BIOTECH BASICS

Do you have questions about plant biotechnology? If you do, you’re not alone. Many people find that they need to visit multiple sources or decipher scientific jargon for complete, accurate answers.

This booklet will answer many of your questions in one place. It is an easy-to-understand collection of infographics that will increase your knowledge of the basics of plant biotechnology and help you understand some of the more complex questions you often hear.

WHAT IS PLANT BIOTECHNOLOGY?

Plant biotechnology is a sophisticated breeding technology that allows plant breeders to precisely introduce beneficial traits into plants. Biotech crops approved for use today have been improved to help farmers tackle insects, disease and weeds in their fields and in the future could offer foods with higher vitamin levels, longer shelf life or the ability to grow even in the face of climate change.

Genetic modification (GM), genetic engineering (GE) and genetically modified organisms (GMO) are a few other terms that are also often used to refer to plant biotechnology.

CropLife International

Plant biotechnology will be a key tool to help farmers produce 70% more food that will be required to feed this growing planet.

7 BILLION PEOPLE populated the world in 2012.

9 BILLION+ PEOPLE will populate the world in 2050.
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Still have questions? VISIT CROPLIFE.ORG TO LEARN MORE.
Why do farmers need to control weeds and insects?

The majority of weeds and insects are unwelcome in a farmer’s field. Left uncontrolled they can reduce plant health, robbing a crop of yield and quality. This also impacts a farmer’s bottom line. It’s in everyone’s best interest to limit weeds and insect pressure to help achieve a harvest of safe, affordable and abundant food.

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A corn plant will face challenges throughout the growing season, beginning with weeds, insects and diseases threatening the crop before it even has a chance to sprout.

Biototechnology can provide built-in protection against insects and weeds, giving a corn plant a strong, healthy start.

Weeds compete with corn plants for nutrients, moisture, sunlight and space, and provide the ideal hiding place for pests and diseases.

Insects feed on corn plants, causing damage and transmitting disease.

Herbicide-tolerant and insect-tolerant biotech traits can help eliminate weed and insect pressure, allowing a corn plant to reach its full potential.

Insect damage lowers the quality of the corn crop, leading to smaller harvests and reduced income for farmers. Insect damage also creates mycotoxins (poisonous substances produced by fungi), which can reduce food quality and safety.

Weed competition leads to smaller cobs, which reduces yields.

Without the weed competition and insect damage that conventional crops face, biotech crops can reach their full yield and quality potential.

Up to 40% of the world’s potential crop production is lost each year because of weeds, insects and diseases.

Since 1996, biotech crops helped farmers produce 231 million tons more corn. This provides farmers with a higher income and better quality of life.

How is a biotech crop created?

For thousands of years, farmers and researchers used traditional breeding methods to develop many of the domesticated crops we enjoy today. In the past 100 years though, our global population tripled and plant breeders needed faster and more effective methods to meet the growing demands of our world. Biotechnology provided precise tools that enabled researchers to add a ‘trait’ or characteristic to a plant. These traits can make the crop heartier and healthier, add higher levels of vitamins, or provide a longer shelf-life after harvest – the opportunities are endless.
FARMERS AND PLANT BREEDERS HAVE BEEN MODIFYING PLANT GENES FOR MORE THAN 10,000 YEARS in order to develop higher-yielding crops and foods with improved nutrition and taste. Plant breeding has evolved over centuries and biotechnology is a continuation of this time-tested process.

1700s
Cross-breeding: farmers and scientists crossbreed plants within a species (e.g. rutabagas are a cross between turnips and cabbage).

1940s
Seed breeding: plant breeders use radiation or chemicals to generate seeds with desirable traits. These random mutations lead to new and useful plant characteristics such as size, sweetness or color (e.g. red grapefruit).

1973
Scientists Stanley Cohen and Herbert Boyer perfect recombinant DNA development—the technique used to cut and paste DNA and reproduce the new DNA in bacteria. This signalled the birth of genetic engineering or modern biotechnology.

1996
First biotech staple crops are commercialized and available for planting.

2015 and beyond
Plant biotechnology continues to evolve with new techniques that will advance food production for farmers and meet the needs of consumers (e.g. genome editing, gene silencing, plastid transformation and inducible genes).

SCIENTIFIC DISCOVERIES DATING BACK TO THE 1800S HAVE PAVED THE WAY FOR MODERN PLANT BREEDERS TO USE MOLECULAR BIOLOGY TO REMOVE THE GUESSWORK AND IMPRECISION OF CONVENTIONAL BREEDING METHODS.

1. IDENTIFICATION
Identify the gene or genetic material that will make the plant more nutritious, heartier or less susceptible to diseases or pests.

2. TRANSFERRING
Genetic researchers use a revolutionary method that utilizes agrobacterium, a natural organism discovered over 100 years ago, to pass on genes to plants. The agrobacterium acts like an automobile, carrying its passengers (the genes) into the seed, where they integrate into a precise area of the plant’s genetic material.

3. PLANTING
The new seed is then tested for safety, reliability and effectiveness. Once it receives approval by regulators, farmers are able to plant and reap the benefits of this new technology.
Are biotech crops safe?

Yes. Health authorities, scientific experts and governments around the world have all found biotech crops to be one of the most rigorously tested products on the market with a proven safety record for our food and our health.

1 Critical Reviews in Biotechnology, March 2014, Vol. 34, No. 1
2 ISAAA Brief 46-2013
3 Agricultural Biotechnology Council
The science is quite clear: crop improvement by the modern molecular techniques of biotechnology is safe.

- AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

No effects on human health have been shown as a result of the consumption of GM foods by the general population in the countries where they have been approved.

- WORLD HEALTH ORGANIZATION

The use of more precise technology and the greater regulatory scrutiny probably makes GMOs even safer than conventional plants and foods.

- EUROPEAN COMMISSION

Health authorities:

- WORLD HEALTH ORGANIZATION (WHO)
- AMERICAN MEDICAL ASSOCIATION (AMA)
- ROYAL SOCIETY OF MEDICINE (UK)
- BRITISH MEDICAL ASSOCIATION
- HEALTH CANADA

Scientific experts:

- AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (AAAS)
- NATIONAL ACADEMIES OF SCIENCE OF MANY COUNTRIES
- NETWORK OF AFRICAN SCIENCE ACADEMIES (NASAC)
- EUROPEAN ACADEMIES SCIENCE ADVISORY COUNCIL (EASAC)
- INTERNATIONAL COUNCIL FOR SCIENCE
- PONTIFICAL ACADEMY OF SCIENCE

Food safety or health issues:

- EUROPEAN COMMISSION
- FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO)
- US-FDA
- FOOD STANDARDS AUSTRALIA NEW ZEALAND
- PHILIPPINES FOOD AND DRUG ADMINISTRATION
- FRENCH FOOD SAFETY AGENCY
- CANADIAN FOOD INSPECTION AGENCY
- U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID)
Where are biotech crops grown?

Biotech crops are grown worldwide, and have become one of the fastest-adopted crop technologies in the history of agriculture. Over 18 million farmers in 28 countries planted biotech crops – from maize to papaya – in 2014 and every year more growers are adopting the technology. In fact, the number of biotech crop hectares planted has increased 100-fold since the first commercialized seeds were sown in 1996. The world’s largest maize and soybean exporters, United States, Brazil and Argentina, almost exclusively grow biotech crops. These trends are expected to continue as more countries embrace biotechnology.
BIOTECH ADOPTION INCREASES ANNUALLY

90% of biotech growers live in developing countries where biotech crop benefits, such as better harvests and higher incomes, can transform rural communities.

NEARLY 100% of farmers replant biotech crops year after year.

5 billion people live in countries that are growing, eating or using biotech crops in their everyday lives.

A TOTAL OF 1.8 billion hectares planted SINCE 1996

COUNTRIES EMBRACE BIOTECH

28 COUNTRIES GROW BIOTECH CROPS*

Developing countries

Industial countries

63 COUNTRIES import biotech crops**

7 AFRICAN countries conduct biotech field trials***

9 ASIAN countries conduct biotech field trials****

BIOTECH ADOPTION IS HIGH

79% of global acres adoption rate in U.S.

94% adoption rate in Brazil

92% adoption rate in Canada

24% of global acres adoption rate in Australia

99% adoption rate in India

70% of global acres adoption rate in Sudan

93% in just second year of planting

The percentage of biotech maize hectares in the U.S., Brazil and Argentina, helping them be the top 3 maize exporters worldwide

PAPAYA 75% adoption rate in Hawaii

SUGAR BEET 95% adoption rate in U.S.

* Argentina, Australia, Bolivia, Brazil, Burkina Faso, Canada, Chile, China, Columbia, Costa Rica, Cuba, Czech Republic, Honduras, India, Mexico, Myanmar, Paraguay, Pakistan, Philippines, Portugal, Romania, Slovakia, South Africa, Spain, Sudan, U.S., Uruguay

** Argentina, Australia, Austria, Bangladesh, Belgium, Bolivia, Brazil, Bulgaria, Burkina Faso, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Egypt, Estonia, Finland, France, Germany, Greece, Honduras, Hungary, Indonesia, India, Iran, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Netherlands, Mexico, Myanmar, New Zealand, Norway, Pakistan, Panama, Paraguay, Philippines, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Taiwan, Thailand, Turkey, United Kingdom, U.S., Uruguay

*** Cameroon, Ghana, Kenya, Malawi, Nigeria, Uganda

**** Bangladesh, China, India, Indonesia, Japan, Malaysia, Pakistan, Philippines, Vietnam
What are the benefits of biotech crops?

Plant biotechnology enables farmers worldwide to boost the profitability, productivity and sustainability of their farms. This helps create a better quality of life for their community by improving the local economy, provides consumers with high-quality nutritious crops and protects the natural environment around us.

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1. ISAAA Brief 26-2013
5. www.madehow.com/Volume-2/Tofu.html#ixzz3ERC318Na
7. IFPRI tool: http://apps.harvestchoice.org/agritech-toolbox/
9. IFPRI tool: http://apps.harvestchoice.org/agritech-toolbox/
Biotech crops help meet the world’s growing demand for food through increased crop productivity. Since 1996, farmers have added 358 million extra tons to our global food supply.

FEED A GROWING POPULATION

In the future, advanced biotech traits like nitrogen-use efficiency will improve plant growth. This could nearly double yields of irrigated maize in Latin America and Sub-Saharan Africa in 2050.

NO-TILL FARMING PREVENTS ENOUGH CO₂ EMISSIONS — AT LEAST 3.2 MILLION TONS EACH YEAR — to offset home electricity use in the United States for nearly 3.5 years.

In India, biotech cotton provides higher incomes and leads to a better quality of life. This includes improved access to telephone systems, drinking water and economic infrastructure as well as more maternal health care, higher school enrollment and increased vaccination rates.

That’s like providing every person on earth with 99 boxes of corn flakes, 125 servings of tofu, and a 14 oz bottle of canola oil.

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Nutrition-enhanced foods developed through biotechnology, from vitamin-A enriched bananas to sorghum with higher levels of essential nutrients, could help the two billion malnourished people in developing regions.

PROGRESS RURAL COMMUNITIES

In 2013, biotech crops helped increase farm incomes and food security, while alleviating poverty for more than 65 million smallholder farmers and their family members through higher crop yields.

LOOK AFTER OUR PLANET

Biotech crops protect the environment.

Herbicide-tolerant crops reduce the need for tillage, keeping carbon in the soil.

NO-TILL FARMING PREVENTS ENOUGH CO₂ EMISSIONS — AT LEAST 3.2 MILLION TONS EACH YEAR — to offset home electricity use in the United States for nearly 3.5 years.

By allowing farmers to grow more on less land, 123 million hectares of natural habitats were preserved between 1996 & 2012.

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How does plant biotech impact our daily lives?

We benefit from plant biotechnology from morning until night – from the food we put on our kitchen table, to the fuel we put in our cars, to the fibers that make your favorite shirt.

http://isaaa.org/resources/publications/pocketk/16/default.asp
www.arborgen.com/biotech-trees/
www.hawaiipapaya.com/rainbow.htm
www.canolacouncil.org/oil-and-meal/canola-oil/health-benefits-of-canola-oil/
www.plenish.com
Biotech corn and soybeans are used to feed livestock on every continent, including Europe, offering the animals a healthy, nutritious source of protein and calories.

Biotechnology increases production of crops such as corn and soybeans to meet biofuel demands, giving you access to cleaner, environmentally friendly sources of renewable energy.

Biotech eucalyptus trees could soon be used as a sustainable paper source that saves native forests for future generations.

Biotech crops mitigate the carbon impacts of your car by reducing on-farm emissions. In 2012 alone, the amount of CO₂ saved by biotech crops was equal to removing every single car from the streets of London for five years.

Bananas are being enhanced through biotechnology to provide more essential vitamins and minerals to your mid-afternoon snack.

Biotech canola and soybean seeds produce new, healthier cooking oils with higher levels of omega-3 fatty acids, no trans-fat and lower saturated fat.

Since 1996, biotech has added 231 million more tons of corn to the food supply or enough corn for approximately 707 billion boxes of corn flakes — that’s nearly 100 boxes for every person on the planet.

New biotech canola and soybean seeds produce new, healthier cooking oils with higher levels of omega-3 fatty acids, no trans-fat and lower saturated fat.

In the United States, this saved the entire papaya industry.

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Does the public sector conduct plant biotech research?

Yes, public sector organizations are developing ground-breaking biotech innovations that can help tackle climate change, fight malnutrition in developing regions, improve food security and more. These projects are poised to deliver incredible benefits to farming communities and improve the health of our world.
Public-Private Partnerships offer a way for the public sector to pursue collaborative projects with the private sector, addressing local challenges and bringing greater innovation to our world’s farmers.

Public Sector Research Delivers Biotech Solutions

Universities, government institutions and non-profits worldwide are working to develop new biotech innovations for farmers and consumers.

Rainbow papaya with built-in protection against a devastating plant virus saved the $17 million U.S. Hawaiian papaya industry from collapse. Today, Hawaii’s papaya farmers are flourishing as a result of biotech papaya.

- Cornell University, University of Hawaii and U.S. Department of Agriculture’s Agricultural Research Service

Vitamin A-rich bananas with six times the normal level of nutrients could one day benefit 52% of Ugandan children under age five whose health suffers from Vitamin A deficiencies.

- Ugandan National Agricultural Research Organization (NARO)

Golden rice, which boasts high amounts of beta-carotene and iron, is expected to significantly reduce Vitamin A deficiency in developing regions, which is responsible for 500,000 cases of irreversible blindness and up to 2 million deaths each year.

- Swiss Federal Institute of Technology, The University of Freiburg, Germany and The International Rice Research Institute

For more info about each of these innovations, visit:

Rainbow Papaya: www.hawaiipapaya.com/rainbow.htm

Drought-tolerant maize with conventional and biotech traits that help farmers in drought-prone Africa maximize crop production will be available in 2017, benefiting more than 300 million Africans who depend on maize as their main food source.

- Water Efficient Maize for Africa (WEMA), A Collaboration Between African National Research Institutes and the Private Sector

Gluten-free wheat developed through biotechnology will one day benefit people who suffer digestive problems triggered by gluten (a protein found in wheat). This breakthrough innovation will help provide individuals with wheat allergies and Celiac disease with a wider range of safe food choices.

- Partnership Between Washington State University and the Private Sector

What are some biotech crops of the future?

Plant biotechnology has already provided farmers with agricultural innovations they never thought possible. The future promises even greater advancements. Biotech seeds in the product development pipeline will help farmers better weather climate change and provide consumers worldwide with solutions to fight malnutrition and health issues.
FUTURE PLANT BIOTECH INNOVATIONS

FROM FARM
Biotech seed innovations will help farmers continually produce a safe and bountiful harvest in the face of increasingly volatile weather conditions. New varieties on the horizon will help farmers continue to build resilience to climate change, resulting in increased productivity, profitability and sustainability.

Nitrogen-use efficient seed varieties will allow crops to use applied nitrogen more efficiently leading to better growth, increased production and reduced carbon footprints.¹

Flood-tolerant varieties will provide yield stability in extremely wet climates.

Drought-tolerant varieties will protect harvests and minimize losses in times of severe drought by using water more efficiently.

Advances in herbicide-, disease- and insect-tolerant seeds will provide even greater control of harmful pests.

Saline-tolerant and heat-tolerant seeds will enable farmers to take advantage of land that is currently unusable for crop production.²

TO FORK
Biotechnology will play an important role in providing developing regions with biofortified foods that help tackle malnutrition. In industrial countries, consumers will also benefit from biotech food innovations that enhance nutrition, quality and convenience.

More nutritious and higher yielding cassava, the primary source of calories for over 250 million people in Sub-Saharan Africa, will help to reduce malnutrition.³

A nutrient-rich and more easily digestible sorghum, containing increased levels of essential amino acids and vitamins, will improve the health of millions of people in Africa who rely on the staple as their primary diet.⁴

Foods with disease-fighting properties such as tomatoes rich in antioxidants, pink-fleshed pineapples with higher levels of lycopene, corn and soybeans with increased vitamin C and E, and oilseeds that produce heart-healthy oils.⁵

Apples and potatoes that don’t brown when sliced, leading to increased consumption for better health and less food waste.⁶

THE FUTURE POTENTIAL OF PLANT BIOTECHNOLOGY IS LIMITLESS
— from crops that enable farmers to maximize productivity and ensure food security to foods that enhance consumer diets and reduce health risks.

² Flood-tolerant varieties will provide yield stability in extremely wet climates.
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² Advances in herbicide-, disease- and insect-tolerant seeds will provide even greater control of harmful pests.
² Saline-tolerant and heat-tolerant seeds will enable farmers to take advantage of land that is currently unusable for crop production.
² These technologies will be most beneficial in developing regions where farmers are increasingly facing volatile weather and extreme growing conditions due to climate change.
² The future potential of plant biotechnology is limitless — from crops that enable farmers to maximize productivity and ensure food security to foods that enhance consumer diets and reduce health risks.
How do farmers stay ahead of pest resistance?

Pests have always been a fact of life for farmers. For thousands of years, they have adopted countless methods to fight them off and protect their crops. However, all pests will inevitably fight back and can develop resistance to these methods. Farms around the world, from biotech to conventional to organic, must work to manage potential resistance and ensure technologies that control yield-robbing pests remain effective.
STAYING AHEAD OF PEST RESISTANCE

Resistance is when a weed, insect or disease evolves to withstand the farmer’s pest management strategy. It is inevitable and happens in every crop production system – from conventional to biotech to organic. Farmers are able to delay the onset of resistance and maximize the effectiveness of the technology by implementing resistance management plans tailored to their field and pest pressures. Three common approaches to resistance management include: crop rotation, refuge planting and stacked traits.

CROP ROTATION

Because different pests attack different crops, CROP ROTATION PREVENTS A BUILDUP OF CERTAIN DISEASES OR INSECTS that can become tolerant to the control method. Through crop rotation, a different crop is planted in a field periodically, limiting the development of resistance.

This corn field will be planted with soybeans next year and a different crop the following year.

REFUGE PLANTING

Farmers who plant insect-tolerant biotech crops often plant a refuge area – a block or strip of crop without the biotech trait. REFUGE PREVENTS FUTURE GENERATIONS OF PESTS FROM BUILDING IMMUNITY BY ENSURING A SMALL PROPORTION OF INSECTS WITHOUT RESISTANCE ARE ALWAYS PRESENT. If a resistant insect is born, it or its offspring will eventually mate with a non-resistant insect thereby delaying the onset of resistance.

This quadruple-stacked corn seed provides four different built-in pest controls – two for insects and two for weeds – so farmers can limit resistance well into the future.

STACKED TRAITS

“Stacked traits” can incorporate MULTIPLE TRAITS IN THE SAME SEED, PROVIDING DIFFERENT METHODS TO CONTROL PESTS WITHIN ONE PLANT. If a pest becomes resistant to one of traits, another trait can eliminate the pest and remove its resistance from the insect population.

RESISTANCE MANAGEMENT PLANS ARE AN ESSENTIAL WAY TO ENSURE NOT JUST A BIOTECH CROP, HOWEVER ANY METHOD OF ELIMINATING PESTS CAN REMAIN EFFECTIVE LONG INTO THE FUTURE. RESISTANT WEEDS AND INSECTS HAVE BEEN FOUND ON BIOTECH FIELDS IN CERTAIN PARTS OF THE WORLD, BUT BY WORKING HAND-IN-HAND ON RESISTANCE MANAGEMENT WITH THE PLANT SCIENCE INDUSTRY, FARMERS HAVE SUCCESSFULLY LIMITED RESISTANCE TO A SMALL NUMBER OF ACRES.
CONTROLLING YIELD-ROBBING PESTS
Farmers control weeds and insects with the help of biotechnology to help achieve a successful harvest of safe, affordable and abundant food.

DELIVERING MORE EFFECTIVE PLANT BREEDING METHODS
Biotechnology provides precise tools that enable plant breeders to effectively develop crops that help meet the growing demands of our world.

CONFIRMING SAFETY
Health authorities, scientific experts and government organizations overwhelmingly endorse biotech crop safety.

INCREASING ADOPTION
Biotech crops are grown worldwide, and have been one of the fastest-adopted crop technologies in the history of agriculture.

BENEFITING OUR WORLD
Plant biotechnology helps our world grow by contributing to progress in rural communities, feeding a growing population, and looking after our planet.
EXCITING FUTURE INNOVATIONS
Biotech seeds now being developed will help farmers better weather climate change and provide consumers worldwide with solutions to fight malnutrition and health issues.

MANAGING RESISTANCE
Farmers around the world, from conventional to biotech to organic, work to manage potential resistance to ensure technologies that control yield-robbing pests remain effective.

IMPACTING OUR DAILY LIVES
We benefit from plant biotechnology from morning until night – from the food we put on our kitchen table, to the fuel we put in our cars, to the fibers that make your favorite shirt.

GROUNDBREAKING PUBLIC SECTOR RESEARCH
Public sector organizations are developing groundbreaking biotech innovations that can help tackle climate change, fight malnutrition in developing regions, improve food security and more.