

# Healing, Fueling, Feeding: How Biotechnology Is Enriching Your Life.





Heal

Heal

## Injections of Hope: Protecting the Most Vulnerable

**20**

the number of **infectious diseases for which vaccines have been developed**—  
many of them for children

**33,000**

the number of **deaths prevented** in the U.S. each year by the recommended  
immunization series

**2.5 million**

the number of **childhood deaths prevented** worldwide each year by  
immunization

**10.5 million**

the number of **cases of infectious diseases prevented** in the U.S each by the  
recommended immunization series

Sources: (1) Zhou, et al, "Economic Evaluation of Routine Childhood Immunization with DTaP, Hib, IPV, MMR and Hep B Vaccines in the United States," Pediatric Academic Societies Conference, Seattle, Washington, May 2003. (2) WHO, UNICEF, and World Bank. State of the World's Vaccines and Immunization, Third Edition. November 2009. Available at [http://whqlibdoc.who.int/publications/2009/9789241563864\\_eng.pdf](http://whqlibdoc.who.int/publications/2009/9789241563864_eng.pdf).

# Injections of Hope: The Impact of Vaccines on Infectious Disease

*Vaccines have helped bring about significant declines in the rates of infectious diseases, including a 78% global decline in measles since 2000, the complete global eradication of smallpox by 1980, and the eradication of polio in the Americas by 1994.*

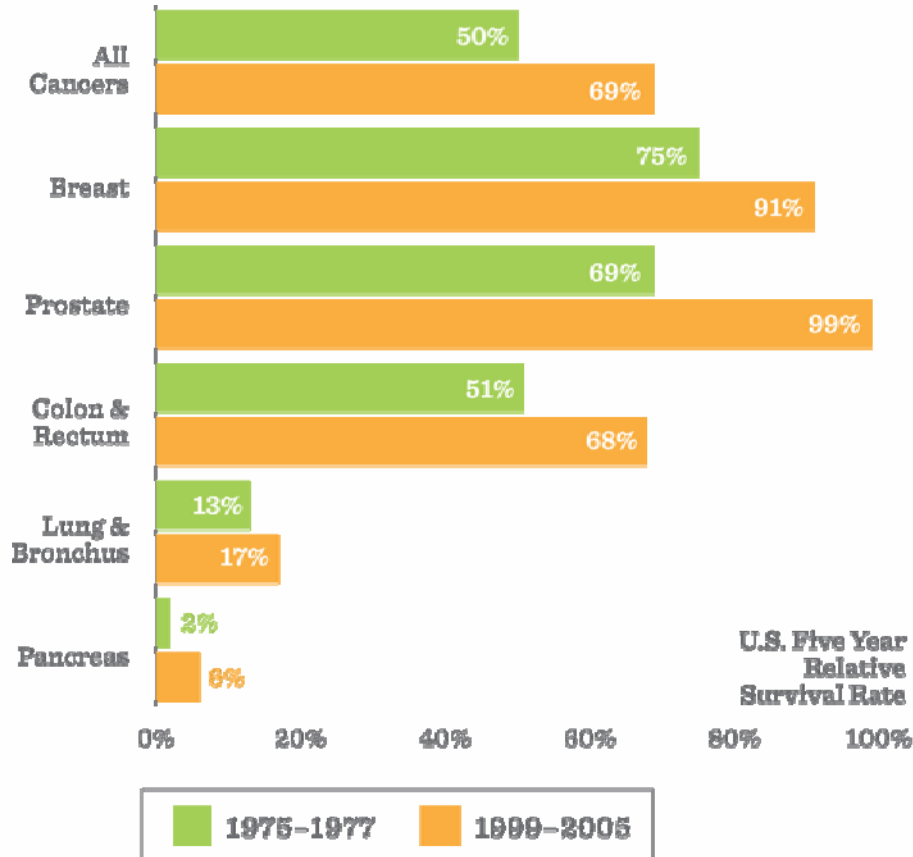
	<b>AVG. ANNUAL U.S. CASES, BEFORE VACCINE</b>	<b>PEAK ANNUAL U.S. DEATHS, BEFORE VACCINE</b>	<b>DECLINE IN U.S. CASES</b>	<b>DECLINE IN U.S. DEATHS</b>
<b>Diphtheria</b>	21,053	3,065	100%	100%
<b>Measles</b>	530,217	552	99%	100%
<b>Mumps</b>	162,344	50	96%	100%
<b>Polio</b>	16,316	5,865	100%	100%
<b>Rubella</b>	47,745	2,184	99%	100%
<b>Tetanus</b>	580	511	93%	99%
<b>Whooping cough</b>	200,752	7,518	92%	99%
<b>Chickenpox</b>	4,085,120	138	85%	82%
<b>Hepatitis A</b>	117,333	298	87%	87%
<b>Acute hepatitis B</b>	66,232	267	80%	80%
<b>Invasive pneumococcal disease</b>	63,067	7,300	34%	25%

Source: USA Today. "Missed vaccines weaken 'herd immunity' in children." By Liz Szabo. January 6, 2010. Available at: [http://www.usatoday.com/news/health/2010-01-06-childhoodvaccines06\\_CV\\_N.htm](http://www.usatoday.com/news/health/2010-01-06-childhoodvaccines06_CV_N.htm). Accessed Feb. 5, 2010.

# Fighting Cancer

*Biotech therapies are helping improve the prognosis for cancer patients by increasing survival rates.*

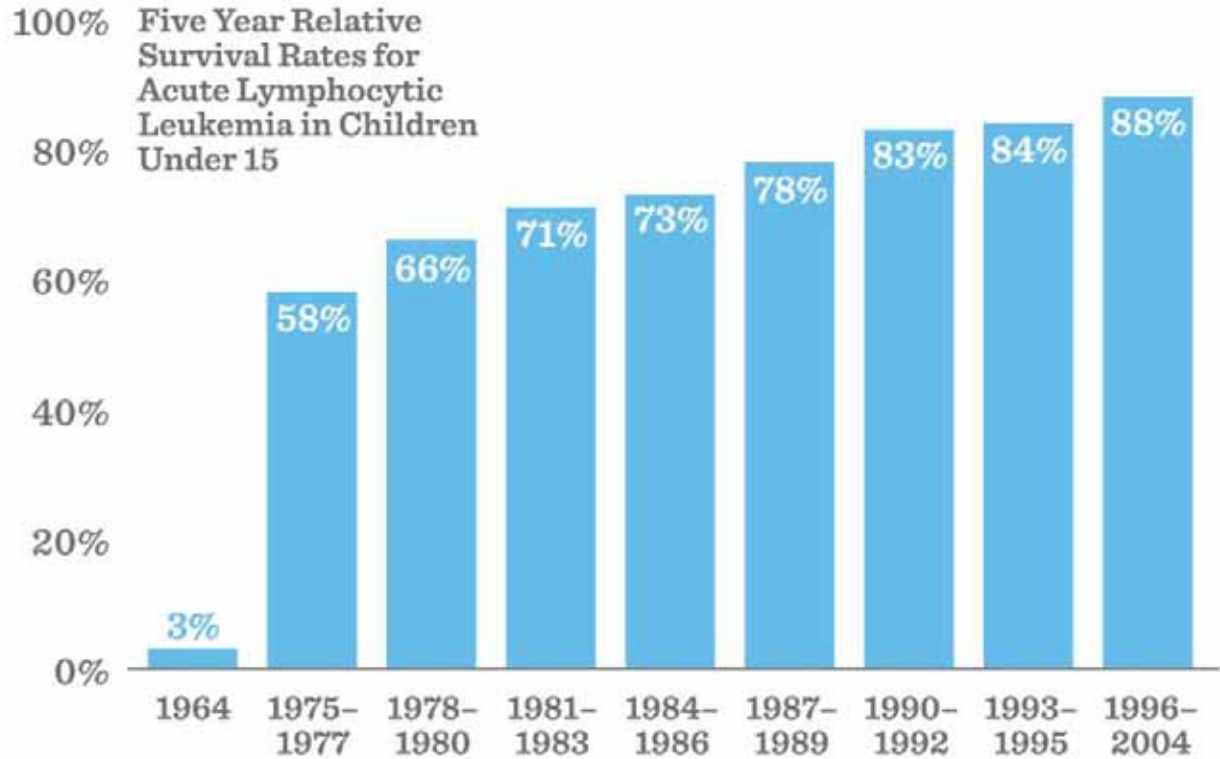
*U.S. Five Year Relative Survival Rates for Selected Cancers*



Source: National Cancer Institute, "SEER Cancer Statistics Review 1975-2006," 2004. Available at <http://www.seer.cancer.gov/>.

# The Life-Saving Impact of Biotech Therapies

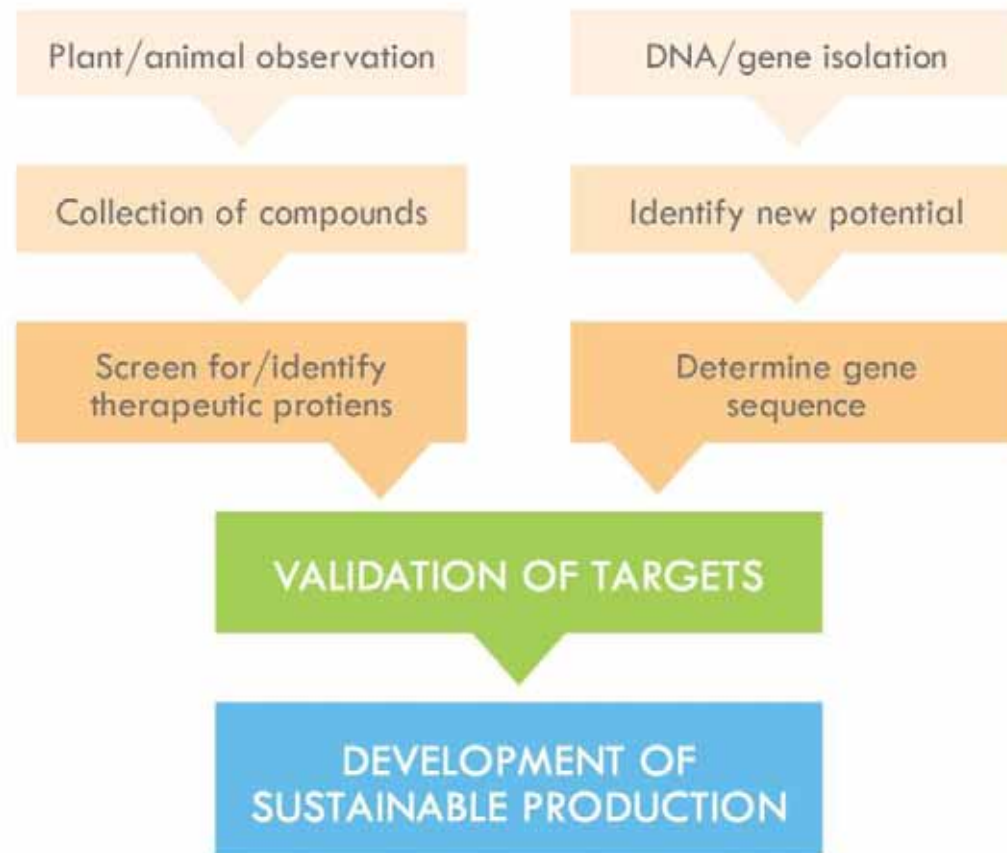
*For a host of diseases, biotechnology is helping change the prognosis for patients by helping them live longer at a higher quality of life. Childhood lymphocytic leukemia is just one example.*



Sources: (1) Zuelzer, W.W. Implications of long-term survivals in acute stem cell leukemia of childhood treated with composite cyclic therapy. *Blood*. 1964; 24:477-494. (2) SEER (Surveillance, Epidemiology and End Results) Cancer Statistics Review 1975-2005. National Cancer Institute, 2008.

# Biotech Research and Discovery

*The biotechnology research and development process is constantly evolving as technology advances. The process below is illustrative; certain steps may occur simultaneously or at different points depending on the specific application under development.*



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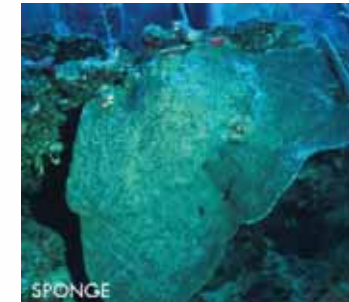
# From Nature to Medicine: Biotechnology Drug Therapies

*Dozens of plant and animal inspired biotech therapies are approved and currently in clinical use, and many more hold promise.*

CONDITION	COMPOUND	SOURCE ORGANISM	GEOGRAPHIC ORIGIN
Cancer	Aplidine	Tunicate	Mediterranean
	Bryostatin 1	Bryozoan	Gulf of California
	Didemnin B	Tunicate	Caribbean
	Dolastatin 10	Sea Hare	Indian Ocean
	Ecteinascidin-743	Tunicate	Caribbean
	Halichondrin B	Sponge	Japan
	Kahalaide F	Gastropod	Hawaii
	Mycaperoxide B	Sponge	
	Taxol	Bark of a Pacific yew tree	California
HIV	Cyclodidemniserinol trisulfate	Tunicate	Palau
	Lammellarin a 20 sulfate		Australia
Asthma	Contignasterol	Sponge	New Guinea
Pain	Conotoxins	Gastropod	Tropical Pacific
Diabetes	Byetta	Gila monster saliva	Southwestern U.S.
Chronic Pain	ziconotide	Cone snail	Philippine Islands



CONE SNAIL



SPONGE

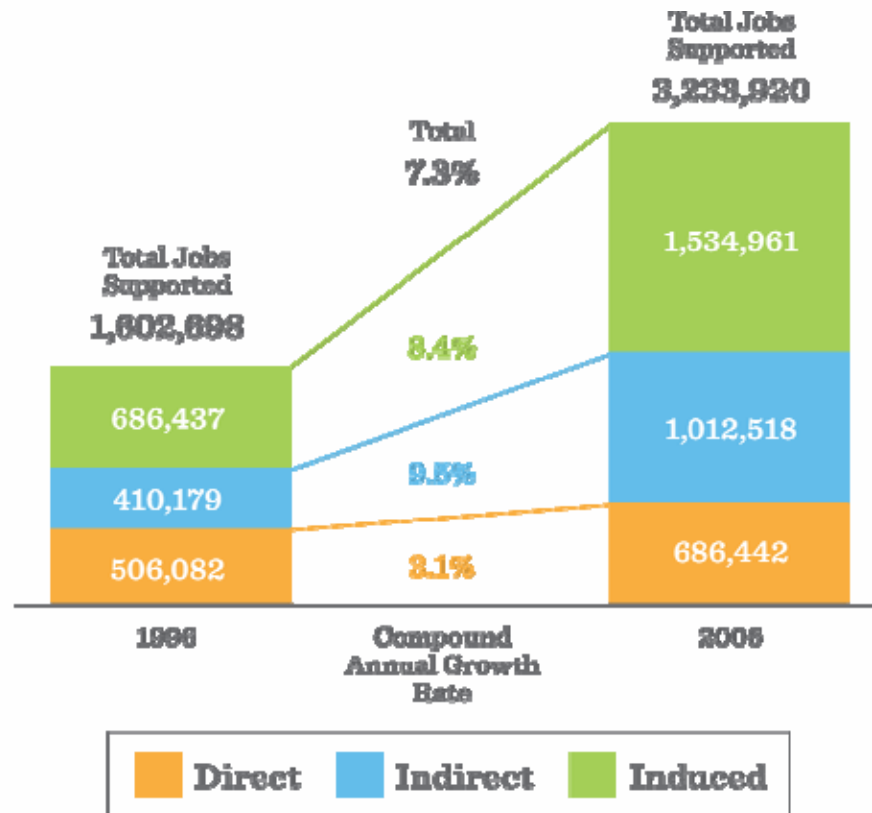


GILA MONSTER

# Keeping America Competitive

1.3 million people were employed by the biotech industry in 2006, and these jobs generated 6.2 million related jobs throughout the rest of the economy, a job multiplier of 5.8.

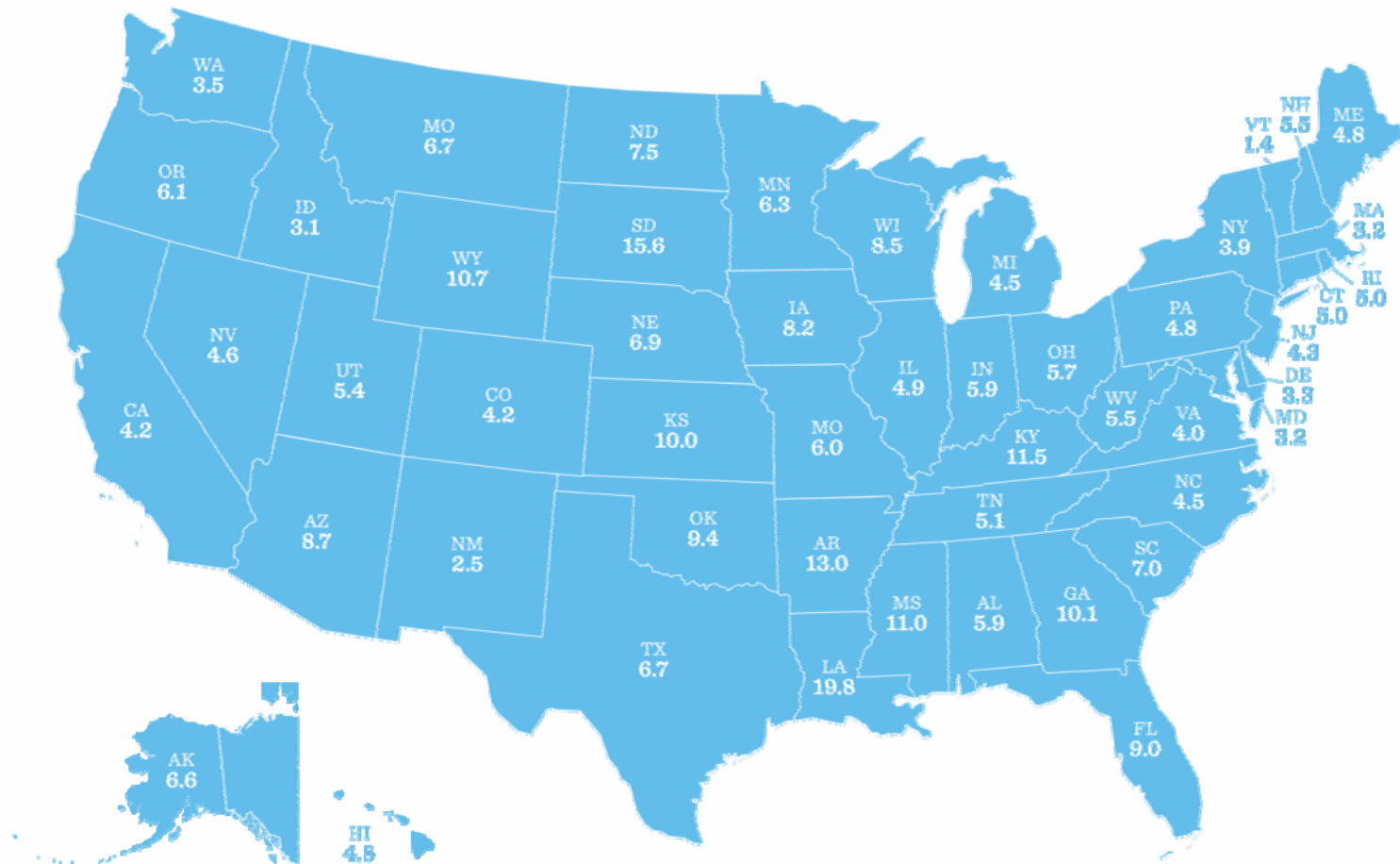
## Employment Supported by the U.S. Biopharmaceutical Sector, 1996-2006



Source: Archstone Consulting. The Biopharmaceutical Sector's Impact on the U.S. Economy: Analysis at the National, State, and Local Levels. March 2009. Available at <http://www.archstoneconsulting.com/biopharma.aspx>.

# 3.2 Million Jobs and Counting

Every new job in the biopharmaceutical sector also generates new jobs in other industries. This is called the employment multiplier. For example, an employment multiplier of 4.5 would mean that each new biopharmaceutical job generates 3.5 new jobs in other industries. Below, we capture the biopharmaceutical employment multiplier for each individual state.

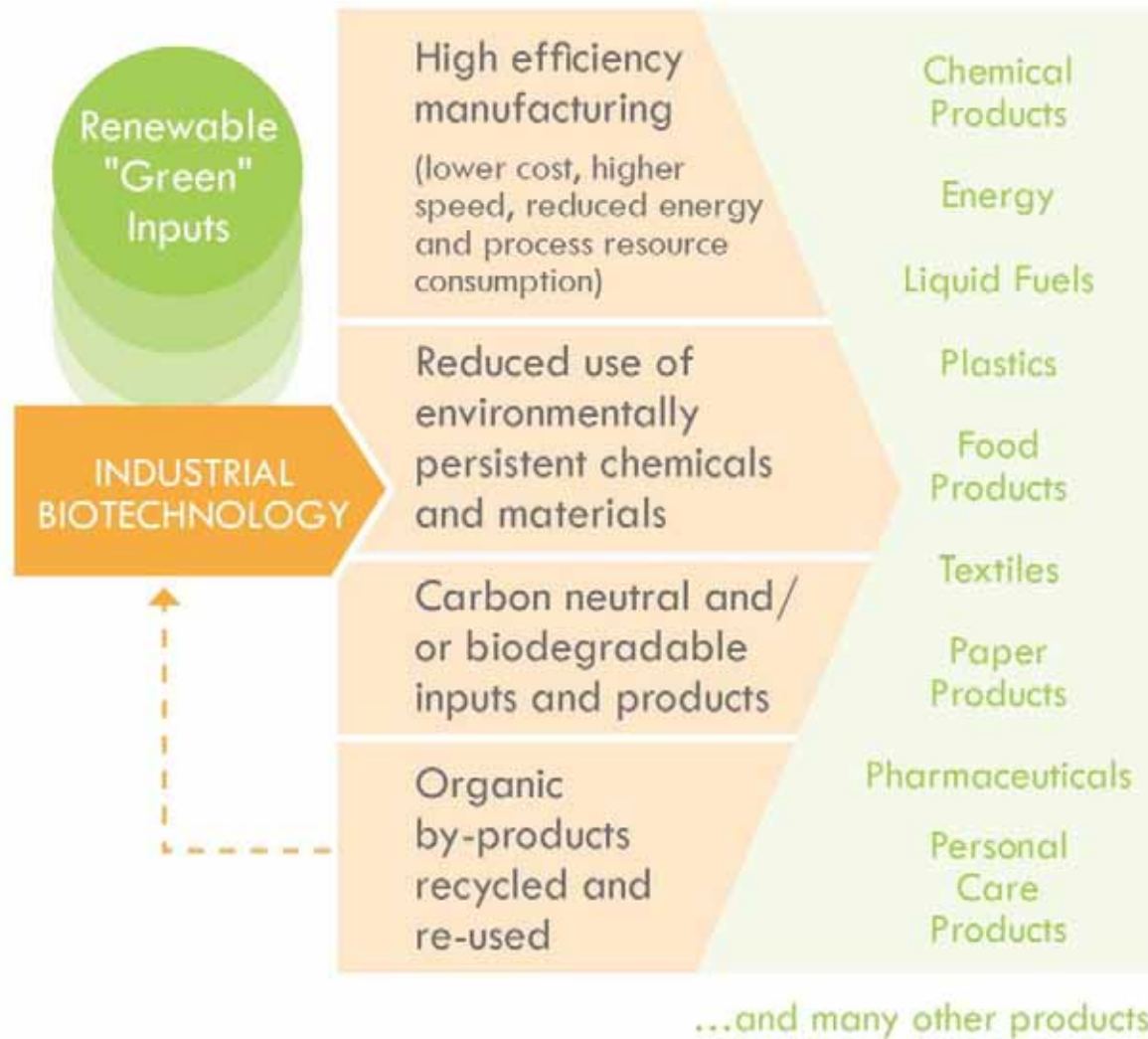


Source: Archstone Consulting. The Biopharmaceutical Sector's Impact on the U.S. Economy: Analysis at the National, State, and Local Levels. March 2009.



Fuel

# Industrial Biotech Provides Solutions to Sustainable Production of Key Goods and Commodities



## How to Save \$4.1 Billion per Year on Laundry

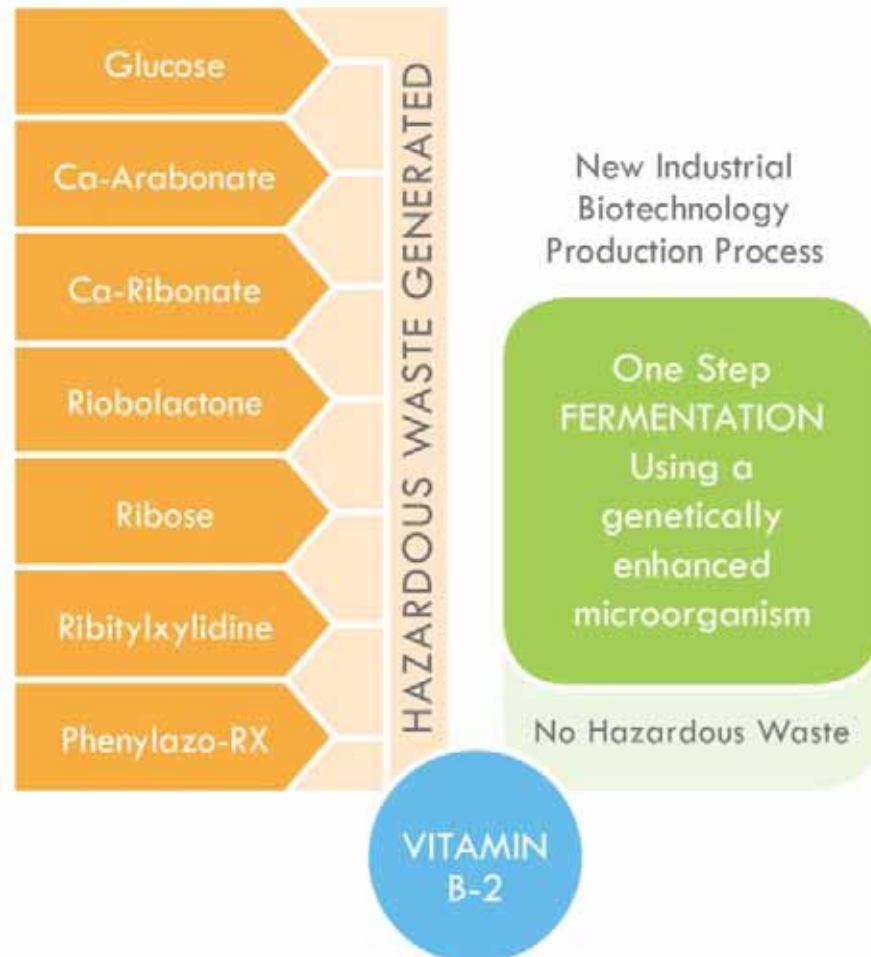
- Biotech detergents help **save energy and money by reducing the temperature** needed to wash clothes.
- By washing at 86°F (30°C) rather than 140°F (60°C), the CO<sub>2</sub> savings potential in the U.S. and Europe alone is around **32 million tons annually**—the equivalent of the emissions from **8 million cars**.
- The net impact: **\$4.1 billion** in energy savings.



Sources: Novozymes. "The Novozymes Report: 2009." Accessed online at: [http://www.novozymes.com/NR/rdonlyres/3F4146B7-9AFD-4D62-9E2B-E538FBD2A953/0/NZ6370031\\_SummaryEN09\\_S.pdf](http://www.novozymes.com/NR/rdonlyres/3F4146B7-9AFD-4D62-9E2B-E538FBD2A953/0/NZ6370031_SummaryEN09_S.pdf); Orrin Cook. 2006. "Energy Tip #17: Wash and Rinse in Cold Water." Terrapass. October 2006. Accessed online at: <http://www.terrapass.com/blog/posts/energy-tip-17-w>.

Fuel

# Streamlining Manufacturing Processes: The Case of Vitamin B-2



- The industrial biotechnology process for manufacturing vitamin B-2 took a laborious and costly traditional multi-chemical synthesis and purification process and reduced it to a **one-step fermentation process**.
- The simplified process resulted in a **30% reduction of CO<sub>2</sub> emissions** and a **95% reduction in waste production**.

Source: Oliver Wolf. Presentation at the "The Biotechnology for Europe Study: Modern Biotechnology in Industrial Production Processes, energy and the Environment". Bio4EU Symposium, 20 April 2007. European Commission DG Joint Research Centre, Institute for Prospective Technological Studies

# Biofuels: Reducing Our Carbon Footprint

- First-generation corn-to-ethanol plants reduce greenhouse gas emissions by as much as **52%** over petroleum-based fuels.
- In 2010, the U.S. EPA designated Brazilian sugarcane ethanol as an advanced biofuel due to its **61%** reduction of total life cycle greenhouse gas emissions.
- Ethanol made from cellulosic feedstocks (e.g., switchgrass), agricultural residues (e.g., corn stover), or wood forest residues has the potential to reduce greenhouse gas emissions by as much as **129%**, compared to gasoline.



Source: U.S. Environmental Protection Agency. Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis, EPA-410-R-10-006. February 2010, p.426. Available at <http://www.epa.gov/otaq/renewablefuels/420r10006.pdf>

# Taking Industrial Biotech Home: New Benefits for Consumers

CONSUMER PRODUCT	OLD NON-BIOTECH MANUFACTURING PROCESS	NEW INDUSTRIAL BIOTECH PROCESS	ENVIRONMENTAL SUSTAINABILITY BENEFITS	CONSUMER BENEFIT
 <p>Bread</p>	Potassium bromate, a suspected cancer-causing agent at certain levels, added as a preservative and a dough strengthening	Genetically enhanced microorganisms produces baking enzymes to <ul style="list-style-type: none"> <li>• Enhance rising</li> <li>• Strengthen dough</li> <li>• Prolong freshness</li> </ul>	Reduces CO <sub>2</sub> emissions in grain production, milling and baking and transportation	<ul style="list-style-type: none"> <li>• High-quality bread</li> <li>• Longer shelf life</li> <li>• Eliminates suspected carcinogen potassium bromate</li> </ul>
 <p>Personal Care</p>	Chemical ingredients such as propylene glycol and butylenes glycol from petroleum used as solvents to mix ingredients	Genetically enhanced microbe produces 1,3 propanediol from renewable feedstocks, which can function as a solvent, humectant, emollient or hand-feel modifier	20% reduction of greenhouse gas emissions compared to petroleum PDO	<ul style="list-style-type: none"> <li>• High purity</li> <li>• Environmentally sustainable and renewable process</li> <li>• Non-irritating for sensitive skin</li> <li>• Enhanced clarity</li> </ul>
 <p>Cosmetics</p>	Mineral oil and petroleum jelly from fossil sources used as ingredients	Metathesis chemistry applied to convert renewable vegetable oils to replacement ingredients	<ul style="list-style-type: none"> <li>• Reduction of process temperatures</li> <li>• Low toxicity products and byproducts</li> </ul>	<ul style="list-style-type: none"> <li>• Smoother, less greasy feel</li> <li>• Semi-occlusive film former</li> <li>• Enhanced hair-care properties</li> </ul>
 <p>Detergent</p>	Phosphates added as a brightening and cleaning agent	Microbes or fungi genetically enhanced to produce biotech enzymes, which are added as brightening and cleaning agents <ul style="list-style-type: none"> <li>• Protease enzymes remove protein stains</li> <li>• Lipases remove grease</li> <li>• Amylases remove starch</li> </ul>	Elimination of water pollution due to phosphates	<ul style="list-style-type: none"> <li>• Brighter, cleaner clothes with lower wash temperature</li> <li>• Energy savings</li> </ul>
 <p>Textiles</p>	New cotton textiles prepared with chlorine or chemical peroxide bleach	Use of biotech cellulose enzymes to produce peroxides <ul style="list-style-type: none"> <li>• allows low-temperature bleaching of textiles, at 65°C, and</li> <li>• at a neutral pH range</li> </ul>	<ul style="list-style-type: none"> <li>• 25% reduction in greenhouse gases</li> <li>• 25% reduction in non-renewable energy use</li> </ul>	New fabrics have <ul style="list-style-type: none"> <li>• lower impact on the environment</li> <li>• better dyeing results</li> <li>• a permanent soft and bulky handle</li> </ul>
 <p>Paper</p>	Wood chips are boiled in a harsh chemical solution to yield pulp for paper making	Wood bleaching enzymes produced by genetically enhanced microbes to selectively degrade lignin and to break down wood cell walls during pulping	Reduces use of chlorine bleach and dioxins in the environment	Cost savings from lower energy and chemical use

# Taking Industrial Biotech Home

Enzymes clean clothes and dishes at lower temperatures than chemical detergents, saving energy.

Enzymes can keep fruits from breaking apart in baked goods.

Enzymes help to extract more fermentable sugars from fruits and starchy vegetables (potatoes) to produce more alcohol or wine, more efficiently.

Enzymes also extract harmful substances from corks, to prevent off-tastes in wine.

Enzymes can help reduce the amount of bleaching needed for paper production. And, enzymes can also remove inks from paper to be recycled.

Enzymes remove more types of stains and soils from clothes than chemical detergents, without bleaching dyes from fabrics.

Fabrics can be pretreated with enzymes to change their texture without wear on the fibers, making them more durable and longer-lasting.



Microorganisms can safely remove more protein stains and mold from carpets and other fabrics.

Enzymes can speed up fermentation in beer.

Enzymes can convert trans fats to more healthful fats in oils.

Enzymes convert the starch in corn, potatoes and other grains to sugars for use in sweeteners and sodas.

Bread baked with enzymes remains fresh longer.

Enzymes allow us to get every single drop of juice out of fruits.

Enzymes can replace harsh chemicals in pretreatment of cotton and in leather softening. Enzymes are biodegradable, cheaper, and less damaging to fabrics.

Enzymes help animals to digest food better, promoting better nutrition and less waste.

# By the Numbers: U.S. Economic Impact of Advanced Biofuels Production

- Impact on job creation could reach:
  - **29,000** direct jobs created by 2012
  - **94,000** direct jobs created by 2016
  - **190,000** direct jobs by 2022
  - Total job impacts (direct and indirect) could reach:
    - **123,000** in 2012
    - **383,000** in 2016
    - **807,000** by 2022.
- Economic output generated by the advanced biofuels industry could reach:
  - **\$20.2 billion** by 2012
  - **\$64.2 billion** by 2016
  - **\$148.7 billion** by 2022
- Anticipated cumulative reduction in petroleum imports over the period 2010-2022 would exceed **\$350 billion.**



Source: "U.S. Economic Impact of Advanced Biofuels Production: Perspectives to 2030." Bio Economic Research Associates. February 2009.

## Benefits of Harnessing the Biobased Economy

- ✓ **Improved national energy security**
  - Reduced reliance on foreign sources of energy
  - Decreased threat of supply disruptions due to natural disasters, political instability, and price volatility
- ✓ **Increased economic growth**
  - Economic opportunities for domestic, rural economies
  - Decreased petroleum trade deficit
- ✓ **Broad-based environmental benefits**
  - Reduced greenhouse gas emissions
  - Reduced petroleum use in fuel production.



Source: U.S. Department of Energy. "Biomass Benefits." U.S. DOE Energy Efficiency and Renewable Energy. Accessed online at: [http://www1.eere.energy.gov/biomass/biomass\\_benefits.html](http://www1.eere.energy.gov/biomass/biomass_benefits.html)

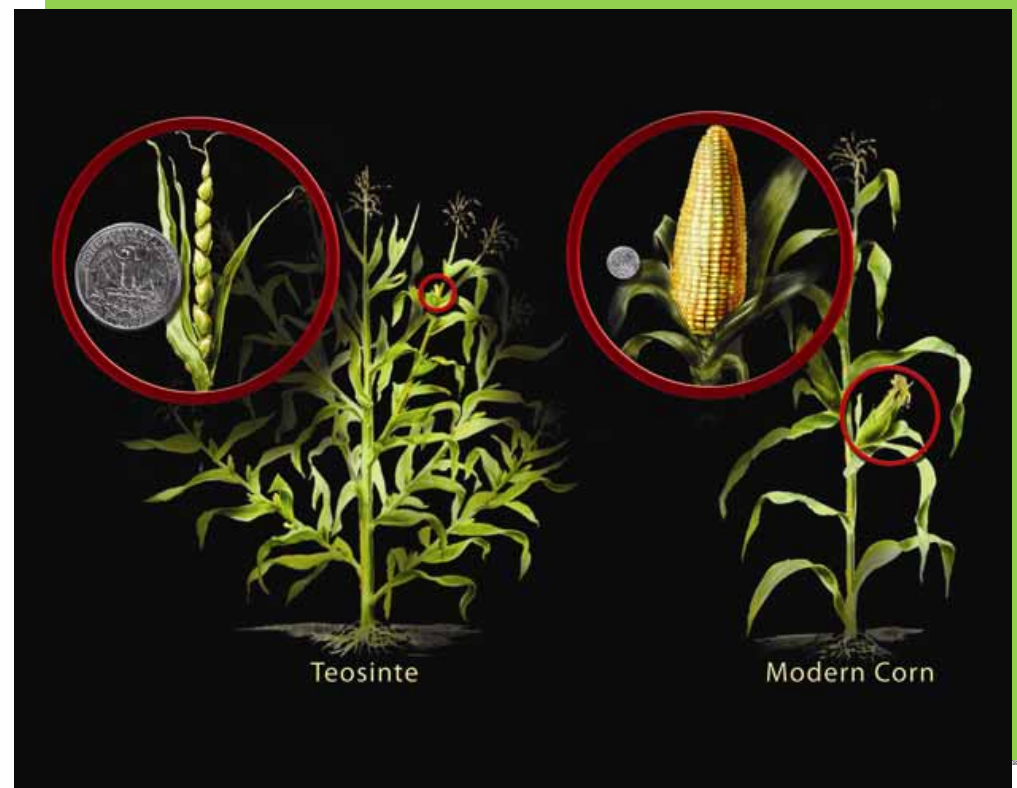


Feed

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# Crop Improvement: Empowering Human Progress through Biotechnology

*The original wild grass ancestor of modern corn bears little resemblance to modern corn because of humankind's selective breeding and hybridization of the plant.*

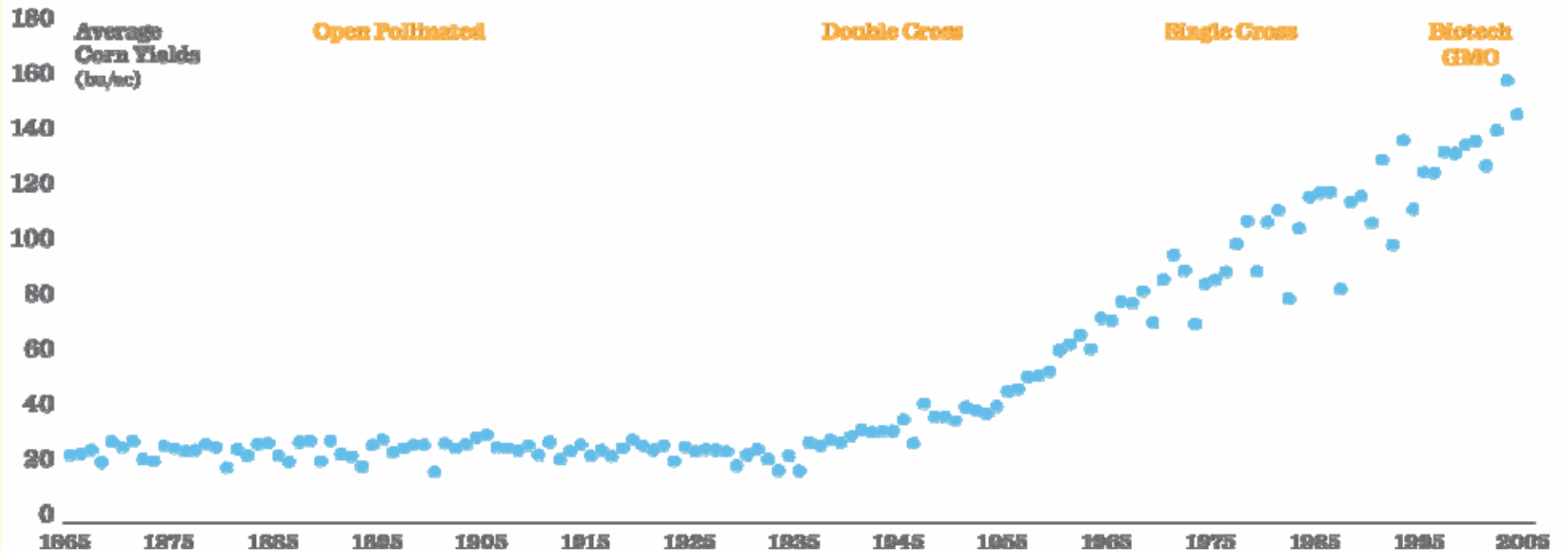


*Illustration by Nicolle Rager Fuller, National Science Foundation.*

# How to Feed 7 Billion People

*Biotech crops are at the forefront of increasing agricultural yields. U.S. Department of Agriculture data on annual corn yields dramatically illustrate the extent to which crop improvements, via selective breeding and hybridization, led to large-scale yield increases from the 1960s through the mid-1990s, and how (starting in 1997) biotechnology has allowed the trend in yield gains to continue. Harnessing these biotech improvements globally is increasingly necessary to feed the expanding population.*

*Average U.S. corn yields and kinds of corn, 1865 to 2004*

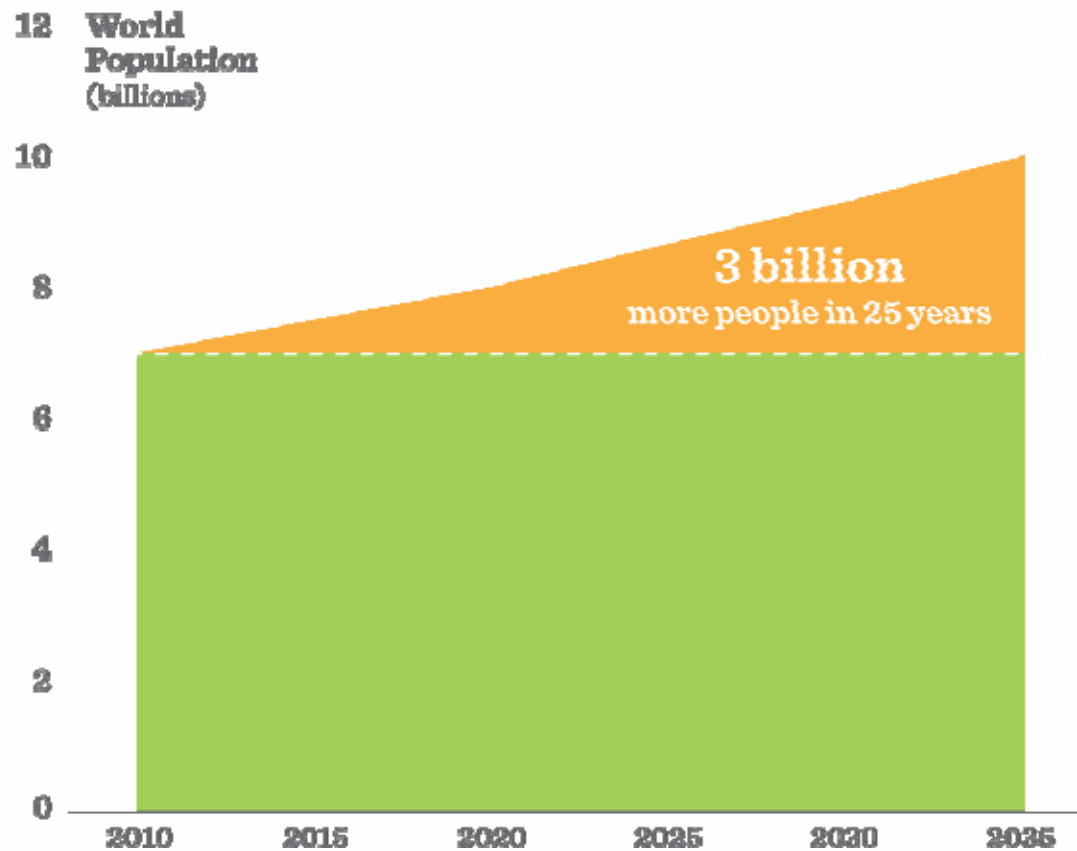


Sources: (1) USDA-NASS Data 2005. (2) A. Forrest Troyer 2006. "Adaptedness and Heterosis in Corn and Mule Hybrids." *Crop Science* 46:528-543 (2006).

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# Biotechnology: Mitigating the Impact of Population Expansion

*The expanding population will increase demands on agricultural land, water, energy, and natural resources—and the use and consumption of these resources impact the global environment. Biotechnology can help meet these challenges.*



Source: University of North Carolina. Ibiblio.org services. Accessed online at: <http://www.ibiblio.org/lunarbin/worldpop>.

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## Bt Technology Improves Crop Yield and Saves Money while Reducing Herbicide and Pesticide Use

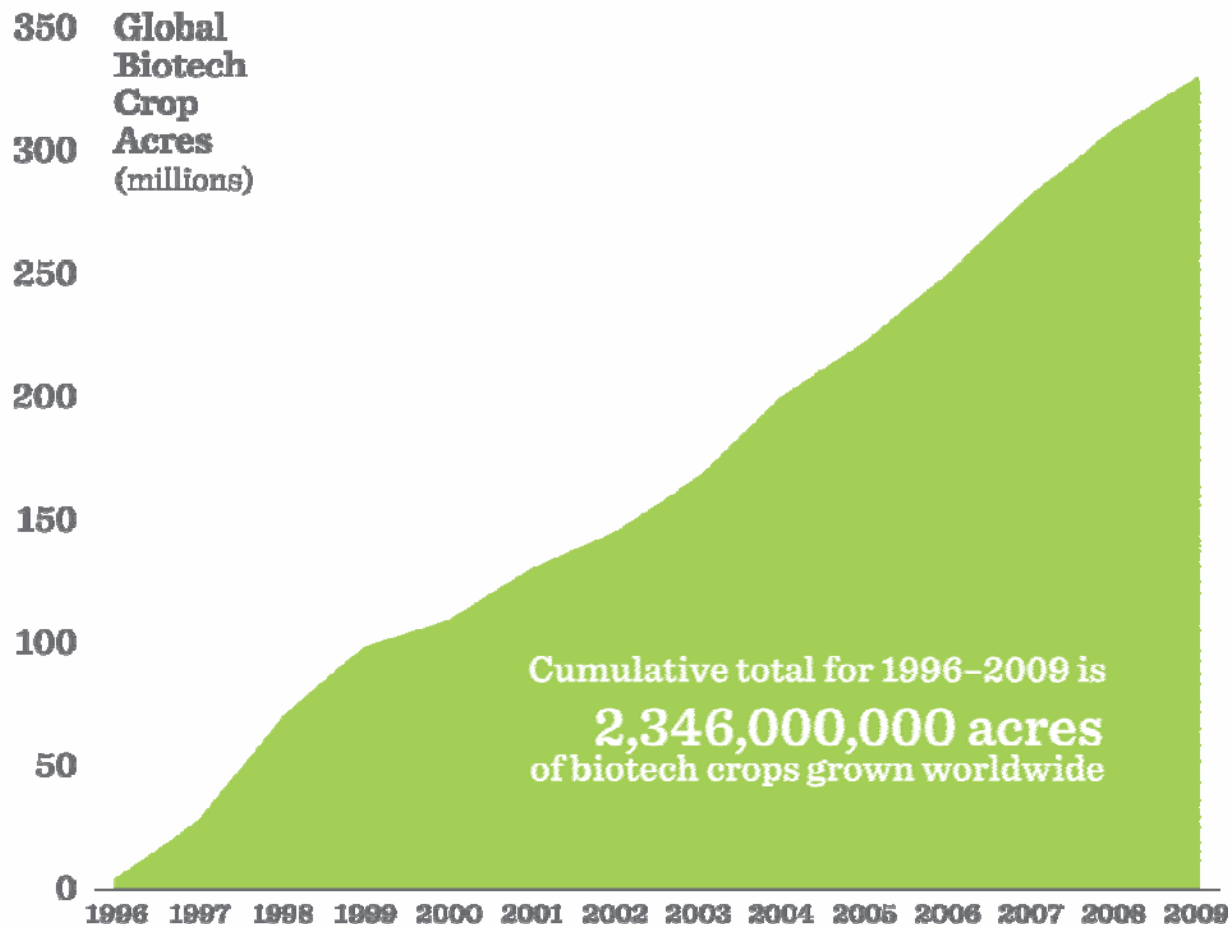
“With the old seed, I used to plant it, and then when it was knee-high, I had to go and buy chemicals to control the insects. With this new seed, I don’t have to buy the chemicals anymore...so I just plant it and leave it. And my life is now easier and better.”

—Elizabeth Jele, South African Cotton farmer



Source: “Biotech Crops Reduce Use of Pesticides Worldwide: Growers Reduce Pesticide Applications by 172,000 metric Tons Between 1996-2004.” in Monsanto Corporation, “Conversations about plant biotechnology: Discussions with farmers and experts around the world.” [www.monsanto.com/biotech-gmo/asp/topic.asp?id=PesticideReduction](http://www.monsanto.com/biotech-gmo/asp/topic.asp?id=PesticideReduction).

# Between 1996 and 2009 More than 2.3 Billion Acres of Biotech Crops Were Grown



Source: Data sourced from Clive James, 2008. "Global Status of Commercial Biotech/GM Crops: 2008." ISAAA Briefs No. 39. ISAAA: Ithaca, NY.

# Nations Growing Biotech Crops in 2009



Source: Data sourced from Clive James, 2009. "Global Status of Commercial Biotech/GM Crops: 2009." ISAAA Briefs No. 41. ISAAA: Ithaca, NY.

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## Biotech Crops Are at the Forefront Of Increasing Agricultural Yields

	1996-2007 ADDITIONAL PRODUCTION [MILLION TONS]	2007 ADDITIONAL PRODUCTION ALLOCABLE TO BIOTECH CROPS [MILLION TONS]	PERCENT CHANGE IN 2007 PRODUCTION ON AREA OF LAND PLANTED WITH BIOTECH CROPS
Soybeans	74.7	15.9	32.8
Corn	68.8	16.6	8.4
Cotton	7.5	2.2	21.8
Canola	4.9	0.6	9.4

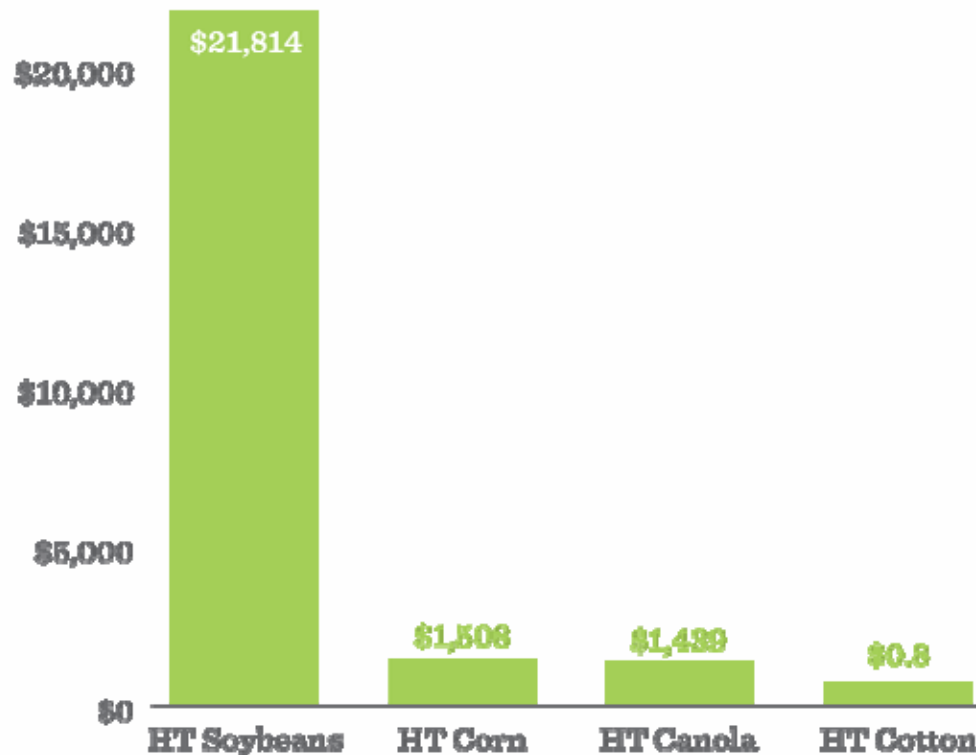
*It takes one-third of a ton of grain to sustain one person for one year (current global average). Therefore an additional 16 million tons of corn produced by biotech crops could potentially feed 48 million people.*

Source: PG Economics, Ltd. "Focus on Yields. Biotech crops: evidence, outcomes and impacts 1996-2007".

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# Farm Incomes Benefit Significantly from Herbicide Tolerant Biotechnology

*Cumulative Farm Income Benefits of Herbicide Tolerant Soybeans, Corn, Canola, and Cotton: 1996-2007*  
**Income Benefits (millions)**

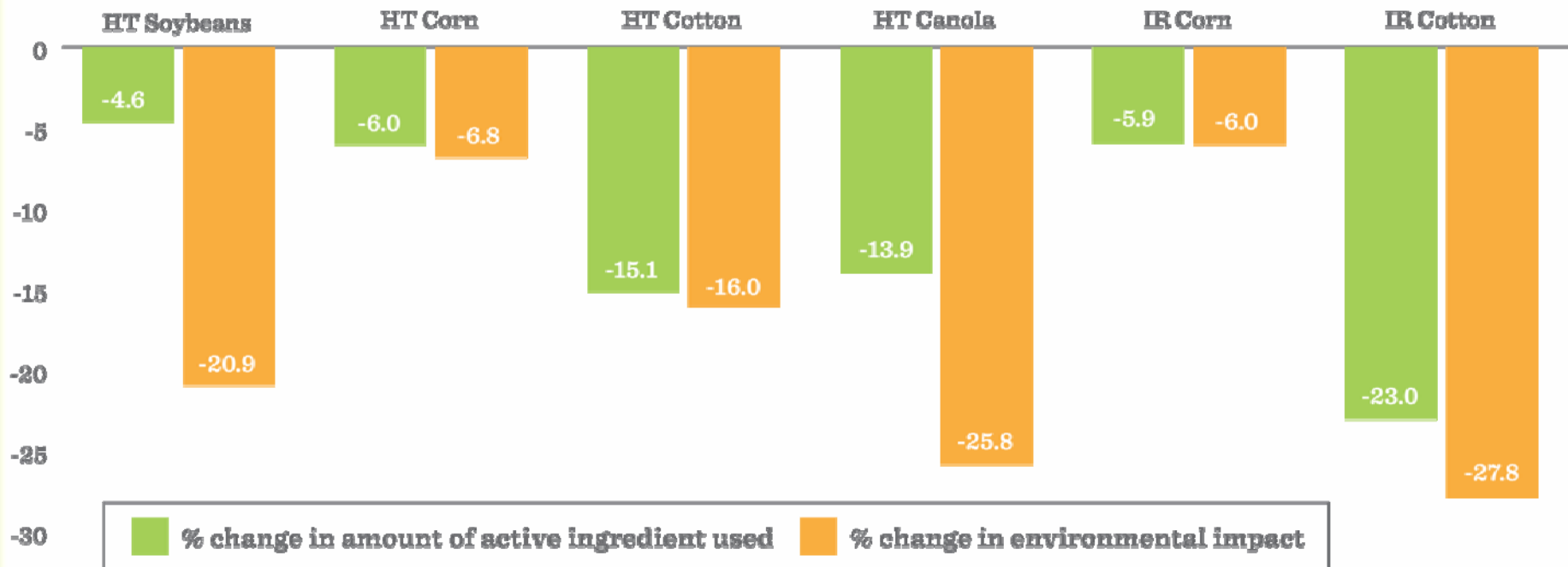


Source: Graham Brookes and Peter Barfoot. "Focus on environmental impacts. Biotech crops: evidence, outcomes and impacts 1996-2007." PG Economics, Ltd. October 2009.

# Biotechnology Reduces Herbicide and Pesticide Use on Crops

*By reducing the amount of insecticide and herbicide applications applied to crops, the biotech industry is helping reduce the chance that these chemicals enter the environment.*

*Reductions in Global Herbicide and Insecticide Use From Growing Biotech Crops: 1996-2007*



Source: Graphic adapted from Graham Brookes and Peter Barfoot. "Focus on yields. Biotech crops: evidence, outcomes and impacts 1996-2007." PG Economics, Ltd. October 2009.