn rootworm protection	YieldGard	APHIS - Oct '02 ; FDA - Dec '01 EPA - 2003
Mon810+ Mon863	corn borer protection + corn rootworm protection	Monsanto YieldGard Plus	EPA/APHIS/FDA do not require formal independent registration of events created by stacking previously registered events
Mon810 + Mon863 NK603	corn borer protection + corn rootworm protection + glyphosate herbicide tolerance	Monsanto YieldGard Plus with Roundup Ready 2	EPA/APHIS/FDA do not require formal independent registration of events created by stacking previously registered events
Mon863 + NK603	corn rootworm protection + glyphosate herbicide tolerance	Monsanto YieldGard Roundup Ready 2	EPA/APHIS/FDA do not require formal independent registration of events created by stacking previously registered events
NK603	glyphosate herbicide tolerance	Monsanto Roundup Ready 2	APHIS - Sep '00, FDA – Oct '00 EPA does not "register" herbicide tolerant events. They review compliance with herbicide label
T25	glufosinate herbicide tolerance	Aventis LibertyLink	APHIS - Jun '95, FDA - '95
TC1507 + NK603	western bean cutworm, corn borer, black cutworm and fall armyworm resistance + glufosinate herbicide tolerance glyphosate herbicide tolerance	Dow Agrosciences Pioneer Hi-Bred Herculex I/Roundup Ready 2	EPA/APHIS/FDA do not require formal independent registration of events created by stacking previously registered events
TC1507	western bean cutworm, corn borer, black cutworm and fall armyworm resistance + glufosinate herbicide tolerance	Dow Agrosciences Pioneer Hi-Bred Herculex I	EPA - Jul '01

U.S. CORN GROWER COMMITMENT TO STEWARDSHIP

Corn is a consumer-driven market that must meet the needs of our customers first. In everything we do, we strive to strike a balance between the benefits of new technology with the critical need to satisfy our customers. That begins by protecting the integrity of the U.S. corn crop. Biotechnology represents nearly half of the total corn crop, or over 40 million acres. That percentage is expected to grow with the introduction of new commercial hybrids. As an industry, corn growers have much to gain from the advancements made possible by biotechnology and also much to lose if they ignore the needs or our customers.

NCGA has taken the lead in stewardship to ensure that biotechnology wins for all parties involved. It starts with sound recommendations for use of biotechnology products not yet approved for certain markets.

CURRENT NCGA BIOTECHNOLOGY STEWARDSHIP PROGRAMS

KNOW BEFORE YOU GROW

To keep corn growers informed on the latest approved uses for biotech corn hybrids, the *Know Before You Grow* initiative was developed as a cooperative effort on the part of NCGA and the industry's leading seed companies. *Know Before You Grow* encourages corn growers to proactively investigate marketing opportunities for their crop before they make their seed purchase decisions. The most recent status updates for many of the nation's corn hybrids are available in the *Know Before You Grow* section of the NCGA Website at www.ncga.com.

INSECT RESISTANCE MANAGEMENT

NCGA supports an Insect Resistance Management (IRM) approach to judicious use of biotechnology. The great majority of U.S. corn growers are using biotechnology where appropriate but not investing in the technology if there is no financial return. For example, products such as Bt corn are used where corn borer pressure is high. In areas where corn borer pressure is low to moderate, Bt corn will likely not be used, primarily for economic reasons. For additional information on Insect Resistance Management strategies and use, please visit www.ncga.com.

In March 2004, NCGA unveiled the industry's first online education center for training growers on the principles of Insect Resistance Management. The Insect Resistance Management Learning Center (IRMLC) is a web-based tool developed by NCGA with the support of ABSTC, the coalition of four leading agriculture biotechnology companies; to address the need for standardized, comprehensive training on the principles of Insect Resistance Management (IRM).

The IRMLC allows growers to understand IRM through self-paced distance learning. For more information on the education tool, please visit www.ncga.com

WEED RESISTANCE MANAGEMENT

Following the successful launch of the IRMLC, NCGA launched the Weed Resistance Management Learning Center (WRMLC) in spring 2005. Similar to the IRMLC, the WRMLC is focused on providing education on grower management strategies that prolong the effectiveness of crop protection products and technologies by preventing weed resistance. Weed resistance can result from the repeated use of a product that possesses a single mode-of-action for control. By incorporating management strategies learned in the WRMLC, a grower can not only prevent weed resistance but will prolong the effectiveness of the biotechnology and other crop protection products they've come to depend upon.

The WRMLC was developed with the support of the leading developers of agriculture biotechnology and reflects the recommendations of Herbicide Resistance Action Committee and the Weed Science Society of America.

The WRMLC can be accessed by growers, industry leaders or anyone interested in learning about preventing weed resistance by visiting www.ncga.com.

Biotechnology Saves Farmers Money on Input Costs

Herbicide Substitution Analysis in Biotechnology-Derived Herbicide-Tolerant (HT) Corn

Program	*Herbicide rate lbs/acre*	*Herbicide costs dollars/acre*
Conventional corn		
Preemergence: Premix of Acetochlor + Atrazine[1]	2.61	22.24
Postemergence: Premix of Primisulfuron + Dicamba[2]	0.15	10.10
Total	2.76	32.34
Herbicide-tolerant corn		
Acetochlor/atrazine1	1.3	11.12
Followed by Glyphosate3	0.5	5.07
Seed costs/technology fee		6.0
Total	1.8	22.19
Difference		
Conventional to Herbicide Tolerant	-0.96	-10.15

1 Trade name: Harness Xtra. 2 Trade name: North Star. 3 Trade name: Roundup

Impacts on U.S. Agriculture of Biotechnology-Derived Crops Planted in 2003

	Key Crops	*Increase in food and fiber production (lbs)*	*Increase in farm income*	*Annual decrease in pesticide use (lbs)*
AL	corn, cotton, soybeans	> 9 mil.	nearly $16 mil.	655,000
AZ	corn, cotton	> 17 mil.	> $12 mil.	389,000
AK	corn, cotton, soybeans	> 99 mil.	nearly $131 mil.	3 mil.
CA	corn, cotton	> 10 mil.	nearly $33 mil.	776,000
CO	corn	> 97 mil.	> $4.6 mil.	149,000
CT	corn	728,000	$53,000	4,000
DE	corn, soybeans	> 10 mil.	> $4.6 mil.	166,000
FL	cotton, squash	almost 5 mil.	> $2.8 mil.	205,000
GA	corn, cotton, soybeans, squash	> 53 mil.	> $38 mil.	2.2 mil.
HI	papaya	nearly 9 mil.	nearly $3 mil.	
ID	corn		$142,000	13,000
IL	corn, soybeans	> 452 mil.	> $176 mil.	> 6.5 mil.
IN	corn, soybeans	> 74 mil.	> $174 mil.	> 6.2 mil.
IA	corn, soybeans	> 1 billion	nearly $239 mil.	> 7.4 mil.
KS	corn, soybeans	> 309 mil.	> $43 mil.	*204,000
KY	corn, soybeans	> 56 mil.	> $10 mil.	*433,000
LA	corn, cotton, soybeans	> 72 mil.	> $40 mil.	843,00
MD	corn, soybeans	> 60 mil.	> $8 mil.	343,000
MA	corn	168,000	$14,000	1,000
MI	corn	> 73 mil.	> $31 mil.	*225,000
MN	corn, soybeans	> 525 mil.	> $176 mil.	> 6.5 mil.
MS	corn, cotton, soybeans	> 86 mil.	> $94 mil.	nearly 2.2 mil.
MO	corn, cotton, soybeans	> 311 mil.	> $114 mil.	> 4.4 mil.
NE	corn, soybeans	> 743 mil.	> $81 mil.	nearly 2.8 mil.
NJ	corn, soybeans	4.2 mil.	> $1.5 mil.	68,000
NM	corn, cotton	> 8.7 mil.	> $1.8 mil.	80,000
NY	corn, soybeans	> 4.3 mil.	> $3.9 mil.	204,000
NC	corn, cotton, soybeans	> 36 mil.	> $51 mil.	*> 1.4 mil.
ND	canola, corn, soybeans	> 58 mil.	> $51 mil.	*> 1.1 mil.
OH	corn, soybeans	> 23 mil.	> $69 mil.	*> 1.2 mil.
OK	corn, cotton, soybeans	> 44 mil.	> $13 mil.	208,000
PA	corn, soybeans	> 37 mil.	> $5.9 mil.	310,000
SC	corn, cotton, soybeans	> 19 mil.	> $10 mil.	26,000
SD	corn, soybeans	> 468 mil.	> $76 mil.	*458,000
TN	corn, cotton, soybeans	> 72 mil.	> $57 mil.	> 1.5 mil.
TX	corn, cotton, soybeans	> 281 mil.	> $74 mil.	> 1.4 mil.
UT	corn		$51,000	5,000
VA	corn, cotton, soybeans	nearly 7 mil.	> $7.6 mil.	319,000
VT	corn	nearly 2.2 mil.	$107,000	7,000
WV	corn, soybeans	> 1.1 mil.	$202,000	310,000
WI	corn, soybeans	> 109 mil.	$14.5 mil.	*1 mil.
WY	corn		$71,000	7,000

* = indicates an increase of pesticide use

Commodity by Commodity Analysis

Crop	*Grown In...*	*% of Nation's Production*	*Increase in Production*	*Reduction in Herbicide / Pesticide Use*	*Enhanced Protection Against...*	*Weed Mgmt Savings*	*Income Improve-ment*
Canola (HT)	ND	75%		over 154,000 lbs per year		$9 mil.	
Cotton (HT)	AL, AZ, AK, CA,FL, GA, LA, MS,MO, NM, NC, OK, SC, TN, TX, VA	over 99%		over 9.6 mil. lbs		$221 mil.	
Cotton (IR-I)	AL, AZ, AK, CA, FL, GA, LA, MS, MO, NM, NC, OK, SC, TN, TX, VA	over 99%	over 362 mil. lbs	over 3.2 mil. lbs	tobacco budworm, pink bollworm	$191 mil.	
Cotton (IR-II)	AL, AZ, AK, CA, FL, GA, LA, MS, MO, NM, NC, OK, SC, TN, TX, VA	over 99%	2.3 mil. lbs	over 38,000 lbs	cotton bollworm, beet armyworms, fall armyworms, soybean loopers, tobacco budworm, pink bollworm		$1.2 mil.
Field Corn (IR-I)	AL, AZ, AK, CA, CT, DE, GA, IL, IN, IA, KS, KY, LA, MA, MD, MI, MN, MS, MO, NE, NJ, NM, NY, NC	99%	over 4.7 bil. lbs	over 3.6 mil. lbs	European corn borer		$146 mil.
Field Corn (IR-II)	CO, IL, IN, IA, KS, MI, MN, MO, NE, OH, SD, WI	88%		over 224,000 lbs	corn root worm		$2.4 mil.
Field Corn (IR-III)	CO, IL, IN, IA, KS, MD, MI, MN, MO, NE, NJ, NM, NY, ND, OH, OK, PA, SD, TX, VA, WI, WV, WY	94%	163 mil. lbs	40,000 lbs	black cutworm, corn borers, corn ear-worm, fall armyworm		$9.7 mil.
Papaya (VR)	HI		9 mil. lbs		papaya ring spot virus		$2.9 mil.
Soybean (HT)	AL, AK, DE, FL, GA, IL, IN, IA, KS, KY, LA, MD, MI, MN, MS, MO, NE, NJ, NY, NC, ND, OH, OK, PA, SC, SD, TN, TX, VA, WV, WI	100%		over 20 mil. lbs			$1.1 bil.
Squash (VR)	FL, GA	31%	24 mil. lbs		four different mosaic viruses		$6.56 mil.

HT = herbicide tolerant, IR = insecticide resistant, VR = virus resistant

"I don't understand all the dread and furor over [biotechnology]. There's no scientific justification for it — it's simply resistance to change."

Dr. Norman Borlaug, Nobel Prize laureate, in comments made at USDA's Agriculture Outlook Forum 2005

"Much of the conversation around agricultural biotechnology has focused on yield or profit increases. While this is important, it ignores quality of life issues. Growing up, I spent summers weeding bean fields instead of playing sports-now kids can enjoy summer time sports. In the past we handled significantly more chemicals for crop protection. Now I don't have to worry about the health impact of these chemicals. This allows me to sleep better at night."

Darrin Ihnen, Ihnen Farms, Hurley, South Dakota, 2005

"These (biotech crop) varieties have 50 percent higher yields, mature 30 to 50 days earlier, are substantially richer in protein, are far more disease and drought tolerant, resist insect pests, and can even out-compete weeds. And they will be especially useful because they can be grown without fertilizer or herbicides, which many poor farmers can't afford anyway."

Mark Malloch Brown, Administrator, United Nations Development Program, Human Development Report 2001, July 10, 2001

"The importance of using technology to enhance crop production cannot be overstated. My research over the years has shown that there would be tremendous crop losses without the protection of pesticides. The reduction in rice yield would be 57 percent and 32 percent in corn. We would not have met global food demands during the past 50 years without pesticides. And we will not be able to feed the growing global population in the next 50 years unless we continue to increase crop yields."

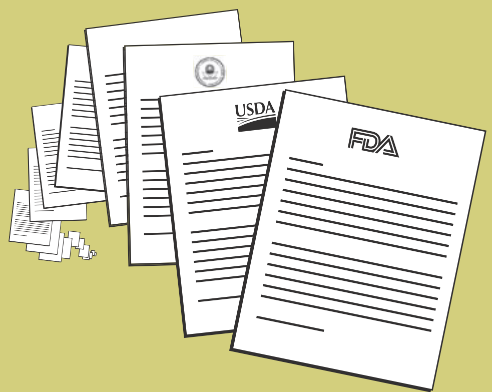
Ron Knutson, professor of agricultural economics, TX A&M University, in The Des Moines Register, September 14, 1999

"The rate of change facing farmers today is truly incredible. Biotechnology is another tool for farmers to utilize to bring abundance to America."

Steve Wentworth, IL Farmer and Chairman, Foundation EARTH

"Ongoing monitoring by companies of Bt cornfields since their introduction also shows that insect biodiversity and population densities in Bt cornfields is significantly higher than in fields treated with chemical sprays."

Val Giddings, Ph.D., Vice President of Food and Agriculture, Biotechnology Industry Organization (BIO)



REGULATION

Since the introduction of plant biotechnology, its adoption has grown every year as farmers around the world have realized its tremendous potential. In 2004, more than 200 million acres of corn, cotton, soybeans, fruit and other crops were planted. It should be noted that this tremendous growth has come without a single incident of an adverse effect to human health. The U.S. government has played an instrumental role in assuring human, animal and environmental safety through a rigid review process of all biotech-derived crops.

The U.S. government plays an essential role in maintaining the public's confidence in the safety of the food supply. The public's continued confidence concerning plant biotechnology ultimately flows from a system of comprehensive regulatory reviews and oversight of developments in biotech crops based on sound science, transparent decision making and public involvement. This system has been in place for over a decade.

Three federal agencies are involved in reviewing advances in plant biotechnology and together provide a coordinated framework to ensure human and environmental safety. The FDA, which oversees food safety and labeling of whole foods and food ingredients; the USDA, which oversees inspections of biotech plants and food stocks; and the EPA, which oversees the registration and regulation of all pesticides, herbicides and biotech crops.

U.S. FOOD AND DRUG ADMINISTRATION (FDA)

Since 1992, the FDA has determined that foods from plants produced through biotechnology are, as a class, as safe as those from plants developed through conventional breeding, and should therefore

The Federal Agencies Which Regulate Biotechnology

Agency	*Areas of Oversight*
FDA	Safety and labeling of whole foods, food ingredients and additives
USDA	Inspect and ensure quality of U.S. food supply; provide safety testing of new biotechnology applications
EPA	Registration and regulatory responsibility for biotechnology applications, as well as pesticides and herbicides

be regulated the same as any other foods entering the market. Accordingly, the FDA evaluates the application of biotechnology to food products on a case-by-case basis, as it does with any other food.

Under the Food, Drug and Cosmetic Act, the FDA usually focuses on the product, the food, or food ingredients, rather than on the plant development processes used in their production, as the basis for regulation. The same holds true for food and ingredients derived through biotechnology. The FDA offers a series of testing procedures that enable food manufacturers to anticipate safety concerns and to consult with the FDA as necessary for regulatory review of new plant varieties and products testing under development.

The FDA assessment process focuses on the following areas:

- Safety and nutritional value of newly introduced proteins
- Identity, composition and nutritional value of modified carbohydrates, fats or oils
- Concentration and bioavailability of nutrients for which food crop is consumed
- Potential for allergens to be transferred from one food source to another.

To ensure safety, a variety of toxicological and other product safety data are supplied to the FDA for food products or ingredients produced through the use of new plant varieties. The FDA requires developers to notify the agency at least four months in advance of commercializing any biotech food or animal feed and does a thorough evaluation of the data. In practice, biotech companies have filed notices of commercialization long before the four-month minimum.

LABELING

The FDA's food labeling policy applies to all foods, including those developed through biotechnology, and is designed to ensure consumer safety and protection. Since 1992, the FDA has maintained that a biotech food or ingredient would require a specific label only if the food is substantially different from its traditional counterpart. As an example, biotech foods that contain higher levels of essential vitamins and nutrients or that have lower levels of saturated fat would require explanatory labeling.

Currently, biotech varieties of corn, cotton, soybeans, papaya and canola are commonly grown by American farmers and are prevalent throughout the food and feed supply. None of these crops is substantially different from their traditional counterparts, and therefore none requires additional labels. The FDA also has developed draft guidelines for companies that wish to voluntarily label food products that do or do not contain biotech ingredients, so long as the label is not false or misleading.

U.S. DEPARTMENT OF AGRICULTURE (USDA)

USDA and EPA currently have primary responsibility for assessing the ecological effects of new plants developed through biotechnology. The Animal and Plant Health Inspection Service (APHIS) within the USDA is the primary agency regulating the safety testing of biotechnology-enhanced plants that are not insect or disease-resistant. APHIS approval must be obtained before proceeding to field-test or commercialize a biotechnology-derived plant.

In order to test a biotechnology-derived plant in the field, applicants seek from APHIS an environmental release permit. Once testing is allowed, APHIS and state agriculture officials can inspect the test field throughout the process to ensure that tests are conducted safely.

Before biotechnology-enhanced crops can be grown commercially, a petition must be submitted to APHIS containing scientific details about the plant, results of field tests and any indirect effects on other plants. This petition is published in the Federal Register, allowing the public time to comment. When the USDA has determined that the product is safe for field use, it is approved for commercialization.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

In addition to APHIS, the EPA also regulates herbicides and has jurisdiction over crops that are insect and disease resistant under the Federal Insecticide, Fungicide and Rodenticide Act. Environmental exposures to pesticide substances produced in crops are regulated by the EPA to ensure that there are no unreasonable adverse effects on the environment, including non-targeted insects, birds, fish, deer and other species.

The EPA's regulations focus on the pesticide produced by the plant, rather than on the plant as a whole. Such pesticides are subject to registration requirements similar to other pesticides. The agency requires developers of new plant-pesticides to obtain experimental use permits. Prior to any field testing, EPA officials must review and approve permit applications for genetically enhanced pesticides in crop plants containing pesticidal properties.

REGULATING PLANT BIOTECHNOLOGY: THREE AGENCIES AND MULTIPLE STEPS TO APPROVAL FOR BIOTECHNOLOGY PRODUCTS

The following are the steps required for a company to receive approval for an agriculture biotechnology product to go from concept to consumption.

It starts with the USDA.

There are four points at which USDA may advance or halt development of a biotech plant product.

1) Greenhouse Approval: USDA determines the adequacy of research facilities, such as greenhouses, for biotech testing and development.

2) Field Trial Authorization: Plant biotech developers must receive USDA approval for field trials and submit summary reports. USDA-APHIS personnel and state agriculture officials may inspect the trials at any time to ensure the research is being conducted safely. Particular scrutiny is given to limit the risk of possible "outcrosses," the unintentional breeding of domestic plants with related wild species. In addition, most plant developers avoid imparting traits that could increase the competitiveness or other undesirable properties of "weedy" relatives.

3) Authorization to Transport Seed: USDA also oversees import and shipment of biotech seeds from the greenhouse or laboratory to the field trial site.

4) Permission to Commercialize: Before a biotech crop can be grown, tested or used for traditional plant breeding without further USDA action, APHIS technical experts review all field trial studies. A "determination of nonregulated status" then is granted only after APHIS concludes the plant will not become a pest nor pose any significant risk to the environment or to wildlife. The reviews, which can take 10 months or longer, require developers to provide detailed scientific data on:

- Environmental Effects – whether the biotech plant variety could crossbreed with other plants, allowing them to "outcompete" with other plants in the ecosystem.
- Wildlife Effects – whether the plant could have adverse effects on wildlife, including birds, beneficial to insects or mammals.
- Weediness – whether the plant could become an uncontrollable or "super" weed.

Prior to the APHIS permit, plant developers must submit copies of their applications to the state departments of agriculture for review. If at any time the plant is found to be a pest, APHIS can stop its further development and sale or allow use under restricted conditions.

NEXT TO THE EPA

Concurrent with some of the USDA approval processes, the EPA also requires much of a company prior to authorizing the commercial use of a biotechnology product. If a biotechnology-derived plant exhibits the capacity to protect itself as if it has been treated with a chemical pesticide, EPA takes three steps.

1) Experimental Use Permit Approval: For tests of 10 acres or more, EPA must grant an experimental use permit (EUP) prior to a company initiating trials for a product.

2) Food Tolerance or Exemption: In establishing the limits (tolerances) for the amount of pest-control proteins in foods derived from the biotech plants, EPA examines:

- Product Characterization – Where in the plant are the new traits expressed? Do traits behave in the plant the same way they behave in nature? What is the mode of action or specific pesticidal substance produced in the plant?
- Toxicology – Is the protein produced by the introduced trait or gene toxic? How long does it take the protein to break down in gastric and intestinal fluids?
- Allergenicity – Does the protein degrade like other dietary proteins? Answering this question helps EPA determine whether the protein may trigger an allergic reaction, thereby requiring a label.
- Non-target Organisms – Is the protein toxic to birds, beneficial to insects, fish or other organisms? If so, will these organisms be exposed to the protein? For organisms that are exposed, data must be generated to ensure the safety of the expressed protein(s).

- Environmental Fate – How fast does the pesticidal protein in the plant's tissue break down in the soil?
- Potential Pest Resistance – What steps need to be followed to manage potential pest resistance?

3) Product Registration: During this final 18-month step, EPA reviews all relevant environmental and toxicological studies before deciding to register the product. If at any time the biotech plant is found to be unsafe, EPA can stop its further development and sale.

FINALLY TO THE FDA

Under a 1992 policy, the FDA treats biotech foods just like conventionally produced foods, unless they contain ingredients or demonstrate attributes that are unusual for the product. Even though the process is voluntary, all food biotechnology products currently on the market have received FDA consultation prior to their market introduction. However, acknowledging the need to increase consumer confidence in the regulatory process, FDA has decided to require developers to notify it at least four months in advance of releasing any biotech ingredients for food and animal feed and to supply the agency with their research data for review.

The FDA review currently includes a thorough safety assessment that compares every significant parameter of the biotech plant with its traditional counterpart:

- Assessment and Testing of Introduced Material – Is the inserted gene already present in another food source? Is it comparable to proteins already present in foods or is it a protein without a history of human consumption? Is it allergenic? Even when the history of the inserted material is well known, studies are conducted to ensure its safety and to identify any unexpected effects in the plant.
- Biological and Agronomic Characteristics – Are the biological and agronomic properties of the biotech plant different from the parental equivalent?
- Nutritional Composition – Studies are performed to determine whether nutrients, vitamins and minerals in the new plant occur at the same level as in the conventionally bred plant. Virtually all crop plants have been changed through traditional plant breeding. Thus, FDA requires labeling of food derived from plant varieties developed through biotechnology only when there are scientifically established issues of safety (such as introduction of a known allergen); a significant change in nutrients or composition (such as a nutritionally significant higher or lower level of certain vitamins); or a change in identity, in which traditional names do not apply (such as broccoflower).

When no changes are detected, FDA concludes the biotech crop to be substantially equivalent to the conventional crop with respect to nutrition and food safety.

FDA also has authority to stop development and sale of a biotech product if at any time it is found to be unsafe.

Even after the commercialization of any biotechnology product, all three regulatory agencies have the legal power to demand immediate removal from the marketplace of any product should new, valid data indicate a question of safety for consumers or the environment.

"While public opinion is quick to accept the innovations and hope that biotechnology brings to the field of health, it is highly resistant when these same innovations are used in farming and food. This attitude stems from doubts and fears fueled by a lack of well-balanced information. It is the obligation of the scientific community—namely, researchers who have the means to do so—to shift the debate over genetically modified organisms to a more balanced, scientific plane."

Giorgio Cantelli Forti, president of the Società Italiana di Tossicologia, at a November 2004 conference where 18 respected Italian associations, representing more than 10,000 researchers, released their first consensus document "Food Safety and GMOs"

"If the goal of regulation is to improve environmental health, we have to determine what benefits will be sacrificed when new products are delayed in reaching the market or made more costly by the regulation in question."

Gregory Conko, director of food safety policy at the Competitive Enterprise Institute, in a May 2003 article titled "The Benefits of Biotech"

"There is no reason to suppose that the process of food production through biotechnology leads to risks of a different nature than those already familiar to toxicologists or that cannot also be created by conventional breeding practices for plant, animal or microbial improvement. It is therefore important to recognize that it is the food product itself, rather than the process through which it is made, that should be the focus of attention in assessing safety."

Society of Toxicology, The Safety of Food Produced Through Biotechnology, March 2002

"As we have evaluated the results of the seeds or crops created using biotechnology techniques, we have seen no evidence that the bioengineered foods now on the market pose any human health concerns or that they are in any way less safe than crops produced through traditional breeding."

Jane E. Henney, M.D. Former U.S. Food and Drug Admin. Commissioner, FDA Consumer Magazine, January/February 2000

"Thirteen years of U.S. experience with biotech products have produced no evidence of food safety risks beyond those of their natural counterparts."[There has been] "not one rash, not one cough, not one sore throat, not one headache attributable to biotech products."

David Aaron, Undersecretary for International Trade, U.S. Commerce Department, in testimony before U.S. Senate Finance Committee, quoted by Reuters, October 1999

"America leads the world in agricultural products developed with biotechnology. These products hold great promise and will unlock benefits for consumers, producers and the environment at home and around the world. We are committed to ensuring the safety of our food and environment through strong and transparent science-based domestic regulatory systems."

Former President Bill Clinton, statement on World Trade Organization objectives, October 13, 1999

"...companies are doing far more extensive testing than has ever been done on commercial varieties… under the guidance of our scientists in the government to ensure proper adequate testing before they go to consumers."

James Maryanski, Ph.D., Biotechnology Coordinator, U.S. Food and Drug Administration, Worldnet interview, May 26, 1999

"From the standpoint of the Food and Drug Administration, the important thing for consumers to know about these new foods is that they will be every bit as safe as the foods now on store shelves. All foods, whether traditionally bred or genetically engineered, must meet the provisions of the Federal Food, Drug and Cosmetic Act."

U.S. Food and Drug Administration Consumer magazine article "Genetic Engineering: Fast Forwarding to Future Foods," published April 1995 and revised February 1998

PLANT DERIVED BIOLOGICS

The true promise of biotechnology may shine brightest in plant-made pharmaceuticals, a new category of therapeutic agents that can be produced in live plants. Advances in biotechnology have made it possible to genetically enhance plants to produce therapeutic proteins essential for the production of a wide range of pharmaceuticals — such as monoclonal antibodies, enzymes and blood proteins.

Therapeutic proteins produced by transgenic plants include antibodies, antigens, growth factors, hormones, enzymes, blood proteins and collagen. These proteins have been grown in field trials in a wide variety of plants, including alfalfa, corn, duckweed, potatoes, rice, safflower, soybeans and tobacco. Field trials with protein-producing plants are providing the essential building blocks for innovative treatments for diseases such as cancer, HIV, heart disease, diabetes, Alzheimer's disease, kidney disease, Crohn's disease, cystic fibrosis, multiple sclerosis, spinal cord injuries, hepatitis C, chronic obstructive pulmonary disease, obesity and arthritis.

In addition, scientists have made excellent progress in using plants as vaccine-manufacturing facility and delivery systems. They have used tobacco, potatoes, tomatoes and bananas to produce experimental vaccines against infectious diseases, including cholera, a number of microbes that cause food poisoning and diarrhea (e.g., E. coli and the Norwalk virus), hepatitis B and the bacterium that causes dental cavities. A cancer "vaccine" (which is therapeutic and not preventative) to non-Hodgkin's lymphoma has also been produced in plants.

Since most proteins cannot be chemically synthesized, there are very few options for protein production for pharmaceutical purposes: mammalian and microbial cell cultures and plants. About $500 million and five years are required to build a facility for mammalian and microbial cell cultures. Using plants to produce therapeutic proteins presents several clear advantages. First, there are significantly lower facility and production costs associated with plant-made pharmaceuticals. Second, because plant-made pharmaceutical growth is not limited to special manufacturing facilities, it will be relatively easy to scale production to meet increased and varied demand. These two factors combined have the potential to provide patients with the benefits of greater and faster access to medicines.

One of the companies developing plant-produced antibodies estimates that this production method is 25 to 100 times less expensive than cell-fermentation methods. Standard fermentation methods can produce 5 to 10 kilograms of a therapeutic antibody per year, while this company reports that it can produce 10,000 kilograms of monoclonal antibodies per year. Using plants as factories to produce therapeutic proteins also enables researchers to develop novel and complex molecular forms that could not normally be grown in mammalian cell cultures.

Because protein-producing plants require relatively little capital investment, and the costs of production and maintenance are minimal, they may provide the only economically viable option for independent production of therapeutic proteins in underdeveloped countries.

HOW ARE PLANT-MADE PHARMACEUTICALS REGULATED?

Plant-made pharmaceutical production is regulated under stringent requirements of the U.S. Department of Agriculture (USDA) and the Food and Drug Administration (FDA). The primary agency that regulates and monitors this technology is USDA's Animal and Plant Health Inspection Service (APHIS). APHIS requires companies to obtain permits for field trials for therapeutic protein production. The agency announced new permit conditions in March 2003. Prior to issuing a test permit, APHIS reviews all plans for seed production, timing of pollination, harvest, crop destruction, shipment, confinement and the storage and use of equipment. Permits are issued for the importation, interstate movement and field testing of the plants. Field sites are inspected at least five times in a single growing season by APHIS or state officials, with those inspections corresponding to critical times in production, such as preplanting site location evaluation, planting, midseason, harvesting and postharvesting.

WHAT ARE PLANT-MADE PHARMACEUTICALS?

Plant-made pharmaceuticals (PMPs) are the result of a breakthrough application of biotechnology to plants to enable them to produce therapeutic proteins that could ultimately be used by the medical community to combat life-threatening illnesses. In this process, plants themselves become "factories" that manufacture therapeutic proteins. These proteins are then extracted, refined and used in pharmaceutical production. Researchers are currently in various stages of field trials and clinical trials of PMP production. It is estimated that it will be at least three to five years before full commercialization of the first PMP is reached. Plant-made pharmaceuticals are strictly regulated by United States regulatory agencies and differ from traditional commodity agriculture on many fronts. Plant-made pharmaceutical research does not represent a new wave of value-added commodity agriculture.

Plant-Made Pharmaceuticals

Sample plant sources
corn, rice, soybean, tobacco, tomatoes

Advantages
Large production capacity
Equivalent purity/activity to other manufacturing systems
Reduced capital requirements
Freedom from potential viral and animal protein contamination

Source: Bio.org

HOW ARE PLANT-MADE PHARMACEUTICALS PRODUCED?

Advances in biotechnology have made it possible to genetically enhance plants to produce therapeutic proteins essential for the production of a wide range of pharmaceuticals - such as monoclonal antibodies, enzymes, and blood proteins. These plants are grown under highly regulated conditions in confined growing environments and are strictly regulated by the USDA, APHIS and FDA.

After the plants are harvested, they go through a series of processing steps that extract, separate, purify and package the therapeutic proteins. The refined therapeutic proteins are ultimately used as the active pharmaceutical ingredient (API) in many life-saving medicines and are regulated by the FDA.

WHAT KINDS OF PLANTS ARE USED TO PRODUCE PMPS?

Plants such as alfalfa, corn, rice, safflower and tobacco have received APHIS regulatory permits for field trials. These field trials are aimed at delivering the next generation of essential proteins for life-saving medicines.

WHY USE PLANTS THAT ALSO CAN BE USED FOR FOOD CROPS?

Plants that also can be used for food crops are a natural choice for PMP production because researchers have extensive agricultural knowledge and familiarity of these plants, as well as experience with their growth. Scientists have a vast understanding of genetics, agronomics and the environmental impact these plants have, as well as their composition. This information is crucial in developing methods for confining and managing these plants.

WHAT KINDS OF DISEASES WILL BE TREATED WITH PMPS?

Plants improved through the use of biotechnology can produce the essential building blocks (therapeutic proteins) for innovative treatments for diseases such as cancer, HIV, heart disease, chronic obstructive pulmonary disease (COPD), diabetes, Alzheimer's disease, kidney disease, Crohn's disease, cystic fibrosis, multiple sclerosis, spinal cord injuries, Hepatitis C, obesity, rheumatoid arthritis, iron deficiency and many others.

ARE PLANT-MADE PHARMACEUTICALS THE SAME PLANTS USED AS FOODS AND FEEDS IMPROVED THROUGH THE USE OF BIOTECHNOLOGY?

No. Protein-producing plants simply are "production factories" and are one step in the pharmaceutical manufacturing process and are handled completely outside the commodity food and feed stream. PMPs leverage much of the agricultural biotechnology applications and knowledge used in genetically enhanced food and feed, but for an entirely different purpose and end-use.

Agricultural biotechnology uses advanced plant breeding techniques and tools of biotechnology to introduce beneficial traits to crops grown for food, feed and fiber. Many foods and feeds improved through the use of biotechnology possess beneficial characteristics, such as higher yield, better nutrition and resistance to disease. Examples of agricultural biotechnology for consumption purposes include "golden rice," which produces pro-Vitamin A, and grains with improved oil content.

The science used to produce proteins in plants represents the new era of biopharmaceutical manufacturing and differs from traditional commodity agriculture on many fronts. PMP research does not represent a new wave of value-added commodity agriculture.

ARE PMPS CURRENTLY ON THE MARKET?

No. Today, researchers are in various stages of field trials and clinical trials of PMP production and it is most likely that it will be at least three to five years before full commercialization of a PMP is reached. The USDA reports in 2002, total U.S. test trials consisted of 20 permits governing 34 field sites for a total of 130 acres. Plants being grown for the manufacture of biotechnological medicines can only be grown under USDA APHIS permit.

Biotechnology Industry Organization member companies working on plant-made pharmaceutical technology include Biolex, Ceres, CropTech, Dow AgroSciences, Epicyte, Medicago, Meristem Therapeutics, Monsanto Protein Technologies, Planet Biotechnology, ProdiGene, SemBioSys, Syngenta and Ventria Bioscience. All permit information for these companies and their field tests are publicly available from USDA at www.aphis.usda.gov.

HOW DOES PMP COMPARE TO AGRICULTURAL BIOTECHNOLOGY?

It is important to distinguish between genetically modified plants used to produce pharmaceuticals and genetically modified crop plants grown for food or feed. The first are used exclusively to produce pharmaceutical proteins and are intended not to be used in food or feed consumption. Like other prescription pharmaceuticals, those developed from plants will be packaged, sold, prescribed and administered. These pharmaceutical proteins will be subject to strict oversight by the FDA, USDA and APHIS, under the Biotechnology Regulatory Services (BRS) department.

Pharmaceutical proteins also are only being grown in a limited number of plants, including alfalfa, corn, duckweed, rice, safflower and tobacco to generate essential proteins for life-saving drugs.

GROWN AND PROCESSED SEPARATELY FROM FOOD AND FEED

The production and handling of pharmaceutical-containing plants is strictly regulated under rigorous federal guidelines for the safety of humans and the environment. APHIS requires companies to obtain permits for field tests and for pharmaceutical protein

"Plants are the most efficient producers of proteins on earth."

Roger Beachy, Ph.D, president, Donald Danforth Plant Science Center production. Strengthened permit conditions for the 2003 growing season were announced by APHIS in March 2003. Permit conditions can be found online at http://www.aphis.usda.gov.

Pharmaceutical protein-producing plants are grown and processed separately from food and feed crops - a system known as confinement, or in a completely closed loop system. After harvest the plant material is processed to separate and purify the proteins, which are then delivered to pharmaceutical manufacturers. In addition, the seeds to grow plant producing pharmaceutical proteins are available only to the registrant, their personnel, or contract grower and cannot be purchased off the shelf at a local seed store.

WHICH GOVERNMENT AGENCIES OVERSEE THE PRODUCTION OF PLANT-MADE PHARMACEUTICALS?

Plant-made pharmaceutical (PMP) production is regulated under stringent requirements of the U.S. Department of Agriculture (USDA) and the Food and Drug Administration (FDA). Several agencies within USDA and FDA regulate and monitor PMPs, including USDA's Animal and Plant Health Inspection Service (APHIS) under the Biotechnology Regulatory Services (BRS), the FDA Center for Biologics Evaluation and Research (CBER), FDA Center for Drug Evaluation and Research (CDER), FDA Center for Food Safety and Applied Nutrition (CFSAN) and FDA Center for Veterinary Medicine (CVM).

WHAT CONFINEMENT MEASURES ARE IN PLACE TO ENSURE THERE IS NO COMMINGLING WITH FOOD OR FEED CROPS?

Confinement includes procedures to prevent commingling with food or feed crops, the environment, humans and non-target organisms. Confinement procedures are based on scientific risk assessments that evaluate the potential for and impact of exposure, and are modeled after Hazard Analysis and Critical Control Point (HACCP) principles. HACCP is a system currently in use in the food industry and identifies hazards and critical control points, and then establishes procedures for maintaining those points. The PMP industry has named its risk assessment Containment Analysis and Critical Control Point (CACCP).

Plant-Made Pharmaceuticals In Trials

Company	*Plant*	*Indication*
Ventria Bioscience	Rice, Barley	Oral Rehydration

These risk assessments developed for plant-made pharmaceuticals take into account the crop, the specific protein, the spatial setting or location of the intended production area and agronomic and crop handling practices. Confinement measures include both spatial isolation and temporal separation. Spatial confinement defines the distance between plots for plants producing pharmaceutical proteins and conventional crops used for food and feed. Temporal boundaries define the time separating the flowering and pollination between plants producing pharmaceutical proteins and nearby conventional crops of the same or related species.

Additionally, there is a perimeter fallow zone (an area not in production) around the field test site of 50 feet. This fallow zone ensures that farm machinery and equipment can freely access the test plot without affecting nearby fields.

Some plants, such as corn grown to produce pharmaceutical proteins, have unique confinement conditions as required by APHIS permit guidelines. Due to corn's unique pollination cycle, no conventional corn can be grown within one mile of a field test that involves open-pollinated pharmaceutical corn. If pollination is controlled within the field test plot (through detasseling or bagging the corn stalks), then spatial confinement is reduced to half a mile, with a temporal buffer of 28 days. For example, controlled transgenic corn producing pharmaceutical proteins must be planted either 28 days before or 28 days after planting or harvesting of any other corn growing within a half mile of the test plot.

DO PMPS REQUIRE DEDICATED EQUIPMENT?

Dedicated equipment is machinery that is solely used for plants producing pharmaceutical proteins and not for any other plants or crops. APHIS permit conditions require dedicated equipment to be used for planting and harvesting for the duration of the growing season for the pharmaceutical plants. This includes harvesters and planters. Tractors or tillage equipment can be used in other fields following APHIS-approved cleaning procedures. Additionally, dedicated facilities for the storage of equipment and regulated articles for the duration of the field test are required. Dedicated equipment can be decommissioned after a thorough cleansing process that has been approved by APHIS.

ARE FARM WORKERS AND OTHER PERSONNEL SPECIALLY TRAINED TO WORK WITH PMPS?

The annual training of contract growers and all other individuals involved with the development and production of PMPs is an APHIS regulatory

How U.S. Agencies Share Regulation Responsibilities for PMPs

USDA	Regulates PMPs during development and field production
USDA/APHIS	APHIS' Biotechnology Regulatory Services (BRS) oversees the process from seed through grain, including the transport and release of the seed in a greenhouse or field
FDA	Regulates the evaluation, production and distribution of pharmaceutical products
FDA CBER & CDER	Regulate biologic products/devices, including plant-made pharmaceuticals, used as human medicines
FDA CFSAN & CVM	Provide additional oversight as needed to ensure the safety of food and feed

requirement. An APHIS-approved training program ensures personnel are prepared to successfully implement and comply with all permit conditions.

WHAT IS THE PROCESS FOR OBTAINING A PERMIT?

While each permit issued by APHIS is unique and approval is granted on a case-by-case basis, the process for obtaining a permit is the same for all parties and involves both federal and state agriculture department approvals. In general, it takes approximately 120 days from the time the permit application is received until the permit is either denied or issued.

APHIS permitting requirements can be found online at http://www.aphis.usda.gov. Additionally, all permit information for companies involved with PMP technology and their field tests are publicly available from USDA at http://www.aphis.usda.gov/bbep/bp/status.html.

HOW MANY PMP TEST PLOTS ARE THERE IN THE UNITED STATES AND WHERE ARE THEY?

APHIS reports that in 2002 total U.S. test trials consisted of 20 permits governing 34 field sites for a total of 130 acres. Plants growing pharmaceutical proteins can only be grown under USDA permit. Permits have been issued in the following 14 states since 2001: AZ, CA, FL, HI, IA, KS, KY, MO, NE, SC, TX, VA, WA and WI.

WHAT HAPPENS IF REGULATIONS ARE VIOLATED?

In the event that permits are violated, APHIS will conduct a full-scale investigation governed by the Plant Protection Act. In the event a violation occurs, the Act provides for both criminal and civil penalties that may be leveled against the company and individuals that violate the act. Companies or individuals that violate the act and permit conditions face civil penalties of up to $250,000 per violation and/or imprisonment for up to five years, or $500,000 per adjudication, and may result in having their permits revoked. Additionally, if necessary, to protect the environment or public health, the transgenic plants can be subjected to the application of remedial measures (including disposal); if the owner fails to take such action, APHIS can take the action and recover the cost of the action from the owner.

WILL PMPS EVER BE DE-REGULATED?

PMP field production will always be under federal oversight and will not be de-regulated. Even when PMPs enter into commercial production, they will continue to be strongly regulated.

IS THE PUBLIC ALLOWED TO VOICE OPINIONS ON PERMIT REQUIREMENTS?

As reported in the Federal Register notice, APHIS recognizes the need to provide additional information about field testing to the public and is in the process of determining how to make information about specific permits and necessary confinement standards available for each field test under permit. The Federal Register notice provides permit condition changes in a more formal way to the public and allows the public to respond during an open comment period. All current rules were developed with notice and comment rulemaking in accordance to the Administrative

"Using plants to produce pharmaceuticals in the field could reduce the cost of goods by as much as 50 percent."

Peter Latham, president, BioPharm Services, Inc.

Growing Commodity Crops Improved through Biotechnology vs. Plants for Pharmaceutical Production

	Commodity Crops	*Plant-Made Pharmaceuticals*
Intended Uses	Crops are harvested for food and feed use	Plants are improved through biotechnology to manufacture therapeutic proteins which are extracted, refined and used in regulated pharmaceutical products.
Permits Required	Permits are required for the field trial phase of crops developed through agricultural biotechnology. Once federal approval is received, no inspections are required.	Can only be grown under USDA/APHIS permit and will never be de-regulated.
Inspections Required	Inspections are required for the field trial phase of crops developed through agricultural biotechnology. Once federal approval is received, no inspections are required.	APHIS or state officials inspect records, facilities (including laboratories and greenhouses) and each field site is inspected a minimum of seven times over two years.
Who Can Plant	Anyone.	Only a few select growers under contract with the manufacturer are identified and undergo annual APHIS-approved training programs on permit conditions and implementation. They are then carefully supervised to grow PMP crops.
Number of U.S. Acres	Hundreds of millions.	In 2002 the total U.S. test trials consisted of 20 permits governing 34 field sites for a total of 130 acres. Plants growing pharmaceutical proteins can only be grown under USDA permit.
Dedicated Equipment	No.	Yes. Most equipment that comes into direct contact with plant-made pharmaceuticals must be dedicated for PMP production only and cannot be used with any crops intended for food or feed.
Confinement Measures	Confinement measures are required for commodity crops developed through agricultural biotechnology when they are under permit and, when necessary, to maintain proper segregation of crops with limited global approvals.	Confinement measures are based on the type of plant, the specific target protein, the location of the intended production area and agronomic and plant handling practices relevant to the circumstances.

Procedures Act (APA).

DOES THE BIOTECHNOLOGY INDUSTRY SUPPORT THE PERMIT REQUIREMENTS?

The PMP biotechnology industry views USDA's approach to establishing new guidelines for field trials of PMPs as a model for establishing a transparent and informative approach to invite public participation in the oversight of an emerging technology. As a whole, the biotechnology industry supports a regulatory system that is grounded in science and believes USDA's guidelines reflect established science and ensures plants grown for pharmaceutical protein production can be isolated for their intended use only. Manufacturers of PMPs recognize their responsibility to maintain the safety of the manufacturing process. They are ready to provide regulatory authorities with validated analytical methods and tools for detecting PMPs and are fully

"As populations age, it will be essential to control health care costs, containing input costs will be key to this. Plant made pharmaceuticals offer one solution to these concerns"

Bill Horan, Horan Brother Farms, Rockwell City, Iowa. 2005 cooperating with regulatory agencies in reviews and audits of confinement procedures.

In addition to adhering to USDA regulations, the PMP biotechnology industry is committed to strict, self-imposed guidelines with a goal to create a uniform code of conduct throughout the industry. Thus, each manufacturer has developed standard operating procedures that cover every aspect of production and handling of PMPs, from pre-planting preparation to the delivery of the plant material or the product derived from plant material to a processing facility. A central focus of the standardized procedures is a confinement system intended to ensure that neither humans nor the environment are unintentionally exposed to PMPs. These plants are used exclusively to produce pharmaceutical proteins and are not intended for food or feed consumption.

WHAT ARE THE CONSUMER BENEFITS OF PLANT-MADE PHARMACEUTICALS?

Traditional methods of producing pharmaceutical materials using microbial fermentation or animal cells are limited by the time and money necessary to build the required manufacturing facilities, and production is limited to manufacturing capacity. It can take a total of five to seven years from laying the first bricks of a traditional biotech facility to extracting pharmaceutical proteins from cultivated cells.

In many cases, it will cost significantly less to grow plants with the ability to mass-produce pharmaceutical proteins because plant-based techniques don't require the same costly capital investments.

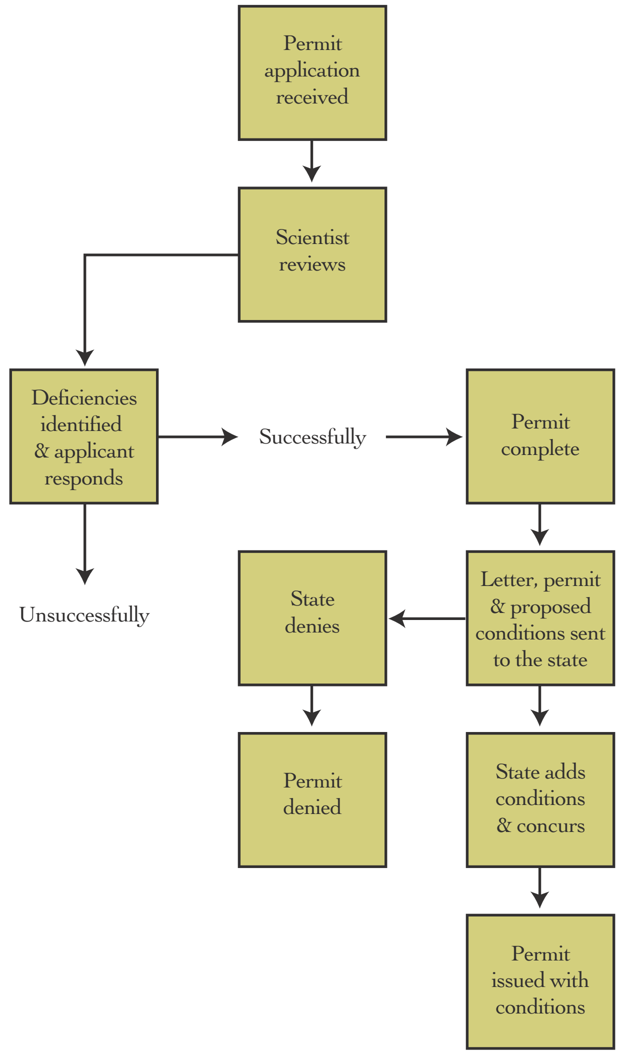
Plant-made pharmaceutical production can also be more easily expanded to provide larger quantities if demand for the drug increases. Additionally, because plants are renewable in nature and can produce pharmaceutical proteins within a single growing season, production can be quickly scaled up to meet patient needs.

Production and cost advantages of plant-made pharmaceuticals can allow more capital to be invested in research and development of new therapeutics, giving patients access to new drugs faster. In addition, expanded manufacturing capacity of high-quality proteins will spur development of more medicines by removing a key hurdle to mass production.

WHAT IS THE INDUSTRY STEWARDSHIP POSITION ON PLANT-MADE PHARMACEUTICALS?

The industry is committed to taking any necessary measures to ensure that plant-made pharmaceuticals are safe. In addition to complying with existing regulations, companies adhere to strict self-imposed guidelines.

Plant-Made Pharmaceutical Permit Process



Companies developing plant-made pharmaceuticals will:

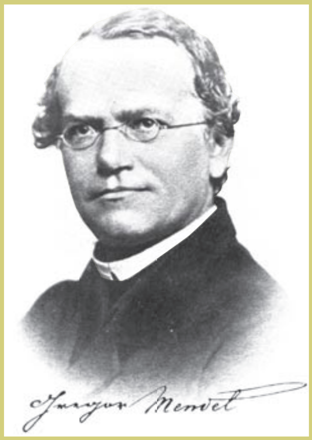
- Grow plant-made pharmaceuticals under closely supervised and regulated conditions referred to in government regulations as "confinement;"
- Ensure rigorous compliance with U.S. FDA regulations and USDA confinement standards, as well as with international regulatory standards for medical products in Canada, Europe and Japan;
- Share with appropriate regulatory agencies validated analytical methods of testing; and
- Fully cooperate in reviews of confinement measures and on-site inspections.

Source: Bio.org

The Future Promise of Plant Made Pharmaceuticals

Some of the benefits we may see within 10 years from plant-made pharmaceuticals:

- Tomatoes enriched with lycopene will help protect against heart disease and cancer
- Rice with beta-carotene will stimulate vitamin A production, the deficiency of which causes blindness in 500,000 children and 2 million deaths annually
- Cooking oils with higher levels of vitamin E and lower levels of trans fatty acids, leading to a healthier immune system and lower incidence of heart disease
- Lettuce fortified with reservatrol will lower levels of "bad" cholesterol and raise the level of "good" cholesterol



A HISTORICAL LOOK AT BIOTECHNOLOGY

The word biotechnology can be traced to 1917, when it was used to refer to large-scale fermentation production techniques. While relatively young in term, the roots of biotechnology can be traced back at least 6,000 years. Here is a brief history of biotechnology [and farming mixed in]:

8000 B.C.
- Humans domesticate crops and livestock.
- Potatoes first cultivated for food.

4000 B.C.
- The Egyptians use yeasts to make bread and wine.

4000-2000 B.C.
- Production of cheese and fermentation of wine (Sumeria, China and Egypt).
- Babylonians control date palm breeding by selectively pollinating female trees with pollen from certain male trees.

1700s B.C.
- Naturalists begin to identify many kinds of hybrid plants — the offspring of breeding between two varieties of plants.

1750 B.C.
- The Sumerians brew beer.

500 B.C.
- First antibiotic: moldy soybean curds used to treat boils (China).

250 B.C.
- The Greeks use crop rotation to maximize crop fertility.

A.D. 100
- First insecticide: powdered chrysanthemums (China).

1322
- An Arab chieftain first uses artificial insemination to produce superior horses.

1500
- The Aztecs make cakes from Spirulina algae.

1590
- Janssen invents the microscope.

1663
- Cells are first described by Hooke.

1675
- Leeuwenhoek discovers bacteria.

1761
- Koelreuter reports successful crossbreeding of crop plants in different species.

1797
- Jenner inoculates a child with a viral vaccine to protect him from smallpox.

1830
- Proteins discovered.

1833
- First enzyme discovered and isolated.

1835-1855
- Schleiden and Schwann propose that all organisms are composed of cells, and Virchow declares, "Every cell arises from a cell."

1856
- Gregor Mendel begins a meticulous study of specific characteristics he found in various plants which were passed to future plant generations.

1857
- Pasteur proposes microbes cause fermentation.

1859
- Darwin publishes his theory of evolution On the Origin of Species.

1861
- Louis Pasteur defines the role of microorganisms and establishes the science of microbiology.

1866
- Mendel proposes basic laws of genetics based on studies with pea plants.

1870-1890
- Using Darwin's theory, plant breeders crossbreed cotton, developing hundreds of varieties with superior qualities.
- Farmers first inoculate fields with nitrogen-fixing bacteria to improve yields.
- William James Beal produces first experimental corn hybrid in the laboratory.

1877
- A technique for staining and identifying bacteria is developed by Koch.

1878
- The first centrifuge is developed by Laval.

1879
- Fleming discovers chromatin, the rod-like structures inside the cell nucleus that later came to be called chromosomes.

1900
- European botanists use Mendel's Law to improve plant species, marking the beginning of classic selection.
- Drosophila (fruit flies) used in early studies of genes.

1902
- The term immunology first appears.

1906
- The term genetics is introduced.

1910
- Genes are discovered to be located on chromosomes.

1911
- The first cancer-causing virus is discovered by Rous.

1914
- Bacteria are used to treat sewage for the first time in Manchester, England.

1915
- Phages, or bacterial viruses, are discovered.

1919
- First use of the word biotechnology in print.

1920
- The human growth hormone is discovered by Evans and Long.

1928
- Penicillin discovered as an antibiotic: Alexander Fleming.
- A small-scale test of formulated Bacillus thuringiensis (Bt) for corn borer control begins in Europe. Commercial production of this biopesticide begins in France in 1938.
- Karpechenko crosses radishes and cabbages, creating fertile offspring between plants in different genera.
- Laibach first uses embryo rescue to obtain hybrids from wide crosses in crop plants-known today as hybridization.

1930
- U.S. Congress passes the Plant Patent Act, enabling the products of plant breeding to be patented.

1933
- Hybrid corn, developed by Henry Wallace in the 1920s, is commercialized. Growing hybrid corn eliminates the option of saving seeds. The remarkable yields outweigh the increased costs of annual seed purchases, and by 1945, hybrid corn accounts for 78 percent of U.S.-grown corn.

1938
- The term molecular biology is coined.

1941
- The term genetic engineering is first used.

1942
- The electron microscope is used to identify and characterize a bacteriophage-a virus that infects bacteria.
- Penicillin mass-produced in microbes.

1944
- DNA is proven to carry genetic information-Avery et al.
- Waksman isolates streptomycin, an effective antibiotic for tuberculosis.

1946
- Discovery that genetic material from different viruses can be combined to form a new type of virus, an example of genetic recombination.
- Recognizing the threat posed by loss of genetic diversity, the U.S. Congress provides funds for systematic and extensive plant collection, preservation and introduction.

1947
- McClintock discovers transposable elements, or "jumping genes," in corn.

1949
- Pauling shows that sickle cell anemia is a "molecular disease" resulting from a mutation in the protein molecule hemoglobin.

1950
- First regeneration of entire plants from an in vitro culture.

1951
- Artificial insemination of livestock using frozen semen is successfully accomplished.

1953
- The double helix structure of DNA is discovered by Watson, Crick and New Zealander, Wilkins. Watson and Crick would later receive the Nobel Prize for their work.

1955
- An enzyme involved in the synthesis of a nucleic acid is isolated for the first time.

1956
- Kornberg discovers the enzyme DNA polymerase I, leading to an understanding of how DNA is replicated.

1958
- Sickle cell anemia is shown to occur due to a change of a single amino acid.
- DNA is made in a test tube for the first time.

1959
- Systemic fungicides are developed. The steps in protein biosynthesis are delineated.

Also in the 1950s
- Discovery of interferons.
- First synthetic antibiotic.

1960
- Exploiting base pairing, hybrid DNA-RNA molecules are created.
- Messenger RNA is discovered.

1961
- USDA registers first biopesticide: Bacillus thuringiensis, or Bt.

1963
- New wheat varieties developed by Norman Borlaug increase yields by 70 percent.

1964
- The International Rice Research Institute in the Philippines starts the Green Revolution with new strains of rice that double the yield of previous strains if given sufficient fertilizer.

1965
- Harris and Watkins successfully fuse mouse and human cells.

1966
- The genetic code is cracked, demonstrating that a sequence of three nucleotide bases (a codon) determines each of 20 amino acids.

1967
- The first automatic protein sequencer is perfected.

1969
- An enzyme is synthesized in vitro for the first time.
- The first gene is isolated.

1970
- Norman Borlaug receives the Nobel Peace Prize (see 1963).
- Discovery of restriction enzymes that cut and splice genetic material, opening the way for gene cloning.

1971
- First complete synthesis of a gene.

1972
- The DNA composition of humans is discovered to be 99 percent similar to that of chimpanzees and gorillas.
- Initial work with embryo transfer.

1973
- Researchers develop the ability to isolate genes. Specific genes code for specific proteins.
- The first genetic engineering experiment is conducted by inserting a gene from the African clawed toad into bacterial DNA.

1974
- The National Institutes of Health forms a Recombinant DNA Advisory Committee to oversee recombinant genetic research.

1975
- Government first urged to develop guidelines for regulating experiments in recombinant DNA.
- The first monoclonal antibodies are produced.

1976
- The tools of recombinant DNA are first applied to a human inherited disorder.
- Molecular hybridization is used for the prenatal diagnosis of alpha thalassemia.
- Yeast genes are expressed in E. coli bacteria.
- First time the sequence of base pairs for a specific gene is determined (A, C, T, G).
- First guidelines for recombinant DNA experiments released: National Institutes of Health-Recombinant DNA Advisory Committee.

1977
- First expression of human gene in bacteria.
- Procedures developed for rapidly sequencing long sections of DNA using electrophoresis.

1978
- High-level structure of virus first identified.
- Recombinant human insulin first produced.
- NC scientists show it is possible to introduce specific mutations at specific sites in a DNA molecule.
- Louise Brown, the world's first 'test-tube' baby is born through in vitro fertilization.

1979
- Human growth hormone first synthesized.

Also in the 1970s
- The Green Revolution introduces hybrid seeds into food-short Third World countries.
- First commercial company founded to develop genetically engineered products.
- Discovery of polymerases.
- Techniques for rapid sequencing of nucleotides perfected.
- Gene targeting.
- RNA splicing.

1980
- The U.S. Supreme Court, in the landmark case Diamond v. Chakrabarty, approves the principle of patenting recombinant life forms, which allows the Exxon Oil Company to patent an oil-eating microorganism.
- The U.S. patent for gene cloning is awarded to Cohen and Boyer.
- The first gene-synthesizing machines are developed.
- Researchers successfully introduce a human gene-one that

codes for the protein interferon-into a bacterium.

- Nobel Prize in Chemistry awarded for creation of the first recombinant molecule: Berg, Gilbert, Sanger.

1981

- Scientists at OH University produce the first transgenic animals by transferring genes from other animals into mice.
- Chinese scientist becomes the first to clone a fish-a golden carp.
- The first gene-synthesizing machines are developed.

1982

- The U.S. Food and Drug Administration approves the first genetically engineered drug, a human insulin produced by bacteria.
- Applied Biosystems, Inc., introduces the first commercial gas phase protein sequencer, dramatically reducing the amount of protein sample needed for sequencing.
- First recombinant DNA vaccine for livestock developed.

1983

- The first transgenic plant is created – petunia plants genetically engineered to be resistant to kanamycin, an antibiotic.
- The chromosomal location of the inherited disease, Huntington's disease, is discovered leading to the development of a screening test.
- The polymerase chain reaction (PCR) technique is conceived. PCR, which uses heat and enzymes to make unlimited copies of genes and gene fragments, later becomes a major tool in biotech research and product development worldwide.
- The first genetic transformation of plant cells by TI plasmids is performed.
- The first artificial chromosome is synthesized.

1984

- The DNA fingerprinting technique is developed.
- The entire genome of the human immunodeficiency virus is cloned and sequenced.

1985

- Genetically engineered plants resistant to insects, viruses and bacteria are field tested for the first time.
- New Zealand develops a hormone extract product from sheep, used to induce reproduction in genetically superior animals throughout the world.
- DNA fingerprinting is first used in a criminal investigation.
- Genetic markers found for kidney disease and cystic fibrosis.
- The NIH approves guidelines for performing gene-therapy experiments in humans.

1986

- New Zealand passes the Hazardous Substances and New Organisms (HSNO) Act which controls the development and importation of genetically modified organisms.
- First recombinant vaccine for humans: Hepatitis B.
- First anti-cancer drug produced through biotech: interferon.
- The U.S. government publishes the Coordinated Framework for Regulation of Biotechnology, establishing more stringent regulations for rDNA organisms than for those produced with traditional genetic modification techniques.
- A University of CA-Berkeley chemist describes how to combine antibodies and enzymes (abzymes) to create pharmaceuticals.
- The first field tests of transgenic plants (tobacco) are conducted.
- The Environmental Protection Agency approves the release of the first transgenic crop-gene-altered tobacco plants.
- The OECD Group of National Experts on Safety in Biotechnology states: "Genetic changes from rDNA techniques will often have inherently greater predictability compared to traditional techniques" and "risks associated with rDNA organisms may be assessed in generally the same way as those associated with non-rDNA organisms."

1987

- First approval for field test of modified food plants: virus-resistant tomatoes.
- Frostban, a genetically altered bacterium that inhibits frost formation on crop plants, is field-tested on strawberry and potato plants in CA, the first authorized outdoor tests of a recombinant bacterium.

1988

- Harvard molecular geneticists are awarded the first U.S. patent for a genetically altered animal-a transgenic mouse.
- A patent for a process to make bleach-resistant protease enzymes to use in detergents is awarded.
- Congress funds the Human Genome Project, a massive effort to map and sequence the human genetic code as well as the genomes of other species.

1989

- First approval for field test of modified cotton: insect-protected (Bt) cotton.
- Plant Genome Project begins.

Also in the 1980s

- Scientists discover how to transfer pieces of genetic information from one organism to another, allowing the expression of desirable traits in the recipient organism. This is called genetic engineering, one process used in biotechnology. Using the technique of "gene splicing" or "recombinant DNA technology" (rDNA), scientists can add new genetic information to form a new protein that creates traits that protect plants from diseases and pests.

- Studies of DNA used to determine evolutionary history.
- Recombinant DNA animal vaccine approved for use in Europe.
- Use of microbes in oil spill cleanup: bioremediation technology.
- Ribozymes and retinoblastomas identified.

1990

- The first successful field trial of genetically engineered cotton plants (Bt cotton) is conducted.
- DEKALB® receives the first patent for transformed corn.
- Chy-Max™, an artificially produced form of the chymosin enzyme for cheese-making, is introduced. It is the first product of recombinant DNA technology in the U.S. food supply.
- The Human Genome Project-an international effort to map all the genes in the human body-is launched.
- The first experimental gene therapy treatment is performed successfully on a 4-year-old girl suffering from an immune disorder.
- The first transgenic dairy cow-used to produce human milk proteins for infant formula-is created.
- First food product of biotechnology approved in U.K.: modified yeast.
- First field test of a genetically modified vertebrate: trout.

1992

- American and British scientists unveil a technique for testing embryos in vitro for genetic abnormalities such as cystic fibrosis and hemophilia.
- The FDA declares that transgenic foods are “not inherently dangerous” and do not require special regulation.

1993

- Merging two smaller trade associations creates the Biotechnology Industry Organization (BIO).
- FDA approves bovine somatotropin (BST) for increased milk production in dairy cows.

1994

- The Flavr-Savr tomato, designed to resist rotting, is approved by the FDA for sale in the United States.
- The first breast cancer gene is discovered.
- Approval of recombinant version of human DNase, which breaks down protein accumulation in the lungs of CF patients.
- BST commercialized as POSILAC bovine somatotropin.

1995

- The first Bt corn product, Event 176, receives commercial approval in the U.S.
- The first baboon-to-human bone marrow transplant is performed on an AIDS patient.
- The first full gene sequence of a living organism other than a virus is completed, for the bacterium Hemophilus influenzae.
- Gene therapy, immune system modulation and recombinantly produced antibodies enter the clinic in the war against cancer.

1995-1996

- Monsanto’s Roundup Ready® soybeans, which are resistant to herbicides, and YieldGard® Corn, which is protected from the corn borer, are approved for sale in the United States. Bollgard® cotton first commercialized in the U.S.

1996

- Novartis Bt 11, insect protected corn, receives approval for commercial sale in the U.S.
- Event 176 (corn borer resistance) receives approval for import into European Union.
- Posilac bovine somatotropin, designed to increase milk efficiency in dairy cattle, is approved for use in the United States.
- First commercial introduction of a ‘gene chip’ designed to rapidly detect variances in the HIV virus and select the best drug treatment for patients.
- The discovery of a gene associated with Parkinson’s disease provides an important new avenue of research into the cause and potential treatment of the debilitating neurological ailment.

1997

- Roundup Ready® cotton first commercialized in the US.
- First animal cloned from an adult cell: a sheep named Dolly in Scotland.
- First weed- and insect-resistant biotech crops commercialized: Roundup Ready soybeans and Bollgard insect-protected cotton.
- Biotech crops grown commercially on nearly 5 mil. acres worldwide: Argentina, Australia, Canada, China, Mexico and the United States.
- A group of Oregon researchers claims to have cloned two Rhesus monkeys.
- A new DNA technique combines PCR, DNA chips and a computer program to create a new tool in the search for disease-causing genes.

1998

- DEKALB markets the first Roundup Ready corn.
- YieldGard Corn is approved for import into European Union.
- New Zealand researchers produce Elsie, a clone of Lady, the last of the rare Enderby cattle line, thereby securing the future of the species.
- Embryonic stem cells are grown successfully, opening new doors to cell- or tissue-based therapies.
- New Zealand researchers develop the first genetically engineered radiata pine in the laboratory.
- University of Hawaii scientists clone three generations of mice from nuclei of adult ovarian cumulus cells.
- Human embryonic stem cell lines are established.
- Scientists at Japan’s Kinki

University clone eight identical calves using cells taken from a single adult cow.
- The first complete animal genome, for the C. elegans worm, is sequenced.
- A rough draft of the human genome map is produced, showing the locations of over 30,000 genes.
- Five Southeast Asian countries form a consortium to develop disease-resistant papayas.

1999
- President Clinton awards four Monsanto scientists National Medal Of Technology.
- A U.S. company announces the successful cloning of human embryonic cells from an adult skin cell.
- New Zealand researchers develop a new vaccine for bovine and human tuberculosis.
- Chinese scientists clone a giant panda embryo.

Also in the 1990s
- First conviction using genetic fingerprinting in the U.K.
- Isolation of gene that clearly participates in the normal process of regulating weight.
- Discovery that hereditary colon cancer is caused by defective DNA repair gene.
- Recombinant rabies vaccine tested in raccoons.
- Biotechnology based biopesticide approved for sale in the U.S.
- Patents issued for mice with specific transplanted genes.
- First European patent on a transgenic animal issued for transgenic mouse sensitive to carcinogens.
- Breast cancer susceptibility genes cloned.

2000
- First complete map of a plant genome developed: Arabidopsis thaliana.
- 108.9 mil. acres of biotech crops grown in 13 countries.
- "Golden Rice" announcement allows the technology to be available to developing countries in hopes of improving the health of undernourished people and preventing some forms of blindness.
- First biotech crop field-tested in Kenya: virus-resistant sweet potato.
- Rough draft of the human genome sequence is announced.

2001
- First complete map of the genome of a food plant completed: rice.
- Scientific journals publish complete human genome sequence.
- Researchers in Australia report developing a technique using "hairpin RNA" that vaccinates crop plants against viruses like Barley Yellow Dwarf Virus.
- Chinese National Hybrid researchers report developing a "super rice" that could produce double the yield of normal rice.
- The European Commission issues rules requiring the labeling of all foods and animal feed derived from GMOs.
- Complete DNA sequencing of the agriculturally important bacterium Sinorhizobium meliloti.
- A single gene from Arabidopsis inserted into tomato plants to create the first crop able to grow in salty water and soil.
- Genome sequence for Agrobacterium tumefaciens, important in agriculture, released.
- Researchers grow thale cress that lights up when it is damaged or stressed-a step toward developing hardier, stress-resistant crops.
- First comprehensive molecular map completed of the peanut.

2002
- The draft version of the complete map of the human genome is published, and the first part of the Human Genome Project comes to an end ahead of schedule and under budget.
- Biotech crops grown on 145 mil. acres in 16 countries, a 12 percent increase in acreage grown in 2001. Over one-quarter (27 percent) of the global acreage was grown in nine developing countries.
- Researchers announce successful results for a vaccine against cervical cancer, the first demonstration of a preventative vaccine for a type of cancer.
- Scientists complete the draft sequence of the most important pathogen of rice, a fungus that destroys enough rice to feed 60 mil. people annually. By combining an understanding of the genomes of the fungus and rice, scientists will elucidate the molecular basis of the interactions between the plant and pathogen.
- Researchers sequence the DNA of rice, the main food source for two-thirds of the world's population. It is the first crop to have its genome decoded.

2003
- Monsanto Mon 863 approved for commercial sale in the United States
- Liberty Link LL Cotton 25 approved for commercial sale in U.S.

2004
- Global plantings of biotech crops reach 200 million acres.
- European Union authorizes use of NK603, Roundup Ready corn for human consumption
- Univ. of Nebraska researcher develops soybean with healthier oil that could improve consumer health.

Information sources: Access Excellence, Genentech, Inc. Biotech 90: Into the Next Decade, G. Steven Burrill with the Ernst & Young High Technology Group, Biotechnology Industry Organization, International Food Information Council, ISB News Report, NC Biotechnology Center, TX Society for Biomedical Research.

GLOSSARY

A

Abiotic - Absence of living organisms.

Abiotic stress - Outside (nonliving) factors that can cause harmful effects to plants, such as soil conditions, drought, extreme temperatures.

Abscisic acid - A phytohormone implicated in the control of many plant responses to abiotic stress, such as extent of stomatal opening under water deficit (i.e. drought) conditions.

Acceptor control - The regulation of the rate of respiration by the availability of ADP as a phosphate acceptor.

Accessory bud - A lateral bud occurring at the base of a terminal bud or at the side of an axillary bud.

Acclimatization - The adaptation of a living organism (plant, animal or microorganism) to a changed environment that subjects it to physiological stress. Acclimatization should not be confused with adaptation.

Acquired - Developed in response to the environment, not inherited, such as a character trait (acquired characteristic) resulting from environmental effect(s).

Adaptation - Adjustment of a population to changes in environment over generations, associated (at least in part) with genetic changes resulting from selection imposed by the changed environment. Not acclimatization.

Adventitious - The presence of a small amount of seed from an unintended or unwanted variety that is comingled with the general supply.

Aerobe - A microorganism that grows in the presence of oxygen.

Aerobic - Active in the presence of free oxygen, e.g. aerobic bacteria that can live in the presence of oxygen.

Agricultural biotechnology (AgBio) - The application of rDNA technology to agriculturally important plants and organisms.

Agrobacterium rhizogenes - A bacterium that causes hairy root disease in some plants. Similar to the crown gall disease caused by Agrobacterium tumefaciens, this is achieved by the mobilization of the bacterial Ri plasmid with the transfer to the plant of some of the genetic material from the plasmid. This process has been used to insert foreign genes into plant cells, but to a lesser extent than the Agrobacterium tumefaciens-mediated transformation system, because regeneration of whole plants from hairy root cultures is problematical.

Agrobacterium tumefaciens - A bacterium that causes crown gall disease in some plants. The bacterium characteristically infects a wound, and incorporates a segment of Ti plasmid DNA into the host genome. This DNA causes the host cell to grow into a tumor-like structure that synthesizes specific opines that only the pathogen can metabolize. This DNA-transfer mechanism is exploited in the genetic engineering of plants.

Aleurone - The outermost layer of the endosperm in a seed, and the site of enzymes concerned with endosperm digestion during seedling growth.

Allele - A given form of a gene that occupies a specific position or locus on a chromosome. Variant forms of genes occurring at the same locus are said to be alleles of one another.

Allelopathy - The secretion of chemicals, such as phenolic and terpenoid comlbs, by a plant's roots, which inhibit the growth or reproduction of competitor plants.

Allergen - A protein or chemical responsible for producing allergic reactions. Allergens typically induce the production of the IgE immunoglobulin and the consequent release of histamine.

Allergy - A general term describing the immune response to nonpathogenic antigens, which leads to inflammation and the other effects common to this affliction.

Allogamy - Cross fertilization in plants.

Allopatric - In the context of natural populations of animals or plants, inhabiting distinct and separate areas.

Allopatric speciation - Speciation occurring at least in part because of geographic isolation.

Amphidiploid - A plant derived from doubling the chromosome number of an interspecific F1 hybrid. Naturally found hybrids of this sort are referred to as allopolyploid.

Amphimixis - True sexual reproduction involving the fusion of male and female gametes and the formation of a zygote.

Anabolism - One of the two subcategories of metabolism, referring to the building up of complex organic molecules from simpler precursors.

Anaerobe - An organism that can grow in the absence of oxygen.

Anaerobic - An environment or condition in which molecular oxygen is not available for chemical, physical or biological processes.

Anaerobic digestion - Digestion of materials in the absence of oxygen.

Anaerobic respiration - Respiration in which foodstuffs are partially oxidized, with the release of chemical energy, in a process not involving atmospheric oxygen. A notable example is in alcoholic fermentation, where sugar is metabolized into ethanol.

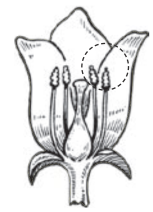
Analogous - Features of organisms or molecules that are superficially or functionally similar but have evolved in a different way or contain different comlbs.

Angiosperm - A division of the plant kingdom that includes all flowering plants, i.e. vascular plants in which double fertilization occurs resulting in development of fruit containing seeds. Divided into two major groups, monocotyledons and dicotyledons.

Annual - 1. (adj:) Taking one year, or occurring at intervals of one year. 2. A plant that completes its life cycle within one year.

Antagonism - An interaction between two organisms (e.g. moulds or bacteria) in which the growth of one is inhibited by the other.

Anther - The upper part of a stamen, containing pollen sacs within which the pollen develops and matures.


Anther

Anthesis - The period during which anthers bear mature and functional pollen.

Antibiosis - The prevention of growth or development of an organism by a substance or another organism.

Antibiotic resistance - The ability of a microorganism to disable an antibiotic or prevent its transport into the cell.

Antibiotic resistance marker gene (ARMG) - Genes (usually of bacterial origin) used as selection markers in transgenesis, because their presence allows cell survival in the presence of normally toxic antibiotic agents. These genes were commonly used in the development and release of first generation transgenic organisms (particularly crop plants), but are no longer favored because of perceived risks associated with the unintentional transfer of antibiotic resistance to other organisms.

Antigen - Any foreign molecule that stimulates an immune response in a vertebrate organism. Many antigens are proteins such as the surface proteins of foreign organisms.

Antinutrient - Comlbs that inhibit the normal uptake or utilization of nutrients.

Anti-oncogene - A gene whose product prevents the normal growth of tissue.

Antioxidant - Comlbs that slow the rate of oxidation reactions.

Antitranspirant - A compound designed to reduce plant transpiration. Applied to the leaves of newly transplanted trees, shrubs etc., or cuttings in lieu of misting. Can interfere with photosynthesis and respiration if the coating is too thick or is unbroken.

Apex - The portion of a root or shoot containing the primary or apical meristem.

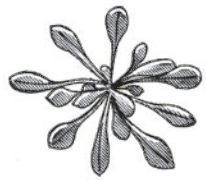

Apex

Apomixis - The production of an embryo in the absence of meiosis.

Apomictic - Higher plants produce asexual seeds, derived only from maternal tissue.

Apoptosis - The process of programmed cell death, which occurs naturally as a part of normal development, maintenance and renewal of tissue. Differs from necrosis, in which cell death is caused by external factors (stress or toxin).

Arabidopsis - A genus of flowering plants in the Cruciferae. A. thaliana is used in research as a model plant because it has a small fully sequenced genome, can be cultured and transformed easily, and has a rapid generation time.



Arabidopsis

Artificial selection - The practice of choosing individuals from a population for reproduction, usually because these individuals possess one or more desirable traits.

Asexual reproduction - Nonsexual means of reproduction, which can include grafting and budding.

Assortative mating - Mating in which the partners are chosen on the basis of phenotypic similarity.

Asymmetric hybrid - A hybrid formed, usually via protoplast fusion, between two donors, where the chromosome complement of one of the donors is incomplete. This chromosome loss can be induced by irradiation or chemical treatment, or can occur naturally.

Autonomous - A term applied to any biological unit that can function on its own, i.e. without the help of another unit, such as a transposable element that encodes an enzyme for its own transposition.

Autosome - A chromosome that is not involved in sex determination.

Autotroph - Organism capable of self-nourishment utilizing carbon dioxide or carbonates as the sole source of carbon and obtaining energy from radiant energy or from the oxidation of inorganic elements, or comlbs such as iron, sulphur, hydrogen, ammonium and nitrites.

Auxin - A group of plant growth regulators (natural or synthetic) which stimulate cell division, enlargement, apical dominance, root initiation, and flowering.

Avirulence gene (avr gene) - Many plants contain R genes, which confer simply inherited resistance to a specific pathogen race. The plants are able to recognize the presence of the pathogen by an interaction between their R gene and the matching pathogen's avirulence gene. Successful recognition triggers a cascade of further genes, often leading to a hypersensitive response.

Axillary bud - A bud found at the axil of a leaf.

Axillary bud

Axillary bud proliferation - Propagation of plant tissue in vitro to promote axillary growth, to generate large numbers of plantlets in culture.

B

Bacillus thuringiensis (Bt) - A bacterium that kills insects; a major component of the microbial pesticide industry. This is the basis of several corn borer control hybrids currently offered by seed companies.

Backcross - Crossing an organism with one of its parent organisms.

Barstar protein - A polypeptide inhibitor of barnase.

Basal - 1. Located at the base of a plant or a plant organ. 2. A fundamental formulation of a tissue culture medium containing nutrients but no growth promoting agents.

Basal factors - Components of the nucleus that associate with chromosomes and enhance gene transcription.

Base - One of the components of nucleosides, nucleotides and nucleic acids. Four different bases are found in naturally occurring DNA - the purines A (adenine) and G (guanine); and the pyrimidines C (cytosine) and T (thymine, the common name for 5-methyluracil). In RNA, T is replaced by U (uracil).

Base analogue - A non-natural purine or pyrimidine base that differs slightly in structure from the normal bases, but can be incorporated into nucleic acids. They are often mutagenic.

Base pair (bp) - A pair of complementary nitrogenous bases in a DNA molecule--adenine-thymine and guanine-cytosine. Also, the unit of measurement for DNA sequences.

Biennial - A plant that completes its life cycle within two years and then dies.

Binding - The ability of molecules to bind each other non-covalently because of the exact shape and chemical nature of parts of their surfaces. A common biological phenomenon, as e.g. an enzyme to its substrate; an antibody to its antigen; a DNA strand to its complementary strand.

Bio - A prefix used in scientific words to associate the concept of "living organisms."

Bioaugmentation - Increasing the activity of bacteria that decompose pollutants; a technique used in bioremediation.

Bioavailability - The proportion of a nutrient or administered drug etc. that can be taken up by an organism in a biologically effective form. For example, some soils high in phosphorus have a low level of P availability because the pH of the soil renders much of the P insoluble.

Biocatalysis - The use of enzymes to improve the efficiency of chemical reactions.

Bioethics - The branch of ethics that deals with the life sciences and their potential impact on society.

Biofuel - A gaseous, liquid or solid fuel derived from a biological source, e.g. ethanol, rapeseed oil or fish liver oil.

Biogas - A mixture of methane and carbon dioxide resulting from the anaerobic decomposition of waste such as domestic, industrial and agricultural sewage.

Bioinformatics - The use and organization of information of biological interest. In particular, concerned with organizing bio-molecular databases (particularly DNA sequences), utilizing computers for analyzing this information, and integrating information from disparate biological sources.

Biolistics - The introduction of genetic material directly into cells or tissues by shooting DNA-coated microparticles at high velocity directly at the target. The device utilized to perform the injection is referred to as a gene gun.

Biological invasion - The introduction of an organism into a new environment or geographical region that rapidly multiplies and spreads throughout the environment.

Bioluminescence - The enzyme-catalyzed production of light by a number of diverse organisms (e.g. fireflies and many deep ocean marine organisms). Utilized as a reporter gene in plant transgenesis, and for the detection of food-borne pathogenic bacteria.

Biomass - 1. The cell mass-produced by a population of living organisms. 2. The organic matter that can be used either as a source of energy or for its chemical components. 3. All the organic matter that derives from the photosynthetic conversion of solar energy.

Biome - A major ecological community or complex of communities, extending over a large geographical area and characterized by a dominant type of vegetation.

Biopesticide - A compound that kills organisms by virtue of specific biological effects.

Biopharming - The use of genetically transformed crop plants and livestock animals to produce valuable comlbs, especially pharmaceuticals.

Biopolymer - Any large polymer (protein, nucleic acid, polysaccharide) produced by a living organism. Includes some materials (such as polyhydroxybutyrate) suitable for use as plastics.

Biosafety - The avoidance of risk to human health and safety, and to the conservation of the environment, as a result of the use for research and commerce of infectious or genetically modified organisms.

Biosensor - A device that uses an immobilized biologically related agent (such as an enzyme, antibiotic, organelle or whole cell) to detect or measure a chemical compound. Reactions between the immobilized agent and the molecule being analyzed are converted into an electric signal.

Biosphere - The part of the earth and its atmosphere that is inhabited by living organisms.

Biosynthesis - Synthesis of comlbs by living cells, which is the essential feature of anabolism.

Biotechnology - The scientific manipulation of living organisms, especially at the molecular genetic level, to produce useful products. Gene splicing and use of recombinant DNA (rDNA) are major techniques used.

Biotic factor - Other living organisms that are a component of an organism's environment, and form the biotic environment, affecting the organism in many ways.

Biotoxin - A naturally produced compound that shows pronounced biological activity, toxic to some or many organisms.

Breeding - The process of sexual reproduction and production of offspring.

Bt - Abbreviation for Bacillus thuringiensis, a soil bacterium that produces toxins that are deadly to some insects.

Bt refuge - A separate area near a field planted to Bt corn that can successfully host European Corn Borer. The goal in planting a refuge is to provide an ample supply of susceptible European Corn Borer moths, greatly decreasing the odds that a resistant moth can emerge from a Bt field and choose another resistant moth for a mate.

Bud - A region of meristematic tissue with the potential for developing into leaves, shoots, flowers or combinations of these; generally protected by modified-scale leaves.

C

Callus (pl.: calli) - A protective tissue, consisting of parenchyma cells, that develops over a cut or damaged plant surface. 2. Mass of undifferentiated, thin-walled parenchyma cells induced by hormone treatment. 3. Actively dividing non-organized masses of undifferentiated and differentiated cells often developing from injury (wounding) or in tissue culture in the presence of growth regulators.

Cambial zone - Region in stems and roots consisting of the cambium and its recent derivatives.

Cambium (pl.: cambia) - A one or two cells thick layer of plant meristematic tissue, between the xylem and phloem tissues, which gives rise to secondary tissues, thus resulting in an increase in the diameter of the stem or root. The two most important cambia are the vascular (fascicular) cambium and the cork cambium.

Candidate gene - A gene whose deduced function (on the basis of DNA sequence) suggests that it may be involved in the genetic control of an aspect of phenotype.

Carotene - A reddish-orange plastid pigment involved in photosynthesis. A carotenoid and precursor of vitamin A.

Carotenoid - A group of chemically similar red to yellow pigments responsible for the characteristic color of many plant organs or fruits, such as tomatoes, carrots, etc. Oxygen-containing carotenoids are called xanthophylls. Carotenoids serve as light-harvesting molecules in photosynthetic assemblies and also play a role in protecting prokaryotes from the deleterious effects of light.

Carpel - Female reproductive organ of flowering plants, consisting of stigma, style and ovary.

Carrier - A heterozygous individual bearing a recessive mutant allele for a defective condition that is "masked" by the presence of the dominant normal allele; the phenotype is normal, but the individual passes the defective (recessive) allele to half of its offspring.

Catabolic pathway - A pathway by which an organic molecule is degraded in order to release energy for growth and other cellular processes.

Catalyst - A substance that promotes a chemical reaction by lowering the activation energy of a chemical reaction, but which itself remains unaltered at the end of the reaction.

Cauliflower mosaic virus 35S promoter (Abbreviation CaMV 35S) - A promoter sequence isolated from the ribosomal gene of the cauliflower mosaic virus.

Caulogenesis - Stem organogenesis; induction of shoot development from callus.

Cell - The basic unit of any living organism.

Cell culture - The in vitro growth of cells isolated from multi-cellular organisms.

Cell division - Formation of two or more daughter cells from a single parent cell. The nucleus divides first, followed by the formation of a cell membrane between the daughter nuclei. Division of somatic cells is termed mitosis; egg and sperm precursors are formed following meiosis.

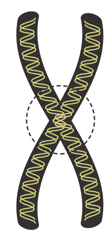
Cell fusion - Formation in vitro of a single hybrid cell from the coalescence of two cells of different species origin. In the hybrid cell, the donor nuclei may remain separate, or may fuse, but during subsequent cell divisions, a single spindle is formed so that each daughter cell has a single nucleus containing complete or partial sets of chromosomes from each parental line.

Cell line - 1. A cell lineage that can be maintained in vitro. Significant genetic changes can occur during lengthy periods in culture, so that the genotype of long-term cell lines may not be the same as that of the starter cell. 2. A cell lineage that can be recognized in vivo.

Cellulose - A complex polysaccharide composed of long linear chains of glucose residues. It comprises 40% to 55% by weight of the plant cell wall.

Centers of origin - Usually the location in the world where the oldest cultivation of a particular crop has been identified.

Centromere - The central portion of the chromosome to which the spindle fibers attach during mitotic and meiotic division.



Centromere

Chakrabarty decision - A landmark legal case in the U.S.A., in which it was held that the inventor of a new microorganism whose invention otherwise met the legal requirements for obtaining a patent, could not be denied a patent solely because the invention was alive. This has set the precedent for the patenting of life forms.

Channeling - Process to ensure grain with a specific trait or characteristic is directed into only approved markets. Channeling usually begins at harvest and continues through delivery to predetermined or approved markets. Channeling may include segregation from other grain. Grain channeled into a predetermined or approved market does not necessarily carry a premium, nor is there a certification process.

Chemical mutagen - A chemical capable of inducing mutations in living organisms.

Chimera (or chimaera) - 1. An organism whose cells are not all genotypically identical. This can occur as a result of: somatic mutation; grafting or because the individual is derived from two or more embryos or zygotes. 2. A recombinant DNA molecule that contains sequences from different organisms.

Chitin - A nitrogenous polysaccharide that gives structural strength to the exoskeleton of insects and the cell walls of fungi.

Chlorophyll - One of the two pigments responsible for the green color of most plants. It is an essential component of the machinery to absorb light energy for photosynthesis.

Chloroplast

Chloroplast - Specialized plastid that contains chlorophyll. Lens-shaped and bounded by a double membrane, chloroplasts contain membranous structures (thylakoids) piled up into stacks, surrounded by a gel-like matrix (stroma). They are the site of solar energy transfer and some important reactions involved in starch or sugar synthesis. Chloroplasts have their own DNA; these genes are inherited only through the female parent, and are independent of nuclear genes.

Chloroplast DNA - The DNA present in the chloroplast. Although the chloroplast has a small genome, the large number of chloroplasts per cell ensures that chloroplast DNA is a significant proportion of the total DNA in a plant cell.

Chlorosis - The appearance of yellow color in plants, due to the failure of development or the breakdown of chlorophyll. This is generally a symptom of either nutritional disturbance or of pathogen infection.

Chromatin - The chromosome as it appears in its condensed state, composed of DNA and associated proteins (mainly histones).

Chromatography - A method for separating the components of mixtures of molecules by partitioning them between two phases, one stationary and the other mobile. Appropriate selection of partitioning mechanism can produce separation of very closely related molecules.

Chromoplast - Plastid containing pigments other than chlorophyll.

Chromosomal aberration - An abnormal change in chromosome structure or number, including deficiency, duplication, inversion, translocation, aneuploidy, polyploidy, or any other change from the normal pattern. Although it can be a mechanism for enhancing genetic diversity, most alterations are fatal or debilitating, especially in animals.

Chromosome jumping - A technique that allows two segments of duplex DNA that are separated by thousands of base pairs (about 200 kb) to be cloned together. After sub-cloning, each segment can be used as a probe to identify cloned DNA sequences that, at the chromosome level, are roughly 200 kb apart.

Chromosome mutation - A change in the gross structure of a chromosome, usually causing severely deleterious effects in the organism, but can be maintained in a population . They are often due to meiotic errors. The main types of chromosome mutation are translocation, duplication and inversion.

Chromosome theory of inheritance - The theory that chromosomes carry the genetic information and that their behavior during meiosis provides the physical basis for segregation and independent assortment.

Chromosome walking - A strategy for mapping or sequencing a chromosome segment and for positional cloning. Large restriction fragments (or BAC clones) are generated and, after probing, a single starting point is identified. New probes are synthesized complementary to sequences of the same fragment (BAC clone) that are adjacent to the starting point, and these are then used to identify different restriction fragments (BAC clones) overlapping the one selected as the starting point. The procedure is used repetitively, working away from the starting point.

Clone - An exact genetic replica of a specific gene or an entire organism.

Cloned DNA - A collection of identical DNA fragments produced when DNA is replicated by insertion into a suitable bacterial or viral vector system.

Co-cloning - The unintentional cloning of DNA fragments, along with the desired one, that can occur when the source of DNA being cloned is not sufficiently purified.

Coding - The specification of a peptide sequence, by the code contained in DNA molecules.

Co-dominance - Where both alleles are expressed in the heterozygous state, so that the phenotype reflects a contribution from both alleles. For example, roan coat color in cattle results from a mixture of red hairs and white hairs, caused by heterozygosity for the red allele and the white allele.

Codon - A sequence of three adjacent nucleotides that designates a specific amino acid or start/stop site for transcription.

Coenzyme (cofactor) - An organic molecule, such as a vitamin, that binds to an enzyme and is required for its catalytic activity.

Co-evolution - The evolution of complementary adaptations in two species brought about by the selection pressure that each exerts on the other. Common in symbiotic associations, in insect-pollinated plants, etc.

Co-factor - An organic molecule or inorganic ion necessary for the normal catalytic activity of an enzyme.

Colony - A group of identical cells (clones) derived from a single progenitor cell.

Companion cell - A living cell associated with the sieve cell of phloem tissue in vascular plants.

Comparative mapping - The comparison of map locations of genes and markers between species. In comparisons between closely related species, this will usually uncover a high degree of conservation of synteny and co-linearity. In these cases, the likely location of many genes can be predicted from model system data. Comparisons across wider phylogenetic distances reveal increasing loss of synteny.

Complementary - Two DNA molecules are complementary to one another when each successive base position from the 5' end in the first molecule is matched by the corresponding residue in the second, starting at the 3' end, according to the normal base pair rules (i.e. A for T, C for G). In the appropriate conditions, two complementary single-stranded DNA molecules will renature to form a double-stranded molecule. Complementary nucleotides are members of the pairs adenine-thymine, adenine-uracil, and guanine-cytosine that have the ability to hydrogen bond to one another.

Complementary DNA (cDNA) - A DNA strand synthesized in vitro from a mature RNA template using reverse transcriptase. DNA polymerase is then used to create a double-stranded molecule. Differs from genomic DNA by the absence of introns.

Conditional lethal mutation - A mutation that is lethal under one set of environmental conditions (the restrictive conditions, commonly associated with high temperature) but is viable under another set of environmental conditions (the permissive conditions).

Conditioning - 1. The effects on phenotypic characters of external agents during critical developmental stages. 2. The undefined interaction between tissues and culture medium resulting in the growth of single cells or small aggregates. Conditioning may be accomplished by immersing cells or callus contained within a porous material (such as dialysis tubing) into fresh medium for a period dependent on cell density and a volume related to the amount of fresh medium.

Consensus sequence - The part of a gene or signal sequence that is shared over a wide range of members of a gene family, both within a given species, and in comparisons between species.

Constitutive gene - A gene that is continually expressed in all cells of an organism.

Constitutive synthesis - Continual synthesis of a gene product by an organism.

Construct - An engineered chimeric DNA designed to be transferred into a cell or tissue. Typically, the construct comprises the gene or genes of interest, a marker gene and appropriate control sequences as a single package. A repeatedly used construct may be called a cassette.

Containment - Measures and protocols applied to limit contact of genetically modified organisms or pathogens with the external environment.

Contig - A set of overlapping cloned DNA fragments that can be assembled to represent a defined region of the chromosome or genome from which they were obtained. Contig definition is a necessary step for assembling whole genome sequences.

Contiguous (contig) map - The alignment of sequence data from large, adjacent regions of the genome to produce a continuous nucleotide sequence across a chromosomal region.

Controlling element - A genetic region, such as a promoter or operator, that can respond to an external signal and decide whether its associated gene should or should not be transcribed.

Convention on Biological Diversity (CBD) - The international treaty governing the conservation and use of biological resources around the world, that has also called for the establishment of rules to govern the international movement of non-indigenous living organisms and genetically modified organisms.

Copy number - The number of a particular plasmid per bacterium cell, or gene per genome.

Cortex - Primary tissue of a stem or root, bounded externally by the epidermis and internally in the stem by the phloem, and in the root by the pericycle.

Co-suppression - A natural gene silencing phenomenon, which probably evolved as part of plants' defense against viral attack, but which has become important in the context of plant transgenesis. Operates by inhibiting the expression of transgenes with homology to native DNA through the interaction of native and transgenic mRNA.

Cotyledon - Leaf-like structures at the first node of the seedling stem. In some dicotyledons, they represent a food storage organ for the germinating seedling.

Coupling - The phase state in which either two dominant or two recessive alleles of two different genes occur on the same chromosome.

Cross - The mating of two individuals or populations.

Cross pollination efficiency - The ease with which cross-pollination can be achieved. Generally measured by the number of hybrid progeny generated per flower pollinated.

Crown - The base of the stem of cereals and forage species from which tillers or branches arise. In woody plants, the root-stem junction. In forestry, the top portion of the tree.

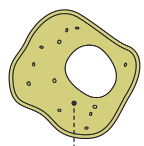
Crown

Crown gall - A tumorous growth at the base of certain plants characteristic of infection by Agrobacterium tumefaciens. The gall is induced by the transformation of the plant cell by portions of the Ti plasmid.

Cry - Designation of gene encoding insecticidal crystal proteins in the soil bacterium Bacillus thuringiensis.

Cultigen - A cultivated plant species with no known wild progenitor.

Cultivar (cv) - An internationally accepted term denoting a variety of a cultivated plant. Must be distinguishable from other varieties by stated characteristics and must retain their distinguishing characters when reproduced under specific conditions.
Culture - A population of plant or animal cells or microorganisms grown under controlled conditions.
Culture medium - Any nutrient system for the cultivation of cells, bacteria or other organisms; usually a complex mixture of organic and inorganic nutrients.
Cuticle - Layer of cutin or wax, formed on the outer surface of leaves and fruits, thought to have evolved to reduce evaporative water loss.
Cutting - A detached plant part that, with appropriate treatment, can regenerate into a complete plant.
Cytogenetics - Study that relates the appearance and behavior of chromosomes to genetic phenomenon.
Cytokinesis - Cytoplasmic division and other changes exclusive of nuclear division that are a part of mitosis or meiosis.
Cytokinin - Plant growth regulators characterized as substances that induce cell division and cell differentiation. In tissue culture, these substances are associated with enhanced callus and shoot development. The comlbs are derivatives of adenine.
Cytology - The study of the structure and function of cells.
Cytoplasm - The living material of the cell, exclusive of the nucleus, consisting of a complex protein matrix or gel, and where essential membranes and cellular organelles (mitochondria, plastids, etc.) reside.



Cytoplasmic genes - Genes located on DNA outside the nucleus, i.e. on plastids.
Cytoplasmic inheritance - Hereditary transmission dependent on cytoplasmic genes.
Cytoplasmic male sterility - Genetic defect due to faulty functioning of mitochondria in pollen development, preventing the formation of viable pollen. Commonly found or inducible in many plant species and exploited for some F1 hybrid seed programs.
Cytotoxicity - Poisoning of the cell.

D

Defined - 1. Fixed conditions of medium, environment and protocol for growth. 2. Precisely known and stated elements of a tissue culture medium.
Deletion - A mutation involving the removal of one or more base pairs in a DNA sequence.
Denature - To induce structural alterations that disrupt the biological activity of a molecule. Often refers to breaking hydrogen bonds between base pairs in double-stranded nucleic acid molecules to produce in single-stranded polynucleotides or altering the secondary and tertiary structure of a protein, destroying its activity.
Determination - Process by which undifferentiated cells in an embryo become committed to develop into specific cell types, such as neurons, fibroblasts or muscle cells.
Dicotyledon (dicot) - A plant with two cotyledons. One of the two major classes of flowering plants (along with the monocotyledons). Examples include many crop plants (potato, pea, beans), ornamentals (rose, ivy) and timber trees (oak, beech, lime).
Differentiation - The process in which cells of uncommitted function develop into specialized cells with a specific function. For example, B cells differentiate into antibody-producing plasma cells, and stem cells differentiate into T cells.
Dihybrid - An individual that is heterozygous for two pairs of alleles; the progeny of a cross between homozygous parents differing at two loci.
Dimorphism - The existence of two distinctly different types of individuals within a species. An obvious example is sexual dimorphism in mammals.
Dioecious - A plant species in which male and female flowers form on different plants.
Diploid - A species having two complete sets (pairs) of chromosomes. Humans and most mammals are diploid in their genome organization, but many plants and lower animals have only a haploid set of chromosomes. Diploidy probably evolved to provide an additional degree of redundancy and safety to the genomes of higher organisms.
Disomy - The presence of a pair of a specific homologous chromosomes. This is the norm for diploids.
Disrupter gene - Used to enforce the sterility of seed saved from a genetically engineered crop.
DNA (Deoxyribonucleic Acid) - The chemical that forms the basis of the genetic material in virtually all living organisms. Structurally, DNA is composed of two strands that intertwine to form a spring-like structure called the double helix. Each strand is formed by a backbone of deoxyribose sugar molecules linked by phosphate residues. Attached to each backbone are chemical structures called bases, which protrude away from the backbone towards the center of the helix, and which come in four types - Adenine, Cytosine, Guanine, and Thymine (designated A, C, G and T). In DNA a C can only hydrogen bond with a G, and an A only with a T, these interactions, formed by so called hydrogen

bonds, hold the two strands together. Each strand of DNA has a series of Gs, As, Ts and Cs attached to its backbone. It is the sequence of these bases that forms the code that is translated by cellular machinery to create a new protein. The other (complementary or antisense) strand always has a sequence that matches the first strand, with each C complemented by a G, and each A by a T, and vice versa.

DNA amplification - Many-fold multiplication of a particular DNA sequence either in vivo in a plasmid, phage or other vector; or most commonly, in vitro using the polymerase chain reaction.

DNA clocks - Genes that control circadian rhythms in a variety of organisms. First identified in fruit flies.

DNA construct - A chimeric DNA molecule, carrying all the genetic information necessary for its transgenic expression in a host cell.

DNA hybridization - The annealing of two single-stranded DNA molecules, possibly of different origin, to form a partial or complete double helix. The degree of hybridization varies with the extent of complementarity between the two molecules, and this is exploited to test for the presence of a specific nucleotide sequence in a DNA sample.

Dominant - A gene that expresses itself in the presence of its allele. Any genetic trait that is expressed when present as a single allele.

Dominant marker selection - Selection of cells via a gene encoding a product that enables only the cells that carry the gene to grow under particular conditions. For example, plant and animal cells that express the introduced neor gene are resistant to neomycin and analogous antibiotics, while cells that do not carry neor are killed.

Down-regulate - To induce genetically a reduction in the level of a gene's expression.

Duplication - Multiple occurrence of: 1. A DNA sequence within a defined length of DNA; or 2. A specific segment in the same chromosome or genome.

E

Embryonic stem cells (ES cells) - Cells of the early embryo that can give rise to all differentiated cells, including germ line cells.

Encode - The gene product specified by a particular nucleic acid sequence.

Endemic - Describing an organism, often a disease or pest, that is always present in a stated area.

Endocytosis - The process by which cells capture and encapsulate foreign particles.

Endodermis - The layer of living cells, with various characteristically thickened walls and no intercellular spaces, which surrounds the vascular tissue of certain plants and occurs in nearly all roots and certain stems and leaves. It separates the cortical cells from cells of the pericycle.

Endogenous - Derived from within; from the same cell type or organism.

Endomitosis - Duplication of chromosomes without division of the nucleus, resulting in a doubling (or more) in the chromosome number within a cell.

Endophyte - An organism that lives inside a plant.

Endoreduplication - Chromosome reproduction during interphase. Four-chromatid chromosomes (diplochromosomes) are seen during this phase.

Endosperm - The nutritive tissue that develops in the seed of most angiosperms, containing varying proportions of carbohydrate (usually starch), protein and lipid. In most diploid plants, the endosperm is triploid.

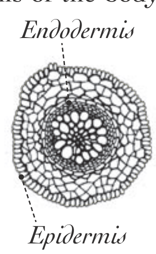
Enolpyruvyl-shikimate-3-phosphate synthase (EPSP synthase or EPSPS) - An enzyme produced by virtually all plants, which is essential for normal metabolism, and for the biosynthesis of aromatic amino acids. Glyphosate- and sulfosate-containing herbicides act by inhibiting EPSP synthase activity, but because strain CP4 of Agrobacterium sp. is unaffected by glyphosate, the introduction of the CP4 EPSPS gene into crop plants generates a tolerance of glyphosate-containing herbicides.

Enzyme - Protein that controls the various steps in all chemical reactions.

Enzyme kinetics - The quantitative characteristics of enzyme reactions.

Enzyme-Linked ImmunoSorbent Assay (ELISA) - An assay where an enzyme that catalyzes a colorimetric reaction is linked to an antibody and the complex is used to measure the amount of antibody bound to a hapten (determined by measuring the intensity of the color produced).

Epidermis - 1. The outmost layer of cells of the body of an animal. In invertebrates the epidermis is normally only one cell thick and is covered by an impermeable cuticle. In vertebrates the epidermis is the thinner of the two layers of skin. 2. The outermost layer of cells covering a plant. It is overlaid by a cuticle and its functions are principally to protect the plant from injury and to reduce water loss. Some epidermal cells are modified to form guard cells or hairs of various types. In woody plants the functions of the shoot epidermis are taken over by the periderm tissues and in mature roots the epidermis is sloughed off and



replaced by the hypodermis.

Epigenesis - Describes the developmental process whereby each successive stage of normal development is built up on the foundations created by the preceding stages of development; an embryo is built up from a zygote, a seedling from an embryo, and so on.

Epigenetic variation - Non-hereditary and reversible variation; often the result of a change in gene expression due to methylation of DNA.

Epiphyte - A plant that grows upon another plant, but is neither parasitic on it nor rooted in the ground.

Essential amino acid - An amino acid required for normal metabolism, but which cannot be synthesized by an organism. It therefore has to be supplied via feed or food.

Essential element - Any of a number of elements required by living organisms to ensure normal growth, development and maintenance.

Ethylene - A gaseous plant growth regulator acting on various aspects of vegetative growth, fruit ripening and abscission of plant parts.

Eukaryote - An organism whose cells possess a nucleus and other membrane-bound vesicles, including all members of the protist, fungi, plant and animal kingdoms; and excluding viruses, bacteria, and blue-green algae.

Euploid - An organism or cell having a chromosome number that is an exact multiple of the haploid number. Terms used to identify different levels in an euploid series are diploid (2x), triploid (3x), tetraploid (4x) etc.

Excision - 1. The natural or in vitro enzymatic removal of a DNA segment from a chromosome or cloning vector. 2. The cutting out and preparation of a tissue, organ, etc., for culture. 3. The removal of adventitious shoots from callus tissue.

Exogenous - Produced outside of; originating from, or due to, external causes.

Exotoxin - A toxin released by a bacterium into the medium in which it grows.

Explant - A portion of a plant aseptically excised and prepared for culture in a nutrient medium.

Explant donor - The plant from which an explant has been taken.

Explantation - The removal of cells, tissues or organs of animals and plants for observation of their growth and development in appropriate culture media.

Explosion method - A technique for the genetic transformation of cells, in which the transgene is driven into the target (plant) cells by the sudden vaporization (effected by the application of a pulse of high voltage) of a water droplet containing the DNA and gold particles.

Express - To translate a gene's message into a molecular product.

Expression (gene or protein) - A measure of the presence, amount, and time-course of one or more gene products in a particular cell or tissue. Expression studies are typically performed at the RNA (mRNA) or protein level in order to determine the number, type, and level of genes that may be up-regulated or down-regulated during a cellular process, in response to an external stimulus, or in sickness or disease. Gene chips and proteomics now allow the study of expression profiles of sets of genes or even entire genomes.

Expression profile - The level and duration of expression of one or more genes, selected from a particular cell or tissue type, generally obtained by a variety of high-throughput methods, such as sample sequencing, serial analysis, or microarray-based detection.

Expression system - Combination of host and vector that provides a genetic context for making a cloned gene functional, i.e. produce peptide, in the host cell.

Extrachromosomal - In eukaryotes, non-nuclear DNA, present in cytoplasm organelles such as mitochondria and chloroplasts. In prokaryotes, non-chromosomal DNA, i.e. plasmids.

Extremophiles - Bacteria or other organisms that grow under extreme conditions such as high temperature. These bacteria are found in volcanoes, hot springs, or conditions of high acidity or basicity, and are often the source of useful stable proteins that have evolved under such conditions e.g. Taq polymerase, which is used in PCR.

F

Farmer privilege - Rights to hold germ plasm, covered by plant variety protection, as a seed source for subsequent seasons. Considered as optional for governments to include in their legislation.

Farmers rights - Rights first recognized by Resolution 5 of the 1989 FAO Conference as "rights arising from the past, present and future contributions of farmers in the conservation, improvement and the making available of plant genetic resources"; this item became an attachment to the 'International Undertaking on Plant Genetic Resources'. The binding 'International Treaty of Plant Genetic Resources for Food and Agriculture' that resulted from the renegotiations of the Undertaking makes provision for the Farmers' Rights in Article 9.

Fermentation - The anaerobic breakdown of complex organic substances, especially carbohydrates, by microorganisms, yielding energy. Often misused to describe large-scale aerobic cell culture in specialized vessels (fermenters, bioreactors) for secondary product synthesis.

Fibrous root - Root system in which both primary and lateral roots have approximately equal diameters.

Field Trial - Test of the ability of a new crop variety to perform under normal cultivation conditions.

Fission - Asexual reproduction involving the division of a single-celled individual into two daughter single-celled individuals of approximately equal size.

Fitness - The survival value and the reproductive capability of an individual, compared to that of competitor individuals of the same or other species within a population or an environment.

Fixation - The situation in which only one allele for a given gene/locus is present in a population. This can occur as a result of direct selection where the allele delivers a greater level of fitness; because of indirect selection, where the locus is linked to a gene that is subject to direct selection; or because of genetic drift.

Food biotechnology - Food biotechnology is an extension of the age-old practice of creating new crops by combining existing plants to make them better. These traditional techniques have created crops like wheat, a hybrid of three separate grasses that help feed the world today. This practice of combining existing plants created seedless watermelons and grapes. And food biotechnology allows researchers to continue to improve food and crops by selectively giving plants new qualities, such as more vitamins or minerals.

Founder principle - The possibility that a new, isolated population, initiated by a small number of individuals taken from a parent population, may be genetically different from the parent population, because the founding individuals might not be typical of the parent population.

Free-living conditions - Natural or greenhouse conditions experienced by plantlets upon transfer from in vitro conditions to soil. Prior to transfer, nutrients were supplied by the culture medium, but following transfer, plantlets must take up nutrients from soil and synthesize their own food supply.

Functional food - A foodstuff that provides a health benefit beyond basic nutrition, demonstrating specific health or medical benefits, including the prevention and treatment of disease.

Functional genomics - The use of genetic technology to determine the function of newly discovered genes by determining their role in one or more model organisms. Functional genomics uses as its starting point the isolated gene whose function is to be determined, and then selects a model organism in which a homolog of that gene exists. This model organism can be as simple as a yeast cell or as complex as a nematode worm, fruit fly, or even a mouse. The gene is selectively inactivated or "knocked out" using a variety of genetic techniques, and the effect of its selective deletion on that organism is determined. By knocking out a gene in this way, its contribution to the function of the organism (and, by implication, its function in man), can be determined. Functional genomics has proven particularly useful as a means of validating or testing novel therapeutic targets. In another approach, a whole set of genes may be systematically inactivated and the effect of this on a particular cellular function examined. Here, a new gene and its function are identified simultaneously.

G

Gall - A tumorous growth in plants.

Gamete - The mature male or female reproductive cell (sperm or ovum) possessing the haploid number of chromosomes (23 in humans).

Gametophyte - The phase of the plant life cycle that carries the gamete producing organs. In flowering plants, the pollen grain is the male gametophyte and the embryo sac is the female gametophyte.

Gametophytic incompatibility - A phenomenon in plants, in which a pollen grain is genetically incapable of fertilizing a particular egg, because both gametes carry the identical allele at an incompatibility locus (usually denoted S). This is a mechanism for forcing cross-fertilization.

GEM - Abbreviation for genetically engineered microorganism.

GenBank - Data bank of genetic sequences operated by a division of the National Institutes of Health.

Gene - The basic unit of heredity; the sequence of DNA that encodes all the information to make a protein. Structurally, a gene is formed by three regions: a regulatory region called the promoter juxtaposed to the coding region containing the protein sequence, and a "3' tail" sequence. In mammalian cells, the promoter is a complex region containing binding sites for many proteins that regulate gene expression. A gene may be "activated" or "switched on" to make protein – this activation is referred to as gene expression - by these proteins which control when, where and how much protein is expressed from the gene. In the human genome, there are an estimated 30,000 to 40,000 genes. Some of these are evolutionarily related and form "gene families" that express related proteins. There are also genes that no longer make a protein; these defective remnants of evolution are called pseudogenes.

Gene activation - The induction of transcription from a gene.

Gene amplification - The presence of multiple genes. Amplification is one mechanism through which proto-oncogenes are activated in malignant cells.

Gene conversion - A process, often associated with recombination, during which one allele is replicated at the expense of another, leading to non-Mendelian segregation ratios.

Gene deletion - The total loss or absence of a gene.

Gene expression - The conversion of information from gene to protein via transcription and translation.

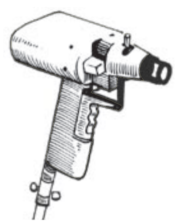
Gene families - Subsets of genes containing homologous sequences that usually correlate with a common function.

Gene flow - The exchange of genes between different but (usually) related populations.

Gene frequency - The percentage of a given allele in a population of organisms.

Gene guns - Device used for firing microparticles into cells or tissue.

Gene imprinting - The differential expression of a single gene according to its parental origin.



Gene gun

Gene index - A listing of the number, type, label and sequence of all the genes identified within the genome of a given organism. Gene indices are usually created by assembling overlapping EST sequences into clusters, and then determining if each cluster corresponds to a unique gene. Methods by which a cluster can be identified as representing a unique gene include identification of long open reading frames (ORFs), comparison to genomic sequence, and detection of SNPs or other features in the cluster that are known to exist in the gene.

Gene insertion - The addition of one or more copies of a normal gene into a defective chromosome.

Gene interaction - The modification of the action of one gene by another, non-allelic gene.

Gene linkage - The hereditary association of genes located on the same chromosome.

Gene mapping - The construction of a localized (around a gene) or broad-based (whole genome) genetic map. More generally, determining the location of a locus (gene or genetic marker) on a chromosome.

Gene pool - 1. The sum of all genetic information in a breeding population at a given time. 2. In plant genetic resources, use is made of the terms 'primary', 'secondary' and 'tertiary' gene pools. In general, members of the primary gene pool are inter-fertile; those of the secondary can be crossed with those in the primary gene pool under special circumstances; but to introgress variation from the tertiary gene pool, special techniques are required to achieve crossing.

Gene product - The product, either RNA or protein, that results from expression of a gene. The amount of gene product reflects the activity of the gene.

Gene regulation - The process of controlling the synthesis or suppression of gene products in specific cells or tissues.

Gene replacement - The incorporation of a transgene into a chromosome at its normal location by homologous recombination, thus replacing the copy of the gene originally present at the locus.

Gene splicing - Combining genes from different organisms into one organism.

Gene stacking - The process of inserting two or more different genes into an organism.

Gene targeting - The selective inactivation of a gene. This strategy is used to delineate the function of a gene.

Gene therapy - The technology that uses genetic material for therapeutic purposes. This genetic material can be in the form of a gene, a representative of a gene or cDNA, RNA or even a small fragment of a gene. The introduced genetic material can be therapeutic in several ways: It can make a protein that is defective or missing in the patient's cells (as would be the case for a genetic disorder), or one which will correct or modify a particular cellular function, or a protein that elicits an immune response. In gene therapy approaches, the genetic material may be introduced into the patient in several different ways. It can be directly injected for some applications in a process known as genetic vaccination, or it can be introduced by using bioengineered viruses that will carry the therapeutic gene as part of their own genetic cargo and deliver it into the cell. The viruses that are commonly used for this purpose are adenovirus, adeno-associated virus (AAV), retrovirus, lentivirus and herpes virus. Reagents known as liposomes can also carry therapeutic genes into cells.

Gene tracking - Following the inheritance of a particular gene from generation to generation.

Gene translocation - The movement of a gene from one chromosomal location to another.

Generally regarded as safe (GRAS) - Designation given to foods, drugs, and other materials with a long-term history of not causing illness to humans, even though formal toxicity testing may not been conducted. Certain host organisms for recombinant DNA experimentation have recently been given this status.

Genetic - Inherited; having to do with information that is passed from parent to offspring through DNA.

Genetic assimilation - Eventual extinction of a natural species as massive gene flow occurs from a related species.

Genetic code - The three-letter code that translates nucleic acid sequence into protein sequence. The relationships between the nucleotide base-pair triplets of a messenger RNA molecule and the 20 amino acids that are the building blocks of proteins.

Genetic complementation - When two DNA molecules that are in the same cell together produce a function that neither DNA molecule can supply on its own.

Genetic distance - A measure of the genetic similarity between any pair of populations. This is measured on the basis of variation in a combination of phenotypic traits, allele frequencies or DNA sequences. For example, the genetic distance between two populations having the same allele frequencies at a particular locus, and based solely on that locus, is zero.

Genetic diversity - The heritable variation within and among populations which is created, enhanced or maintained by evolutionary or selective forces.

Genetic drift - Random variation in gene frequency from one generation to another.

Genetic engineering - The manipulation of an organism's genetic endowment by introducing or eliminating specific genes through modern molecular biology techniques. A broad definition of genetic engineering also includes selective breeding and other means of artificial selection.

Genetic equilibrium - The maintenance of a steady state with respect to allele frequencies in a group of interbreeding organisms.

Genetic erosion - The loss over time of allelic diversity, particularly in farmed organisms, caused by either natural or man-made processes.

Genetic gain - The increase in productivity achieved following a change in gene frequency effected by selection.

Genetic imprinting - The different expression patterns exhibited by a single gene; the differential expression is modulated by the differential methylation of cytosine residues (inherited from each parent) near the promoter of that gene.

Genetic linkage map - A linear map of the relative positions of genes along a chromosome. Distances are established by linkage analysis, which determines the frequency at which two gene loci become separated during chromosomal recombination.

Genetic map - The linear array of genes on a chromosome, based on recombination frequencies (linkage map) or physical location (physical or chromosomal map).

Genetic marker - A gene or group of genes used to "mark" or track the action of microbes.

Genetic pollution - Uncontrolled spread of genetic information (frequently referring to transgenes) into the genomes of organisms in which such genes are not present in nature.

Genetic resources - Genetic material of actual or potential value.

Genetic selection - The process of selecting genes, cells, clones, etc., within populations or between populations or species. Genetic selection usually results in differential survival rates of the various genotypes, reflecting many variables, including the selection pressure and genetic variability present in populations.

Genetic use restriction technology (GURT) - A proposed technology applying transgenesis to genetically compromise the fertility or the performance of saved seed of a cultivar or of second generation animals. The intention is to protect the market for the seed producer or to prevent undesired escape of genes. Two types of GURTs have been patented: variety-level GURT (V-GURT), which produces sterile progeny, and trait-specific GURT (T-GURT), in which only the added value transgenic trait is genetically protected.

Genetic variation - Differences between individuals attributable to differences in genotype.

Genetically engineered organism (GEO) - Occasional alternative term for genetically modified organism.

Genetically enhanced - The industry recognized term to describe a beneficial plant trait that has been inserted into the plant genome, which under natural conditions would not occur.

Genetically modified (GM) - See GMO.

Genetically modified organism (GMO) - An organism that has been transformed by the insertion of one or more transgenes.

Genetics - The science of heredity. In production agriculture and biotechnology, genetics is the foundation for all plant variety development.

Genome - The complete genetic content of an organism.

Genomic library - A library composed of fragments of genomic DNA.

Genomics - The analysis of the entire genome of a chosen organism.

Genotype – A group or class of organisms having the same genetic makeup.

Germ - 1.The botanical term for a plant embryo. 2. Colloquial: a disease-causing microorganism.

Germ plasm - 1. An individual, group of individuals or a clone representing a genotype, variety, species or culture, held in an in situ or ex situ collection. 2. Original meaning, now no longer in use: the genetic material that forms the physical basis of inheritance and which is transmitted from one generation to the next by means of the germ cells.

Gibberellins - A class of plant growth regulators which are active in the elongation, enhancement of flower, fruit and leaf size, germination, vernalization and other physiological processes.

Glucosinolates - A class of molecules produced in the seeds and green tissue of a range of plants, in particular brassicas. Their natural role is thought to be involved in plant-insect interactions. Their importance in plant breeding is largely because of their negative influence on taste and their positive effect on the prevention of cancers of the alimentary tract.

Glyphosate - An active ingredient in some herbicides, killing plants by inhibiting the activity of plant enolpyruvyl-shikimate 3-phosphate synthase.

Glyphosate oxidase - An enzyme which catalyses the breakdown of glyphosate, discovered in a strain of Pseudomonas bacteria which were found to produce unusually large amounts of the enzyme. The gene responsible has been incorporated into a variety of crop plants to enable them to tolerate applications of glyphosate-containing herbicides.

Glyphosate oxidoreductase - An enzyme from the microorganism Ochrobactrum anthropi, which catalyses the breakdown of glyphosate. If the encoding gene (called goxv247) is inserted and properly expressed in a plant, these plants become tolerant of the application of glyphosate- and/or sulfosate-containing herbicides.

Golden rice - A biotechnology-derived rice, which contains beta carotene (a precursor of vitamin A) in its seeds. Achieved by inserting two genes from daffodil and one from the bacterium Erwinia uredovora.

Green revolution - Name given to the dramatic increase in crop productivity during the third quarter of the 20th century, as a result of integrated advances in genetics and plant breeding, agronomy, and pest and disease control.

Growth factor - A serum protein that stimulates cell division when it binds to its cell-surface receptor.

Guard cell - Specialized epidermal cells found in pairs around a stoma. Their function is to control the opening and closing of the stoma through changes in turgor.

Gymnosperm - A class of plant (e.g. conifers) whose ovules and the seeds into which they develop are borne unprotected, rather than enclosed in ovaries, as are those of the flowering plants, the (angiosperms).

H

Hairy root (culture) disease - A disease of broad-leaved plants, where a proliferation of root-like tissue is formed from the stem. Hairy root disease is a tumorous state similar to crown gall, and is induced by the bacterium Agrobacterium rhizogenes, when containing an Ri plasmid.

Halophyte - A plant species adapted to soils containing a concentration of salt that is toxic to most plant species.

Haploid - A cell or organism containing only one set of chromosomes without the homologous pairs.

Heredity - Resemblance among individuals related by descent; transmission of traits from parents to offspring.

Heritability - The degree to which a given trait is controlled by inheritance, as opposed to being controlled by non-genetic factors.

Heterologous - From a different source.

Heterotroph - Organism noncapable of self-nourishment utilizing carbon dioxide or carbonates as the sole source of carbon and obtaining energy from radiant energy or from the oxidation of inorganic elements, or comlbs such as iron, sulphur, hydrogen, ammonium and nitrites.

Heterozygote - An individual with non-identical alleles for a particular gene or genes. The condition is termed "heterozygous".

Homoeologous - Referring to chromosomes which are descended from a common progenitor, but which have evolved to be no longer fully homologous. Homoeologous chromosomes have similar gene content to one another, but are structurally altered in subtle ways to inhibit, and sometimes completely prevent their pairing with one another at meiosis.

Homologous - Strictly, corresponding genetic loci. Commonly, a term describing two or more genes or alleles sharing a significant degree of similarity in their respective DNA sequences.

Homologous chromosomes - Chromosomes that have the same linear arrangement of genes--a pair of matching chromosomes in a diploid organism.

Homology - 1. The degree of identity between individuals, or characters. 2. The degree of identity of sequence (nucleotide or amino acid) between a number of DNA or polypeptide molecules.

Homozygote - An organism whose genotype is characterized by two identical alleles of a gene.

Host - An organism that contains another organism.

Host-specific toxin - A metabolite, produced by a pathogen, and which is responsible for the adverse effects of the pathogen. The toxin has a host specificity equivalent to that of the pathogen. Utilized for in vitro selection experiments to screen for tolerance or resistance to the pathogen.

Housekeeping genes - Genes that are always expressed (i.e. they are said to be constitutively expressed) due to their constant requirement by the cell.

Hybrid - The offspring of two parents differing in at least one genetic characteristic (trait). Also, a heteroduplex DNA or DNA-RNA molecule.

Hybrid dysgenesis - Infertility and an increased incidence of chromosome mutations thought to be caused by the activation of transposons.

Hybrid seed - 1. Seed produced by crossing genetically dissimilar parents. 2. In plant breeding, used colloquially for seed produced by specific crosses of selected pure lines, such that the F1 crop is genetically uniform and displays hybrid vigor. As the F1 plants are heterozygous with respect to many genes, the crop does not breed true and so new seed must be purchased each season.

Hybrid selection - The process of choosing individuals possessing desired characteristics from among a hybrid population.

Hybrid vigor - The extent to which a hybrid individual outperforms both its parents with respect to one or many traits. The genetic basis of hybrid vigor is not well understood, but the phenomenon is widespread, particularly in inbreeding plant species.

Hybridization - 1. The process of forming a hybrid by cross pollination of plants or by mating animals of different types. 2. The production of offspring of genetically different parents, normally from sexual reproduction, but also asexually by the fusion of protoplasts or by transformation. 3. The pairing of two DNA strands, often from different sources, by hydrogen bonding between complementary nucleotides.

Hypomorph - A mutation that reduces, but does not completely abolish gene expression.

I

Identity preserved (IP) - The process of managing a product so that 1) the product does not become unintentionally commingled with unlike product, 2) the product's history through the process is documented and 3) intrinsic or management-related product characteristics may be capitalized upon or marketed. IP relies on documentation, communication, and coordination of all parties involved in the process and can also include external verification or certification parties.

Idiotype - An identifying property or characteristic of an item or system. 1. A plant form expected on physiological grounds to represent an optimal type for the environment in which the plant is to be grown. 2. A classification of antibody molecules according to the antigenicity of the variable regions. Each idiotype is unique to a particular immunoglobulin raised to a particular antigen.

In silico (biology) (Lit. computer mediated) - The use of computers to simulate, process, or analyze a biological experiment.

In situ - In the natural place or in the original place. 1. Experimental treatments performed on cells or tissue rather than on extracts from them. 2. Assays or manipulations performed with intact tissues.

In vitro - Occurring outside the living organism (literally, in glass); typically an experiment performed in a test tube or other artificially designed environment. (Compare with in vivo).

In vivo - Occurring within a living organism. (Compare with in vitro).

Inbred line - The product of inbreeding, i.e. the intercrossing of individuals that have ancestors in common. In plants and laboratory animals, it refers to populations resulting from at least 6 generations of selfing or 20 generations of brother-sister mating, so that they have become, for all practical purposes, completely homozygous. In farm animals, the term is sometimes used to describe populations that have resulted from several generations of the mating of close relatives, without having reached complete homozygosity.

Inbreeding - Matings between individuals that have one or more ancestors in common, the extreme condition being self-fertilization, which occurs naturally in many plants and some primitive animals.

Inbreeding depression - The reduction in vigor over generations of inbreeding. This affects species which are normally out breeding and highly heterozygous.

Incomplete dominance - A gene action in which heterozygotes have a phenotype that is different from either homozygote, and is usually intermediate between them.

Incomplete penetrance - Where the phenotype does not allow perfect prediction of the genotype as a result of interference in gene expression by the environment.

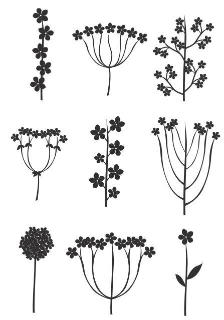
Indehiscent - Describing a fruit or fruiting body that does not open to release its seeds or spores when ripe.

Independent assortment - The random distribution during meiosis of alleles (at different genes) to the gametes that is the case when the genes in question are located on different chromosomes or are unlinked on the same chromosome.

Inducible - A gene or gene product whose transcription or synthesis is increased by exposure of the cells to an inducer or to a condition, e.g. heat.

Induction - The act or process of causing some specific effect to occur; for example the transcription of a specific gene or operon, or the production of a protein by an organism after it is exposed to a specific stimulus.

Inflorescence - The flowers of a plant, and the way those flowers are arranged.



Inflorescence

Inheritance - The transmission of genes and phenotypes from generation to generation.

Insect Resistance Management (IRM) - A management approach focused on preserving the many benefits of Bt corn technology. Producers implement an IRM plan, which includes items such as Bt refuges, a separate area near a field planted to Bt corn that can successfully host European corn borer. The Bt refuge is a strategy for protecting against resistance. All Bt corn products designed to control European corn borer, Southwestern corn borer and corn earworm require implementation of an IRM program according to the refuge size and distance guidelines.

Insecticide – A substance that kills insects.

Insert - 1. To incorporate a DNA molecule into a cloning vector; also used as a noun to describe such a DNA molecule. 2. To introduce a gene or gene construct into a new genomic site or into a new genome.

Insertion site - 1. A unique restriction site in a vector DNA molecule into which foreign DNA can readily be inserted. This is achieved by treating both the vector and the insert with the relevant restriction endonuclease and then ligating the two different molecules, both having the same sticky ends. 2. The position of integration of a transposon.

Integrating vector - A vector that is designed to integrate cloned DNA into the host's chromosomal DNA.

Integration - The physical insertion of DNA into the host cell genome. The process is used by retroviruses where a specific enzyme catalyses the process or can occur at random sites with other DNA (e.g. transposons).

Intellectual property rights (IPR) - The legal framework, which includes patenting and plant variety protection, by which inventors control the commercial application of their work.

Interleukin - A group of proteins that transmit signals between immune cells and are necessary for mounting normal immune responses.

International Treaty on Plant Genetic Resources for Food and Agriculture - The international treaty resulting from the revision of the International Undertaking on Plant Genetic Resources was adopted by the 2001 FAO Conference as a binding international instrument to enter into force after ratification by 40 states. Its objectives are the conservation and sustainable use of plant genetic resources for food and agriculture and equitable sharing of the benefits of this use.

International Undertaking on Plant Genetic Resources - The first comprehensive voluntary, international agreement (adopted in 1983) dealing with plant genetic resources for food and agriculture. Designed as an instrument to promote international harmony in matters regarding access to plant genetic resources for food and agriculture. Following extensive negotiations to revise the Undertaking in harmony with the Convention on Biological Diversity, the binding International Treaty on Plant Genetic Resources for Food and Agriculture was adopted by the 2001 FAO Conference.

Interspecific cross - A hybrid made between parents belonging to two different species.

Introgression - Backcrossing of hybrids of two plant populations to introduce new genes into a wild population.

Invasiveness - The ability of a plant, particularly a weed, to spread beyond its presently established site, and become established in new locations.

Isoform - A tissue-specific form of a protein.

Isogamy - Fusion of gametes of similar size and structure.

Isogenic - A group of individuals that possesses the same genotype, irrespective of their being homozygous or heterozygous.

Isolating mechanism - The properties of an organism that prevent interbreeding (and therefore exchange of genetic material) between members of different species that inhabit the same geographical area.

K

Karyotype - All of the chromosomes in a cell or an individual organism, visible through a microscope during cell division.

Knockout - A mutant individual, in which a single functional gene has been replaced by a non-functional form of the gene. Used to understand gene function via the comparison of the phenotypes of wild type and knockouts.

L

Lag phase - The initial growth phase, during which cell number remains relatively constant prior to rapid growth.

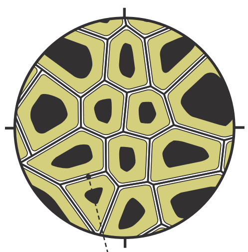
Lagging strand - The DNA strand that is assembled discontinuously during replication, in the direction away from the replication fork.

Legume - Simple dry dehiscent fruit that splits along two seams, a pod. Member of the fabaceae; a type of bean or pea.

Life cycle - The sequence of events from a given developmental stage in one generation to the same stage in the following generation. In sexually reproduced organisms, the starting point is the fusion of gametes to form the zygote.

Lignification - The thickening and strengthening of a plant cell wall with lignin.

Lignin - A group of high-molecular-weight amorphous polymers of phenylpropanoid comlbs, giving strength to certain tissues. A major component of wood.



Lignocellulose - The combination of lignin, hemicellulose and cellulose that forms the structural framework of plant cell walls.

Linkage - The association of genes (or genetic loci) on the same chromosome. Genes that are linked together tend to be transmitted together.

Linkage map - A linear or circular diagram that shows the relative positions of genes on a chromosome as determined by recombination fraction.

Linked gene, linked marker - A gene or marker that is linked to another gene or marker.

Locus (plural = loci) - A specific location or site on a chromosome.

M

Map - 1. verb: To determine the relative positions of loci (genes or DNA sequences) on a chromosome. Linkage maps are obtained from the frequency of recombination between loci. Physical maps are obtained commonly by the use of in situ hybridization of cloned DNA fragments to metaphase chromosomes, or by somatic-cell hybrids or radiation hybrids. 2. noun: A diagram showing the relative position of, and distances between, loci on a chromosome.

Map distance - The standard measure of genetic distance between loci, expressed in centiMorgans (cM) or map units. Estimated from recombination fraction via a mapping function.

Mapping – The construction of a localized (around a gene), or broad based (whole genome) genetic map. More generally, determining the location of a locus (gene or genetic marker) on a chromosome.

Marker - An identifiable DNA sequence that is inherited in Mendelian fashion, and which facilitates the study of inheritance of a trait or a linked gene.

Marker gene - A gene of known function or known location, used for marker-assisted selection or genetic studies.

Meiosis - A process within the cell nucleus that results in the reduction of the chromosome number from diploid (two copies of each chromosome) to haploid (a single copy) through two reductive divisions in germ cells.

Mendel's Laws - Two laws summarizing Gregor Mendel's theory of inheritance. The Law of Segregation states that each hereditary characteristic is controlled by two 'factors' (now called alleles), which segregate and pass into separate germ cells. The Law of Independent Assortment states that pairs of 'factors' segregate independently of each other when germ cells are formed.

Metabolism - The biochemical processes whereby nutritive material is converted to living matter, or aids in building living matter, or by which complex substances and food are broken down into simple substances.

Mitosis - The nuclear division that results in the replication of the genetic material and its redistribution into each of the daughter cells during cell division.

Modern biotechnology - The application of a) In vitrio nucleic acid techniques including recombinant deoxyribonucleic acid (DNA) and direct injection of nucleic acid into cells or organelles, or b) Fusion of cells beyond the taxonomic family, that overcome natural physiological reproductive or recombination barriers and that are not techniques used in traditional breeding and selection (Convention on Biological Diversity).

Molecular biology - The study of the biochemical and molecular interactions within living cells.

Molecular genetics - The study of the flow and regulation of genetic information between DNA, RNA, and protein molecules.

N

National Institutes of Health (NIH) - A nonregulatory agency which has oversight of research activities that the agency funds.

National Science Foundation (NSF) - A nonregulatory agency which has oversight of biotechnology research activities that the agency funds.

Natural selection - The differential reproduction of alleles in response to random selection processes, occurring from one population to the next over several generations; it results is an increase in the occurrence of some alleles and the decrease in the occurrence of others.

Neutraceutical - Drugs produced by rDNA methods in edible plants or vegetables, allowing their delivery within the body by simple consumption.

No-till - A method of farming in which a crop is planted directly into the residue of the previous year's crop, rather than planting into a field in which the soil has been tilled and the residue broken up. No-till is a valuable tool in conserving topsoil in addition to reducing the required number of trips a producer needs to make across a field.

Nucleic acid - A macromolecule consisting of polymerized nucleotides. Two forms are found, DNA and RNA. Nucleic acids may be linear or circularized, and single- or double-stranded.

Nucleus - The membrane-bound region of a eukaryotic cell that contains the chromosomes.

O

Open pollination - Pollination by wind, insects, or other natural mechanisms.

Organism - An individual living system, such as animal, plant or micro-organism, that is capable of reproduction, growth and maintenance.

Outcrossing - Mating between different individuals/species.

P

Parallel evolution - The development of different organisms along similar evolutionary paths due to similar selection pressures acting on them.

Patent - A legal permission to hold exclusive right - for a defined period of time - to manufacture, use or sell an invention.

Phenotype – The genetically and environmentally determined appearance of an organism.

Phyto (Prefix) - To do with plants.

Phytochemical - Molecules characteristically found in plants.

Phytohormone - A substance that stimulates growth or other processes in plants. Major species are auxins, abscisic acid, cytokinins, gibberellins and ethylene.

Phytoremediation - The use of plants actively to remove contaminants or pollutants from either soils (e.g. polluted fields) or water resources (e.g. polluted lakes). An example is the exploitation of the Brazil water hyacinth (Eichhornia crassipes) to accumulate in its tissues toxic metals such as lead, arsenic, cadmium, mercury, nickel, and copper.

Phytosterol - One of a group of biologically active phytochemicals present in the seeds of certain plants. Evidence suggests that human consumption of certain phytosterols, such as â-sitosterol, can help to lower total serum cholesterol and low-density lipoproteins levels, thereby reducing the risk of coronary heart disease.

Pistil - Central organ of the flower, typically consisting of ovary, style and stigma. Usually referred to as the female part of a perfect flower.

Plant breeders' rights (PBR) - Legal protection of a new plant variety granted to the breeder or his successor in title. The effect of PBR is that prior authorization is required before the material can be used for commercial purposes.

Population - An interbreeding group of organisms of the same species.

Population density - Number of cells or individuals per unit. The unit could be an area, or a volume of medium.

Population genetics - The branch of genetics that deals with frequencies of alleles and genotypes in breeding populations.

Precautionary principle – An approach to the management of risk when scientific knowledge is incomplete.

Progeny testing - With respect to discrete loci, the inference of the allelic state of an individual from the pattern of segregation among its offspring. For a quantitative trait, the use of progeny performance to estimate the breeding value of an individual.

Protein - A polymer of amino acids linked via peptide bonds and which may be composed of two or more polypeptide chains.

Quantitative genetics - The area of genetics concerned with the inheritance of quantitative traits that show continuous variation, as opposed to qualitative traits. Since many of the critical targets in both plant and animal breeding are of this type, most practical improvement programs involve the application of quantitative genetics.

Q

Quiescent - A temporary suspension or reduction in the rate of activity or growth, while retaining the potential to resume prior activity. Applies particularly to cell division.

R

R genes - A class of plant genes conferring resistance to a specific strain (or group of strains) of a particular pathogen. Their primary function is to sense the presence of the pathogen and to trigger the defense pathways in the plant. R genes have been cloned from a number of plant species.

RNAi-RNA interference - A process to interrupt gene expression that employs short pieces of homologous RNA to target and disrupt specific genes.

Recessive gene - Characterized as having a phenotype expressed only when both copies of the gene are mutated or missing.

Recombinant DNA (rDNA) - DNA molecules created by the fusion of DNA from different sources; the technology employed for splicing DNA from different sources and for amplifying the resultant heterogeneous DNA.

Recombination - The production of a DNA molecule with segments derived from over one parent DNA molecule. In eukaryotes, this is achieved by the reciprocal exchange of DNA between non-sister chromatids within an homologous pair of chromosomes during prophase of the first meiotic division.

Regulatory gene - A gene whose protein controls the activity of other genes or metabolic pathways.

Regulatory sequence - A DNA sequence involved in regulating the expression of a gene, e.g. a promoter or operator region (in the DNA molecule).

Resistance - The ability to withstand abiotic (high temperature, drought, etc.) or biotic (disease) stress, or a toxic substance. Often in the context of genetic determination of resistance.

Resistance factor - A plasmid that confers antibiotic resistance to a bacterium.

Reverse genetics - The use of protein information to elucidate the genetic sequence encoding that protein. Used to describe the process of gene isolation starting with a panel of afflicted patients.

Reversion - An alteration to a mutant allele that reverts it back to the wild-type allele.

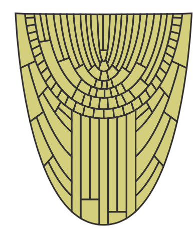
Rhizobacterium - A microorganism whose natural habitat is near, on, or in, plant roots.

Rhizobia - Bacteria in a symbiotic relationship with leguminous plants that results in nitrogen fixation.

Rhizosphere - The soils region on and around plant roots.

Ribonucleic acid (RNA) - A category of nucleic acids which along with DNA forms the genetic material of a cell. While DNA stores the genetic information in the nucleus of every cell, RNA is a "carrier" of this information from DNA to other parts of the cell where the message is converted to protein. Structurally, RNA is a single-stranded structure. The component sugar that forms the backbone of RNA is ribose (as opposed to deoxyribose in DNA) and the four bases in RNA are Uracil, Guanine, Adenine and Cytosine (DNA contains Thymidine instead of Uracil). There are three types of RNA, all of which play an intermediary role in converting DNA information into protein: messenger RNA (mRNA) is a copy of the DNA in the nucleus and carries it to the cytoplasm where the cellular machinery for decoding that information lies; transfer RNA (tRNA) allows the code to be read three bases (one codon) at a time and transfers the information from RNA to protein (each tRNA carries one particular amino acid); and ribosomal RNA (rRNA) has a structural role forming part of the ribosome--the machinery that converts RNA into protein.

Root apex - The apical meristem of a root; very similar to the shoot apical meristem in that it forms the three meristematic areas: the protoderm (develops into the epidermis); the procambium (the stele); and the growth meristem (the cortex).



Root apex

Root cap - A mass of reinforced cells covering and protecting the apical meristem of a root.

Root culture - The culture of isolated apical or lateral root tips to produce in vitro root systems with indeterminate growth habits. Used to study mycorrhizal, symbiotic and plant-parasitic relationships.

Root hairs - Outgrowths from epidermal cell walls of the root, specialized for water and nutrient absorption.

Root hairs

Roundup-Ready® - Describing transgenic crop varieties that carry the bacterial gene which detoxifies the herbicide glyphosate, thereby making them resistant to its application.

S

Secondary pests - Those species within an ecosystem that are normally kept in check by natural enemies.

Seed - Botanically, the matured ovule without accessory parts. Colloquially, anything which may be sown;

i.e. seed potatoes (which are vegetative tubers); seed of wheat (karyopses), etc.

Seed shattering - The spontaneous dispersal of mature seed from a plant following ripening.

Seed storage proteins - Proteins accumulated in large amounts in protein bodies within seeds. They act as a source of amino acids during germination. Of interest in biotechnology: 1. As a major source of human and animal nutritional protein. 2. As a model expression system. Since they are produced in large amounts relative to other proteins, and are stored in stable, compact bodies in the plant seed, it may be possible to engineer transgenes which are expressed in the same way as seed storage proteins - i.e. in large amounts and in a convenient form.

Segregation - For genes, the separation of allele pairs from one another and their resulting assortment into different cells at meiosis. For chromosomes, the separation and re-assortment of the two homologues in anaphase of the first meiotic division. For individuals, the occurrence of different genotypes and/or phenotypes among offspring, resulting from chromosome or allele separation in their heterozygous parents.

Selectable - Having a gene product that, when present, enables the identification and preferential propagation of a particular genotype.

Selectable marker - A gene whose expression allows the identification of a specific trait or gene in an organism.

Selection - 1. Differential survival and reproduction of phenotypes. 2. A system for either isolating or identifying specific genotypes in a mixed population.

Selective pressure - The operation of natural selection on the allele frequency in a population, resulting in the increase in frequency of favored alleles and the decrease in frequency of unfavored alleles.

Self-incompatibility - In plants, the inability of the pollen to fertilize ovules (female gametes) of the same plant.

Self-pollination - Pollen of one plant is transferred to the female part of the same plant or another plant with the same genetic makeup.

Single copy - A gene or DNA sequence which occurs only once per (haploid) genome. Many structural genes are single copy.

Soil amelioration - The improvement of poor soils. Includes the fungal and bacterial breakdown of plant organic matter, to form humus; the release of minerals - such as phosphates - to the soil, making them available to plants; the fixation of nitrogen. Can sometimes include an element of bioremediation.

Soil-less culture - Growing plants in nutrient solution without soil.

Specialty trait - Grain produced that has a quality characteristic (non-substantial equivalent) that typically adds end-user value, above commodity grade. Traits can be either compositional (e.g. high oil, white, waxy, etc.) or be based on management and handling characteristics (e.g. low heat drying, organic, non-biotech, etc.). The value associated with these traits is determined in the contract and is reflective of the additional value.

Species - A classification of related organisms that can freely interbreed.

Splicing - The joining together of separate DNA or RNA component parts. For example, RNA splicing in eukaryotes involves the removal of introns and the stitching together of the exons from the pre-mRNA transcript before maturation.

Sporophyte - The diploid generation in the life cycle of a plant, and that produces haploid spores by meiosis.

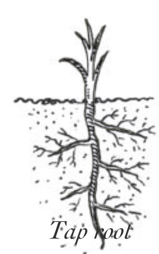
Sport - An individual plant, or portion thereof, showing a recognizably different phenotype from the parent, presumably as a result of spontaneous mutation. Novel traits displayed by some sports can become of great agricultural worth, but generally they are disadvantageous.

Stacked genes - Refers to the insertion of two or more genes into the genome of an organism. An example would be a plant carrying a Bt transgene giving insect resistance, and a bar transgene giving resistance to a specific herbicide.

Stock plant - The source plant from which cuttings or explants are obtained. Stock plants should be well maintained to optimize explant and cutting quality.

Sustainable agriculture - A systematic approach to agriculture that focuses on ensuring the long-term productivity of human and natural resources for meeting food and fiber needs. Examples of sustainable agricultural practices include use of crop rotation, animal and green manures, soil and water conserving tillage systems such as no-till planting methods, and integrated pest management.

T



Tap root - Root system in which the primary root has a much larger diameter than any lateral roots (e.g. carrot).

Telomere - The end of a chromosome.

Template – A macromolecule, usually DNA, that serves as the blueprint for the synthesis of another molecule.

Terminal bud - A branch tip, an undeveloped shoot containing rudimentary floral buds or leaves, enclosed within protective bud scales.

Terminator - 1. A DNA sequence just downstream of the coding segment of a gene, which is recognized by RNA polymerase as a signal to stop synthesizing mRNA. 2. A term used in GMO technology for a transgenic method which genetically sterilizes the progeny of the planted seed, thereby preventing the use of farm-saved seed.

Terminator gene - A specific variety-level genetic use restriction technology. A patented technique.

Testcross - A cross between a genetically unknown individual and a recessive tester to determine whether the individual in question is heterozygous or homozygous for a certain allele. It can also used as a method to test for linkage, i.e. to estimate recombination fraction.

Thallus - Plant body without true roots, stems, or leaves.

Thermophile - An organism which is adapted to high temperatures, such as in hot springs and geysers, smoker vents on the sea floor, and domestic hot water pipes. A wide range of bacteria, fungi and simple plants and animals can grow at temperature up to 50 °C; thermophiles grow and reproduce at above 50 °C. They can be classified, according to their optimal growth temperature, into simple thermophiles (50-65 °C); thermophiles (65-85 °C), and extreme thermophiles (>85 °C).

Thinning - 1. Removal of older stems to promote new growth. 2. Removal of excess fruits to improve the size and quality of the remaining fruits. 3. Removal of seedlings spaced too closely for optimum growth.

Ti (tumor-inducing) plasmid - A giant plasmid of Agrobacterium tumefaciens that is responsible for tumor formation in infected plants. Ti plasmids are used as vectors to introduce foreign DNA into plant cells.

Tillage, conventional - Practice of preparing the seedbed for planting by overturning/aerating the soil. Conventional tillage is the historic practice for field preparation but can lead to increased risk of erosion by environmental conditions.

Tillage, minimum - Tillage practice that reduces the number of trips across the seedbed prior to planting. Typically does not overturn the soil. Minimum tillage provides the aeration benefits of conventional tillage while reducing the trips across the field, saving both time and money.

Tolerance - A specific lack of responsiveness by the immune system to selected antigens.

Tonoplast - The cytoplasmic membrane bordering the vacuole of plant cells. It plays a prominent role in regulating the osmotic pressure exerted by the cell sap.

Totipotency - The ability of a cell or tissue to be induced to regenerate into a complete organism.

Toxigenicity - The ability of bacteria or other pathogens to produce toxic substances.

Traceability - A common component of identity preservation. The ability to follow the production, transport and management process of a product back to its source. In a general sense, this may only include knowledge of who has been involved in the process. In more detailed situations, traceability may include other auxilary data from each point along the process. Also referred to as the documentation of a product's pedigree.

Trait - One of the many characteristics that define an organism. The phenotype is a description of one or more traits.

Transcription – The synthesis (combining of parts) of RNA (ribonucleic acid) molecules that help to transfer the sequence of DNA into the structure of protein molecules.

Transcription factor - A protein that regulates the transcription of genes.

Transcription unit - A segment of DNA that contains signals for the initiation and termination of transcription, and is transcribed into one RNA molecule.

Transduction - The transfer of genetic material into a cell by a viral vector.

Transfection - The infection of a cell with isolated viral DNA (or RNA), resulting in the production of intact viral particles.

Transformant - A cell or organism that has been genetically altered through the integration of a transgene(s). Primary: the first generation following the transformation event. Secondary: progeny of the primary transformant.

Transformation - A genetic alteration to a cell as a result of the incorporation of DNA from a genetically different cell or virus; can also refer to the introduction of DNA into bacterial cells for genetic manipulation.

Transformation efficiency or frequency - The fraction of a cell population that takes up and integrates the introduced transgene; expressed as the number of transformed cells recovered divided by the total number of cells in a population.

Transgenic plant - Genetically engineered plant or offspring of genetically engineered plants. The transgenic plant usually contains material from at least one unrelated organisms, such as from a virus, animal, or other plant.

Transient expression - Short-term activity of a transgene following its introduction into target tissue. Transient expression usually implies non-integration of the transgene into the host genome.

Translation - The process of converting the genetic information of an mRNA on ribosomes into a polypeptide. Transfer RNA molecules carry the appropriate amino acids to the ribosome, where they are joined by peptide bonds.

Translocation - A chromosomal alteration (mutation) in which a chromosome segment or arm is transposed to a new location.

Transposase - An enzyme encoded by a transposon gene that catalyses the movement of a DNA sequence to a different site in a DNA molecule.

Transposition - The movement of a DNA segment within the genome of an organism.

Transposon tagging - A method of gene isolation that exploits the disruption of normal gene expression that is the result of an insertion of a transposon within, or close to the target. Since the sequence of the transposon is known, this can be used as a DNA probe to define the DNA fragment containing the target gene. Large-scale experiments to generate populations of gene mutations are colloquially referred to as gene machines.

Transposons - Short stretches of DNA with the capacity to move between different points within a genome.

Trisomy - The presence in a diploid cell or organism of an extra chromosome of one homologue.

Tropism - Plant response to an external stimulus, resulting in the bending/turning of stem or root growth. Typical tropisms are phototropism (light), geotropism (gravity) or hydrotropism (water).

U

U.S. Department of Agriculture - The U.S. agency responsible for regulation of biotechnology products in plants and animals. The major laws under which the agency has regulatory powers include the Federal Plant Pest Act (PPA), the Federal Seed Act, and the Plant Variety Act (PVA). In addition, the Science and Education (S&E) division has nonregulatory oversight of research activities that the agency funds.

Understock - Host plant for a grafted scion, a branch or shoot from another plant; an understock may be a fully-grown tree or a stump with a living root system.

Undifferentiated - Undifferentiated cells are those that have not been committed to become part of a specialized tissue.

V

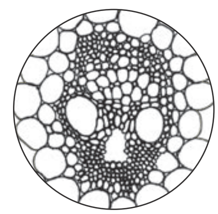
Vacuole - A fluid-filled membrane-bound cavity inside many plant cells, in which various plant products and by-products are stored.

Variegation - The occurrence, within a single tissue, organ or organism, of mosaicism. Usually referring to plants showing either both green and albino coloration in a leaf, or flecks of contrasting color in a flower. The origin of variegation can be through viral infection, nutritional deficiency, or genetic instability caused by transposon activity.

Variety - 1. A naturally occurring subdivision of a species, with distinct morphological characters. 2. A defined strain of a crop plant, selected on the basis of phenotypic (sometimes genotypic) homogeneity.

Vascular - Plant tissue specialized for the conduction of water or nutrients.

Vascular bundle - A strand of tissue containing primary xylem and primary phloem (and procambium if present) and frequently enclosed by a bundle sheath of parenchyma or fibers.



Vascular bundle

Vascular cambium - In biennials and perennials, cambium giving rise to secondary phloem and secondary xylem.

Vascular plant - Plant species possessing organized vascular tissues.

Vascular system - 1. A specialized network of vessels for the circulation of fluids throughout the body tissue of an animal. 2. The system of vascular tissue in plants.

Vector – Any organism or DNA construct that enables the movement or transmission of another organism of gene.

Vernalization - Chilling juvenile plants for a minimum period in order to induce flowering. Some plants require vernalization to flower, but others have no such requirement.

Vessel - A series of xylem elements whose function is to conduct water and nutrients in plants.

Virulence - The degree of ability of an organism to cause disease.

Virus - A small organism that is often pathogenic. Viruses have a simple structure that is composed of a protein shell that surrounds the viral genome. This genome can be RNA or DNA based. Some viruses have a fatty acid sheath that is wrapped over the protein shell. Viruses enter the host cell and generally utilize cellular components for survival and growth, hence, viruses can be thought of as intracellular parasites.

Vitamin - Naturally occurring organic substance required by living organisms in small amounts to maintain normal health.

Vitrified - Cultured tissue having leaves and sometimes stems with a glassy, transparent or wet and often swollen appearance. The process of vitrification is a general term for a variety of physiological disorders that lead to shoot tip and leaf necrosis.

Volunteer plant - Crop plants that exist without deliberate cultivation due to previous seed bank.

W

Water potential - The pressure gradient that induces the flow of water, particularly with reference to plant water uptake from the soil, comprising the net effects of suction, solutes and matric forces.

Water stress - Occurs when plants are unable to absorb enough water to replace that lost by transpiration. Short-term water stress leads to turgor loss (wilting). Prolonged stress leads to cessation of growth, and eventually plant death.

Wilting point - The moisture content of soil at which plants start to wilt, but not to the extent that they fail to recover when placed in a humid atmosphere.

X

X chromosome - In mammals, the sex chromosome that is found in two copies in the homogametic sex (female in humans) and one copy in the hererogametic sex (male in humans).

Xanthophyll - A yellow oxygen-containing carotenoid, present in chloroplasts.

Xenia - The immediate effect of pollen on some characters of the endosperm.

Xenobiotic - A chemical compound that is not produced by, and often cannot be degraded by, living organisms.

Xerophyte - A plant very resistant to drought, typically adapted to extremely dry environments.

X-linked disease - A genetic disease caused by a mutation on the X chromosome. In X-linked recessive conditions, a normal female "carrier" passes on the mutated X chromosome to an affected son.

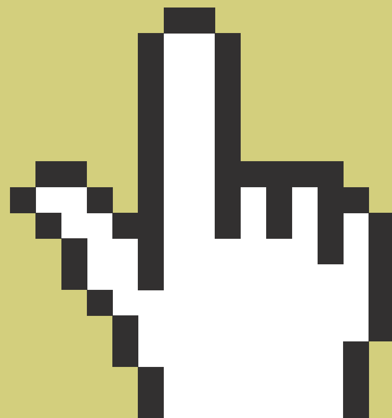
Y

Yeast - A unicellular ascomycete fungus, commonly found as a contaminant in plant tissue culture.

Z

Zone of elongation - The section of the young root or shoot just behind the apical meristem, in which the cells are enlarging and elongating rapidly.

Zygote - The diploid cell formed by the fusion of two haploid gametes during fertilization in eukaryotic organisms with sexual reproduction.



W E B   S I T E S

www.aaas.org

Founded in 1848 to represent all disciplines of science, AAAS supports scientific exchange and discussion of science and society issues.

www.accessexcellence.org

Access Excellence is a national educational program that provides high school biology and life science teachers access to their colleagues, scientists, and critical sources of new scientific information via the World Wide Web.

www.afia.org

AFIA is the only national organization devoted exclusively to providing strong, highly qualified leadership representing the business, legislative and regulatory interests of the animal feed and pet food industries and their suppliers.

www.agbioforum.missouri.edu

AgBioForum publishes articles that enhance the ongoing dialogue on the economics and management of agricultural biotechnology. The purpose of AgBioForum is to provide unbiased, timely information and new ideas leading to socially responsible and economically efficient decisions in science, public policy, and private strategies pertaining to agricultural biotechnology.

www.agbios.com

AGBIOS is a Canadian company dedicated to providing public policy, regulatory, and risk assessment expertise for products of biotechnology. AGBIOS has worked with federal departments and agencies on issues of policy and regulation pertaining to genetically modified and other novel foods, crops, and forest tree species. The Company also provides experience and expertise to commercial enterprises seeking regulatory approval of biotechnology products, and to other public and private sector groups seeking clarification of issues associated with the development and utilization of biotechnology processes and products.

http://agbiosafety.unl.edu

This web site is a source of scientific, regulatory and educational materials relevant to crop biotechnology and the current debate on the genetic modification of food.

www.agbiotechnet.com

AgBiotechNet® publishes information about agricultural biotechnology and biosafety for researchers, policy-makers and industry worldwide. The site provides rapid and convenient access to research developments in genetic engineering, in vitro culture and molecular genetics and updates on economic and social issues. Developments in transgenic plants and animals are a particular focus.

www.agbioforum.missouri.edu.

This is an informative site provided by the Journal of Agro Biotechnology Management and Economics. The AgBio Forum supplies farmers, producers, and researchers with new and current ag biotech information. The site hosts articles from both invited and submitted contributors providing information about progress in agro biotechnology with reference to the effects on the economy and politics. The articles are edited by the University of Missouri, assisted by other editors from private sectors, as well as government and agribusiness media.

www.agbioworld.org

AgBioWorld Foundation is a non-profit organization supporting the use of biotechnology to improve agriculture in the developing world.

www.agcare.org

AGCare provides science and research-based information and policy initiatives on pesticide use, crop biotechnology developments, nutrient management and other related environmental issues surrounding field and horticultural crop production in Ontario.

www.agnic.org

AgNIC is a guide to quality agricultural information on the Internet as selected by the National Agricultural Library, Land-Grant Universities, and other institutions.

www.agwest.sk.ca

Ag-West Biotech focuses on initiating, promoting and supporting the growth of Saskatchewan, Canada's agricultural biotechnology industries and the commercialization of related food and non-food technologies.

www.amseed.com

The American Seed Trade Association prides itself on being an effective tool on development, marketing and movement of seed, and enhanced plant breeding

throughout the world. They use their influence to help develop improved seed production and increase economic well being of seed producers and agriculturalists alike. Founded in 1883 ASTA remains one of the oldest trade organizations in the U.S.

www.aphis.usda.gov

The Animal and Plant Health inspection Service (APHIS) is responsible for protecting and promoting U.S. agricultural health, administering the Animal Welfare Act, and carrying out wildlife damage management activities.

www.ars.usda.gov

The USDA Agricultural Research Service is geared toward providing genetic and bioinformatic tools, genomic information, and genetic raw materials, to ensure safe and abundant supplies of inexpensive food, feed, fiber, and industrial products to the United States and other nations throughout the world.

www.betterfoods.org

The Alliance encourages fact-based discussion about development in plant biotechnology. Our membership represents diverse agriculture and food-related groups, including farmers, processors, distributors, retailers, scientists, food technologists and professionals in other fields dedicated to improving nutrition, protecting the environment and fighting world hunger.

www.bio.org

Advocates the industry's positions to elected officials and regulators, to inform national and international media about the industry's progress, contributors to quality of life, goals and positions and provides business development services to member companies, such as investor and partnering meetings.

www.bioalberta.com

BioAlberta is the central voice and the organizing hub for biotechnology in Alberta. We advocate for, promote and proactively facilitate the growth of Alberta's biotechnology industry.

www.bioatlantech.nb.ca

BioAtlantech brings biotechnological solutions to the marketplace and enhances public awareness of life science.

www.bio-scope.org

Provides the Internet community, from lay people to highly educated experts, the chance to have access to scientific information at all levels. Bio-Scope also offers the possibility for experts and others to exchange views and plan concerted actions.

http://biotech.icmb.utexas.edu

Biotech aims to educate those who may not have as much experience with biology and biotechnology while at the same time providing quick access to biology-related resources for those who are dealing with much more specific and detailed information.

www.biotech.uiuc.edu

The Biotechnology Center at the University of Illinois, Urbana-Champaign was set up to be a primary source of research for biotechnology and provide premium research services and opportunities. The Center provides educational training and career opportunities while creating partnerships with corporations and other institutions for research in biotechnology.

http://biotech-info.net

Ag BioTech InfoNet covers all aspects of the application of biotechnology and genetic engineering in agricultural production and food processing and marketing. The focus is on scientific reports and findings and technical analysis, although the page also covers emerging issues of widespread interest, developments in the policy arena, and major media coverage.

www.biotech-monitor.nl

The Biotechnology and Development Monitor is a quarterly magazine, published in the Netherlands by The Network University in Amsterdam. It deals with topics in the biotechnology and development fields and is directed at developing countries and sustainable development.

www.biotech.ucdavis.edu

The Biotechnology Program at UC Davis was created to promote and coordinate the development of biotechnology and biotechnology-related research on the campus, assist with development of new and improved facilities for biotechnology research, promote research interactions between faculty and private industry and public agencies, recommend and implement curriculum development and training in biotechnology and serve as an information and education resource on biotechnology for the campus and the public.

www.biotech.wisc.edu

The mission of the UW Biotechnology Center is to maximize the benefits of biotechnology to the University of WI-Madison, University of WI System, state and nation by being an excellent quality, comprehensive, multidisciplinary biotechnology center that supports, coordinates, disseminates and advances biotechnology.

www.biotechknowledge.com

The Knowledge Center, sponsored by Monsanto, is an evolving collection of news items, technical reports and other documents and that the material assembled here -- which represents many points of view -- will promote a deeper understanding of agricultural biotechnology.

http://bti.cornell.edu

The mission of the Boyce Thompson Institute is "to use basic research to expand the frontiers of plant biology and related areas, and contribute, through science and technology, to the improvement of the environment and the quality of human life." Broadly, it is a mission that sets worldwide leadership in plant biology as its goal. Specifically, it is a mission to understand the interactions between plants and their environment for the enhancement of life.

www.cals.cornell.edu/extension

The Cornell Cooperative Extension educational system enables people to improve their lives and communities through partnerships that put experience and research knowledge to work.

www.cast-science.org

CAST assembles, interprets, and communicates science-based information regionally, nationally, and internationally on food, fiber, agricultural, natural resource, and related societal and environmental issues to our stakeholders--legislators, regulators, policy makers, the media, the private sector, and the public.

www.colostate.edu/programs/lifesciences/transgeniccrops

The goal of this web site from Colorado State University is to provide balanced information and links to other resources on the technology and issues surrounding transgenic crops (also known as genetically modified or GM crops).

www.corn.org

The Corn Refiners Association is an organization that represents the corn refining industry of the United States. They focus on research programs, technical service, public relations and government relations, promoting corn producers and members of the refining industry. The CRA also contributes to schools, government agencies, and agribusinesses by supplying them with educational information related to corn and products from corn.

http://croptechnology.unl.edu

The Library of Crop Technology is an educational environment from NU that presents unbiased, research-based information through lesson modules focused on plant genetics, genetic engineering, and biochemistry. These lessons are composed of text enhanced with images, animations, a hyper-linked glossary and quizzes.

http://ccr.ucdavis.edu

The Center for Consumer Research, (CCR), focuses on consumer attitudes toward food safety and quality. Increased information on consumer attitudes and perceptions can increase the exchange between those who provide goods and services and those who utilize them. Research findings lay the basis for more effective information dissemination and public policy. Projects have focused on consumer attitudes toward new techniques, food safety, food labeling, nutritional issues, and produce quality.

www.cgiar.org

The goal of the Consultative Group on International Agricultural Research (CGIAR) is to contribute to food security and poverty eradication in developing countries through research, partnerships, capacity building, and policy support, promoting sustainable agricultural development based on the environmentally sound management of natural resources.

www.coafes.umn.edu

The College of Agricultural, Food and Environmental Sciences at the University of MN promotes professional competence in agricultural, food and environmental sciences and a sense of social responsibility.

www.croplifeamerica.org

CropLife America promotes innovation and the environmentally sound manufacture, distribution and use of crop protection and production technologies for safe, high-quality, affordable and abundant food, fiber and other crops.

www.crops.org

This site is the official website for the Crop Science Society of America. Here you can find current information on research and advances in biotechnology. CSSA promotes the conservation of natural resources while promoting safe and effective ways to produce food, feed, and fiber crops while maintaining and improving the environment.

www.danforthcenter.org

The Donald Danforth Plant Science Center centers around four basic points; to increase understanding of basic plant biology, to apply new knowledge for the benefit of human nutrition and health and to improve the sustainability of agriculture worldwide, to facilitate the rapid development and commercialization of promising technologies and products and to contribute to the education and training of graduate and postdoctoral students, scientists and technicians from around the world.

www.epa.gov

EPA's mission is to protect human health and to safeguard the natural environment — air, water, and land — upon which life depends. For 30 years, EPA has been working for a cleaner, healthier environment for the American people.

www.fao.org/biotech

The Food and Agriculture Organization of the United Nations works to raise levels of nutrition and standards of living, to improve agricultural productivity, and to better the condition of rural populations.

www.fas.usda.gov/itp/biotech/index.html

The Foreign Agricultural Service is a branch of the U.S. Department of Agriculture. The agency was designed to improve markets as well as the position of U.S. agriculture in world markets. The agency also is intended to provide food and aid, in addition to technical assistance to foreign countries.

www.fb.org

The Farm Bureau is a non-governmental organization that promotes and implements policies designed to improve financial stability and quality of life for farmers. This is a website intended to voice views and ideas of farmers at all levels, and to analyze and improve education and economic welfare of agriculturalists.

www.foodbiotechnology.com

Food Biotech Info.com is part of an effort to help deliver science-based information on various issues concerning the benefits and safety of genetically modified foods. In addition to providing information, this site also will offer a schedule of lectures and seminars on food biotechnology as well as downloadable PowerPoint presentations.

www.foodsafetynetwork.ca

The Food Safety Network at the University of Guelph provides research, commentary, policy evaluation and public information on food safety issues from farm-to-fork. Using electronic networks, extensive databases and rigorous field research, the Food Safety Network works closely with the Canadian Research Institute for Food Safety as well as national and international collaborators to put science into action -- to develop and implement scientific and publicly credible policies and programs to enhance the safety of the food supply.

http://gophisb.biochem.vt.edu

Information Systems for Biotechnology (ISB) provides information resources to support the environmentally responsible use of agricultural biotechnology products. Here you will find documents and searchable databases pertaining to the development, testing and regulatory review of genetically modified plants, animals and microorganisms within the U.S. and abroad.

www.grains.org

U.S. Grains Council represents U.S. grains markets around the world and plays a critical role in helping to facilitate trade issues that pertain to biotechnology.Founded in 1960, the Council is a private, non-profit corporation with 10 international offices and programs in over 80 countries. Its unique membership includes producer organizations and agribusinesses with a common interest in developing export markets.

http://ific.org

The IFIC Foundation is the educational arm of the International Food Information Council (IFIC). IFIC's mission is to communicate science-based information on food safety and nutrition to health and nutrition professionals, educators, journalists, government officials and others providing information to consumers. IFIC's purpose is to bridge the gap between science and communications by collecting and disseminating scientific information on food safety, nutrition and health and by working with an extensive roster of scientific experts and through partnerships to help translate research into understandable and useful information for opinion leaders and ultimately, consumers.

www.ifpri.org

International Food Policy Research Institute works to identify and analyze policies for sustainably meeting the food needs of the developing world. Research at IFPRI concentrates on economic growth and poverty alleviation in low-income countries, improvement of the well-being of poor people, and sound management of the natural resource base that supports agriculture. IFPRI seeks to make its research results available to all those in a position to use them and to strengthen institutions in developing countries that conduct research relevant to its mandate.

www.ift.org

The Institute of Food Technologists advances the science and technology of food through the exchange of knowledge.

www.iia.msu.edu/absp

ABSP is a USAID-funded project based in the Institution of International Agriculture at MI State University. ABSP works with private and public institutions to improve the capacity and policy environment for the use, management and commercialization of agricultural biotechnology in developing countries.

www.ilsi.org

International Life Sciences Institute (ILSI) is a nonprofit, worldwide foundation that seeks to improve the well-being of the general public through the pursuit of balanced science. Its goal is to further the understanding of scientific issues relating to nutrition, food safety, toxicology, risk assessment, and the environment by bringing together scientists from academia, government, and industry.

www.isaaa.org

ISAAA'S mission is to contribute to poverty alleviation, by increasing crop productivity and income generation, particularly for resource-poor farmers, and to bring about a safer environment and more sustainable agricultural development.

www.isaaa.org/kc

Crop Biotech Net is the home of the Global Knowledge Center on Crop Biotechnology (KC), an information service that provides regular updates and information about the global status of crop biotechnology, products and issues, regular news, communication materials, and links to other information sources.

www.nal.usda.gov/bic/Biotech_Patents/

The U.S. Department of Agriculture is one of three agencies accountable for the regulation of biotechnology in the U.S. They regulate products according to their development and intended use. The USDA offers this site as reference to patents on biotechnology and gives researchers multiple tools and information related to biotechnology.

www2.nasda.org/NASDA

The National Association of State Departments of Agriculture is intended to inform the public, private sectors, and all organizations contributing to agriculture and agribusiness, and supports all programs in the American agriculture industry. The NASDA represents all state departments of agriculture by promoting the development, implementation and communication of public policy while protecting the environment.

www.ncbiotech.org

The mission of the NC Biotechnology Center is to provide long-term economic benefit to NC through support of biotechnology research, development and commercialization statewide.

www.ncfap.org

The Center for Food and Agricultural Policy informs farmers and the public on current legislation, policies and requirements involving the development of food and crop production. Providing important information on economic and environmental progress, this site includes links and information related to public policy and communicates new legislation to farmers and all rural agriculturists.

www.ncga.com

National Corn Growers Association (NCGA) is a national organization founded in 1957 and represents nearly 33,000 dues-paying corn growers from 48 states and the interests of over 300,000 farmers who contribute to corn checkoff programs in 20 states. Their Web site provides a great variety of information sources for biotechnology, including Know Before You Grow, an initiative that includes an up-to-date listing of approved biotech corn hybrids, and Insect Resistance Management, an education program geared at training producers strategies for using biotechnology products.

www.nfpa-food.org

The National Food Processors Association. NFPA is the voice of the $500 billion food processing industry on scientific and public policy issues involving food safety, food security, nutrition, technical and regulatory matters and consumer affairs.

www.ngfa.org

The National Grain and Feed Association is an association that focuses on economic growth and performance of U.S. agriculture. They are a non-profit trade association that represents grain and feed producers as well as providing services to those industries. The NGFA also provides education and effective communication to its members, the public, and the government.

www.nuffieldbioethics.org

The Nuffield Council on Bioethics covers ethical issues in new developments in biology and medicine. The Nuffield Council studies the issues raised and uses their input to advise policy makers, address the public, and keeps communication ongoing in relations to bioethics.

www.oecd.org

The Organization for Economic Cooperation and Development (OECD), is an international organization helping governments tackle the economic, social and governance challenges of a globalized economy.

www.omniomix.com

Omniomix has a website dedicated to providing all the latest information on biotechnology. The site furnishes news updates, press releases, stock prices and analyst information. Omniomix offers free postings of job listings and resumes, and also provides a database of biotechnology companies from around the world.

www.ostp.gov

The mission of the Office of Science and Technology Policy is "to inform the President and others in Executive positions on the effects of science and technology on domestic and international affairs." They create and apply policies to establish quality science and technology programs that improve economic prosperity, environmental quality, and national security.

www.pewagbiotech.org

The Pew Initiative on Food and Biotechnology was established to be an independent and objective source of credible information on agricultural biotechnology for the public, media and policymakers. The Initiative is committed to providing information and encouraging debate and dialogue so that consumers and policymakers can make their own informed decisions.

www.plantstress.com

A site dedicated to coping with environmental stresses on crops.

www.riskassess.org

This web site is designed to help provide answers to these questions and necessary background information to understand the process of gene engineering and the available data relating to the safety of GMOs and the risk assessment questions asked.

http://sbc.ucdavic.edu/outreach

The Seed Biotechnology Center is a focal point for interaction between the seed industry and the research and educational resources of the University of CA, Davis. It coordinates research to address problems of interest to the seed industry and provides continuing education in seed biology and technology.

http://scope.educ.washington.edu

SCOPE is establishing on-line, intellectual communities focused on current controversies in science that concern leading research scientists and also connect to the interests of the general public.

www.soygrowers.com

The American Soybean Association, over the last 80 years has met the increased demands of the need for soybean production. Nearly 30,000 soybean producers are represented by the American Soybean Association, whose number one goal is policy development and implementation of soybean production. The ASA represents farmers and members by developing policies on production, market development, domestic and foreign issues and trade policies. The ASA is devoted to improving marketing, new uses and research for the American soybean farmer.

www.tomorrowsbounty.org

This web site is provided as a resource for producer-members of U.S. agricultural commodity organizations. The information on this site is designed to help you communicate to others the value and safety of biotechnology so that as a farmer, you will be able to capitalize on the benefits agriculture's new technologies deliver today, and the promises they hold for tomorrow.

www.usda.gov/agencies/biotech/

The USDA's Ag Biotechnology website. The United States Department of Agriculture (USDA) is one of three Federal Agencies, along with the Environmental Protection Agency (EPA) and the U.S. Food and Drug Administration (FDA), primarily responsible for regulating biotechnology in the United States. Products are regulated according to their intended use, with some products being regulated under more than one agency.

http://vm.cfsan.fda.gov

The U.S. Food and Drug Administration Center for Food Safety and Applied Nutrition works to assure that the use of food ingredients is safe by: Evaluating new applications efficiently & effectively, expediting applications that mitigate food hazards, meeting high performance standards with strong science and modern infrastructure, directing resources to issues of greater public health importance while anticipating future trends, maintaining data to monitor safety over time and conducting research that supports the FDA regulatory agenda.

www.who.int/foodsafety/en

This website is home to the World Health Organization, Food Safety Department. The FOS is an organization committed to reducing food and water borne diseases, a leading cause of illness and death in under developed countries. FOS provides advice and takes steps to improving the development, production, and distribution of food, to decrease the current conditions and the risk of future food borne illness.

www.whybiotech.com

The Council for Biotechnology Information communicates science-based information about the benefits and safety of agricultural and food biotechnology. Through our award-winning Web site, the Council for Biotechnology Information is committed to bringing you the facts about these exciting new developments — complete with footnotes and hyperlinks to scientific research and other information.

BIOTECHNOLOGY ON THE MARKET

CANOLA

LibertyLink® Canola (Developed by Bayer CropScience) Introduced in 1995, LibertyLink Canola allows growers a wide application window to apply Liberty® herbicide over-the-top during the growing season. This results in effective weed control while maintaining excellent crop performance and yield.

InVigor® Hybrid Canola (Developed by Bayer CropScience) InVigor Hybrid Canola are high-yielding hybrid canola varieties that are also tolerant to Liberty herbicide. InVigor hybrid seed was first sold in Canada in 1996 and in the United States in 2000.

Natreon® Naturally Stable Canola Oil from Nexara® Canola Seed (Developed by Dow AgroSciences, Canada) Nexara canola seed is a new line of canola seed that makes canola better. These varieties produce a naturally stable canola oil (Natreon) that contains virtually no trans fats. This makes it a very attractive oil for baking, frying, snack food and other uses.

Roundup Ready® Canola (Developed by Monsanto) Roundup Ready canola allows growers to apply Roundup® herbicide over-the-top of the crop during the growing season, for superior weed control with enhanced crop safety.

CORN

Rogers® brand Attribute® Bt Sweet Corn (Developed by Syngenta Seeds) Attribute™ insect-protected sweet corn varieties from Syngenta provide a high level of built-in protection against European corn borer and corn earworm, protecting crops from ear damage and yield loss.

Herculex® I Insect Protection (Developed by Dow AgroSciences and Pioneer Hi-Bred International, Inc.) These corn hybrids will provide broader spectrum control of insect pests than what is currently available, including first- and second-generation European corn borer, Southwestern corn borer, black cutworm and fall armyworm.

LibertyLink® Corn (Developed by Bayer CropScience) Introduced in 1997 in the United States and 1998 in Canada, LibertyLink Corn allows growers a wide application window to apply Liberty herbicide over-the-top during the growing season. Liberty herbicide kills over 100 grass and broadleaf weeds fast, without crop injury.

NK Knockout™ Corn, NK YieldGard™ Hybrid Corn (developed by Syngenta Seeds) Syngenta Seeds has produced several corn varieties that have been modified to provide natural protection against certain pests.

NK® brand YieldGard® (Bt 11) Corn (Developed by Syngenta Seeds) Syngenta Seeds has been producing and selling several corn hybrids since 1997 that have been modified to provide built-in protection against certain insect pests. (YieldGard is a registered trademark of the Monsanto Company.)

Roundup Ready® Corn (Developed by Monsanto) Approved in 1997, Roundup Ready Corn allows over-the-top applications of Roundup herbicide during the growing season for superior weed control.

YieldGard® Corn Borer (Developed by Monsanto Company) Introduced in 1997 in the United States, YieldGard Corn Borer hybrids offer season-long, whole-plant protection from the European corn borer and also controls the Southwestern corn borer.

YieldGard® Rootworm-Protected Corn (Developed by Monsanto) YieldGard corn carries built-in protection against corn rootworm. Current products include YieldGard Rootworm stacked with Roundup Ready technology. In addition, future products may be stacked with YieldGard Corn Borer or with both the corn borer and herbicide-tolerant traits. Research shows that YieldGard Rootworm offers significant benefits to corn growers including providing a more convenient approach to pest control that offers reduced exposure to insecticides, more consistent control of the corn rootworm and less overall environmental impact.

CARNATIONS

Moondust Carnation (Introduced in 1996 by Florigene [Formerly Calgene Pacific]) The first mauve carnation followed by Moonshadow (1998), a violet carnation. Carnations are among the species that account for 75 percent of worldwide flower sales. Conventional breeding failed to produce these flowers with hues in the mauve-blue-violet range because of a genetic gap; they lack the ability to produce the blue pigment, delphinidin. Florigene also has an active research and development program to extend the vase life of flowers.

COTTON

Bollgard® Insect-Protected Cotton (Developed by Monsanto) Introduced in 1996, cotton with Monsanto's Bollgard gene is protected against cotton bollworms, pink bollworms and tobacco budworms. Bollgard cotton is a great example of how biotechnology can reduce the amount of pesticide applications on a specific crop. According to the technology provider, growers using Bollgard technology sprayed an average of 2 1⁄2 less applications per acre than conventional cotton growers. This data is further underscored by EPA research. In just one year, 1999, EPA estimated that growers who planted Bollgard cotton reduced their insecticide application by 1.6 mil. lbs.

Bollgard® II Insect-Protected Cotton (Developed by Monsanto) Bollgard II is Monsanto's second generation of insect-protected cotton technology. This new cotton technology is designed to offer new benefits to cotton growers, including a broader spectrum of control of damaging insects and better defense against the development of resistance in target insects. Research indicates that Bollgard II will provide greater control of cotton bollworm, beet and fall armyworm, and soybean loopers compared with Bollgard.

Roundup® Ready Cotton (Developed by Monsanto) Approved in 1996, Roundup Ready cotton tolerates both over-the-top and postdirected applications of Roundup herbicide. Roundup Ready cotton provides growers with an excellent resource for practicing conservation tillage in their fields.

MILK PRODUCTION

Chymogen® (Developed by Genencor International and Marketed by Chr. Hansen's) Chymogen is the biotechnology-produced version of an enzyme (chymosin) found in calves that makes milk curdle to produce cheese. Because it is produced through biotechnology, it is purer, is more plentiful and eliminates variability in the quality and availability of the enzyme in calves' stomachs. It is used in approximately 60 percent of all hard-cheese products made today.

Posilac® Bovine Somatotropin (BST) (Developed by Monsanto) BST is a naturally occurring protein hormone in cows that induces them to produce milk. BST improves milk production by as much as 10 to 15 percent and is now used by farmers whose herds represent over 30 percent of the nation's cows. The FDA approved it in 1993.

ChyMax® (fermentation-derived) (Developed by Pfizer, marketed by Chr. Hansen's) ChyMax is another version of chymosin, an enzyme that causes milk to coagulate. It is an advanced fermentation ingredient that is of higher purity, quality and activity than natural rennet.

PAPAYA

Rainbow and SunUp (Developed by Cornell Research Foundation and the Papaya Administrative Committee) Rainbow, a yellow-fleshed hybrid between a conventional papaya and a genetically enhanced one; and SunUp, a red-fleshed transgenic papaya, have been enhanced to resist papaya ringspot virus (PRSV), the deadly disease which almost eliminated the papaya industry in the Hawaii during the 1990s.

PEANUTS

Flavr Runner Naturally Stable Peanut (Developed by Mycogen) Peanuts with modified fatty acid profile to produce nuts in high oleic acid. The benefit to the industry is longer life for nuts, candy and peanut butter.

RAPESEED

Laurical® (Developed by Calgene, LLC) A less expensive source of high-quality raw materials for soaps, detergents and cocoa butter replacement fats. Rapeseed plants with over 45 percent laurate in oil have been produced.

SOYBEANS

Roundup Ready® Soybeans (Developed by Monsanto) Introduced in 1996, Roundup Ready Soybeans allow growers to apply Roundup herbicide over-the-top during growing season. The result is dependable, superior weed control with no effect on crop performance or yield.

SUNFLOWERS

Naturally Stable Sunflower (Developed by Mycogen) Sunflowers with modified fatty acid profile to produce sunflower oil that contains virtually no trans-fatty acids. These naturally stable characteristics make this oil very attractive for nutritional drinks, release oils, baking frying snack foods and other uses.

AG BIOTECHNOLOGY PRODUCTS TO COME

ALFALFA

Roundup® Ready Alfalfa (Developed with Monsanto technology) Allows over-the-top applications of Roundup herbicide during the growing season for superior weed control.

APPLES

Bt Insect-Protected Apple (Developed with Monsanto technology) These apples will contain built-in insect protection against codling moth.

BANANAS

Disease-Resistant Bananas (Developed by DNA Plant Technology Corporation) These bananas will be resistant to the fungal disease black sigatoka.

Long-Shelf-life Banana (Developed by Syngenta) These bananas will maintain their ripeness for three to five days longer than conventional bananas. This is an important feature for consumers, growers, shippers and retailers of bananas.

CANOLA

Disease-Resistant Canola (Developed by DuPont) Canola that can resist yield-robbing diseases such as Sclerotina.

CORN

Improved Drought Response Corn (Developed by DuPont) Hybrid corn that can mine the existing moisture in the soil more efficiently or survive drought periods and still produce high yields.

Increased-Energy-Availability Corn (Developed by DuPont) Corn that livestock can more readily digest and more efficiently use nutrients in the grain.

Nutritionally Enhanced Corn (Developed by Dow AgroSciences) Corn hybrids that are "nutritionally enhanced" will provide higher energy and more abundant nutrients for a better-balanced ration formulation for livestock.

Rootworm-Resistant Corn (Developed by Dow Agro-Sciences and Pioneer Hi-Bred International, Inc.) These new hybrids will produce a protein that is toxic to the corn rootworm, thus eliminating or reducing the need for soil-applied insecticides. Corn hybrids containing this new trait will have built-in protection against western and northern corn rootworm. This will provide growers another choice in the marketplace other than traditional insecticides. In addition, this trait will be stacked with Herculex I Insect Protection to provide the broadest spectrum in-plant insect protection option available in the corn market.

Second-Generation YieldGard® Corn Borer (Developed by Monsanto) The second-generation corn borer protected product in the YieldGard family is expected to provide an even broader spectrum of insect control than today's YieldGard. In addition to the control of the European and southwestern corn borer, field trials indicate it will provide enhanced control of the corn earworm, fall armyworm and black cutworm. The next-generation corn-borer protected corn will contain a new gene with a unique mode of action compared with YieldGard Corn Borer or other products on the market, thus providing a defense against insect resistance and ensuring that insect-protected products will remain effective and continue to deliver benefits for many years to come.

Corn Amylase for Enhanced Ethanol Production (Developed by Syngenta) Amylase breaks starch down to sugar and including amylase expression in processor corn has the potential to reduce the costs of ethanol production up to 10 percent.

Glyphosate-Tolerant Corn (Developed by Syngenta) Developed from a plant-derived glyphosate-resistant gene that is evenly expressed throughout the plant, this new corn hybrid will give farmers another tool for managing weed pests.

Insect-Resistant Corn (Developed by Syngenta) Second-generation Bt control for both European corn borer and corn rootworm. Will be stacked with the Vegetative Insecticidal Protein technology to provide growers broader insect management controls.

COTTON

Insect-Protected Cotton (Developed by Dow AgroSciences) This new trait will provide a broader spectrum of insect protection than any other product currently on the market. This trait protects against a broad spectrum of damaging lepidopteran pests, including cotton bollworm, pink bollworm, tobacco budworm, armyworms and loopers.

LibertyLink® Cotton (Developed by Bayer CropScience) LibertyLink cotton allows growers a wide application window to apply Liberty herbicide over-the-top during the growing season. Liberty herbicide kills over 100 grass and broadleaf weeds fast, with no crop injury. LibertyLink cotton will be offered in top FiberMax® varieties.

Next-Generation Roundup-Ready Cotton (Developed by Monsanto) Next Generation Roundup Ready cotton is expected to provide growers with an expanded window of application of Roundup herbicide. At this time, Monsanto does not expect that Next Generation Roundup Ready will be in the marketplace before 2006.

Vegetative Insecticidal Protein Cotton (Developed by Syngenta) This second-generation insect control has a broader spectrum and a novel mode of action. VIP Cotton will provide growers an alternative to existing Bt producers and will improve grower flexibility in managing insect resistance.

LETTUCE

Roundup® Ready Lettuce (Developed with Monsanto technology) Allows over-the-top applications of Roundup herbicide during the growing season for superior weed control.

RICE

LibertyLink® Rice (Developed by Bayer CropScience) Bayer CropScience is obtaining appropriate regulatory clearances in key countries. When LibertyLink Rice is used together with Liberty herbicide, it will allow farmers greater weed control flexibility and may promote water conservation.

SOYBEANS

Insect-Protected Soybeans (Developed by Monsanto) These soybeans will contain built-in insect protection to key soybean insect pests.

LibertyLink® Soybeans (Developed by Bayer CropScience) Bayer CropScience is obtaining appropriate regulatory clearances in key countries. When used together with Liberty herbicide, it will allow farmers greater weed control flexibility. (It is not in commercial production at this time.)

Soybeans with Improved Protein Functionality (Developed by DuPont) Food soy ingredient that does a better job of improving quality and consistency of food products.

STRAWBERRIES

Strawberry (Developed by DNA Plant Technology Corporation) The company is adding genes to confer resistance to glyphosate herbicide and fungal diseases.

SUGAR BEETS

Roundup Ready® Sugar Beets (Developed by Monsanto) Roundup Ready sugar beets are tolerant of Roundup herbicide and provide growers with a new weed-control option while the crop is growing.

TURF GRASS

Roundup® Ready Creeping Bentgrass (Developed with Monsanto technology) Allows over-the-top applications of Roundup herbicide to control Poa Annua, Poa Trivialis and other weeds of turf on golf course fairways and greens allowing more flexible weed control and reduced turf management inputs.

WHEAT

Roundup Ready® Wheat (Developed by Monsanto) Allows over-the-top applications of Roundup herbicide during the growing season for superior weed control and better crop safety than conventional herbicides.

Fusarium Resistant Wheat (Developed by Syngenta) Fusarium head blight, commonly known as scab, is a fungal disease that affects wheat quality and yields. Fusarium-resistant wheat has the potential to provide farmers another tool for managing this significant wheat disease.

MISCELLANEOUS

AquaAdvantage® Salmon, Tilapia, Trout and Flounder (Developed by Aqua Bounty Farms) The AquaAdvantage salmon have the capability of growing from egg to market size (6 to 10 lb.) in one to one-and-a-half years. Conventional fish-breeding techniques require two to three years to bring a fish to market. This new salmon could make fish farming more environmentally sustainable, decrease over-fishing of wild salmon and lower consumer costs. Aqua Bounty expects to introduce the AquaAdvantage salmon within two to three years to a public for whom salmon is an increasingly popular food.

Genetically Modified Fruits and Vegetables with Longer Postharvest Shelf Life (Developed by Agritope, Inc., a wholly owned subsidiary of Epitope, Inc.) Using ethylene-control technology, Agritope, Inc., has created delayed-ripening, longer-lasting tomatoes and raspberries.

Phytase for Animal Feed (Developed by Syngenta and Zymetrics) The phytase enzyme releases phosphorous-based nutrients in animal feed in a form that can be easily digested by single-stomach animals such as pigs, chickens and turkeys. A phytase supplement can enhance the nutritional value of the feed and reduce phosphorus levels in animal manure, which can help improve environmental quality. The new microbial (Zymetrics) and corn phytase (Syngenta) supplements are designed with enhanced thermostability, which provides livestock producers more options in developing feed rations.

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