Bioteknologi Tanaman

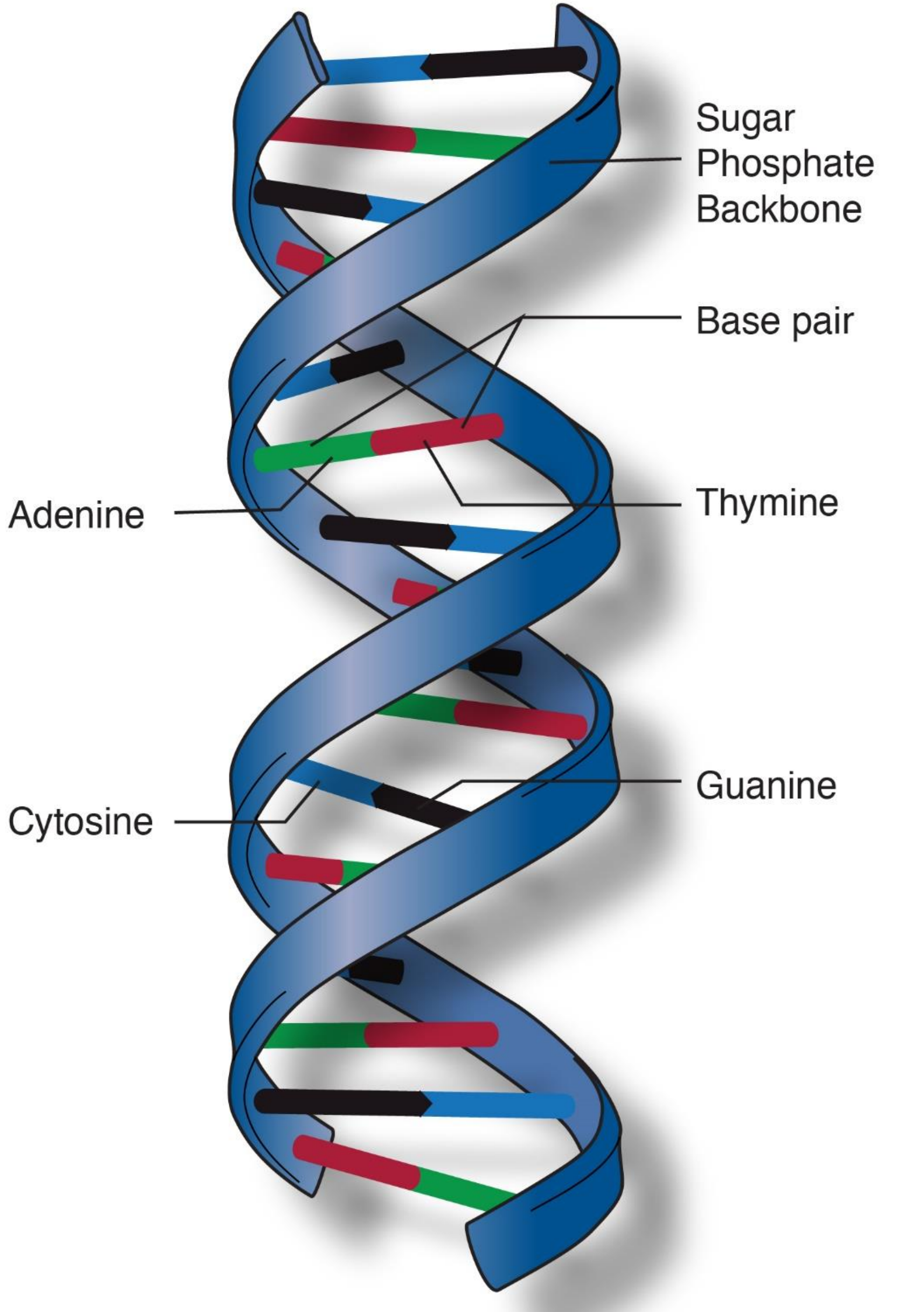
REKAYASA GENETIKA TANAMAN

Gabriel Tirtawijaya

FAKULTAS TEKNOBIOLOGI

UBAYA
UNIVERSITAS SURABAYA

Apa itu rekayasa genetika?



Rekayasa Genetika

- Penerapan teknik biologi molekuler dalam mengubah susunan genetik dalam kromosom atau mengubah sistem ekspresi genetik yang diarahkan pada kemanfaatan tertentu.
- Meningkatkan keragaman tanaman
- Menjamin ketahanan pangan
- Meningkatkan kualitas dan hasil panen

Tujuan Rekayasa Genetika Tanaman

Memberikan karakter baru pada tanaman melalui pengintegrasian gen-gen yang berasal dari organisme lain untuk perbaikan sifat tanaman itu sendiri.

- ✓ to produce needed chemicals
- ✓ to carry out useful processes
- ✓ to give an organism desired characteristics

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Bioteknologi Tanaman

Traditional Biotechnology

- Growing plants
- Plant breeding (selective & interspecies crosses)

Gene Manipulation & Introduction

- Identify gene from another species which controls a trait of interest or modify an existing gene (create a new allele)
- Introduces that gene into an organism
  → transformation (forms transgenic organisms)

THE EVOLUTION OF MAIZE

GET TO KNOW

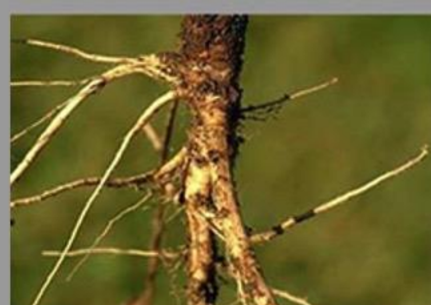
GMO BASICS

watermelon

corn

banana

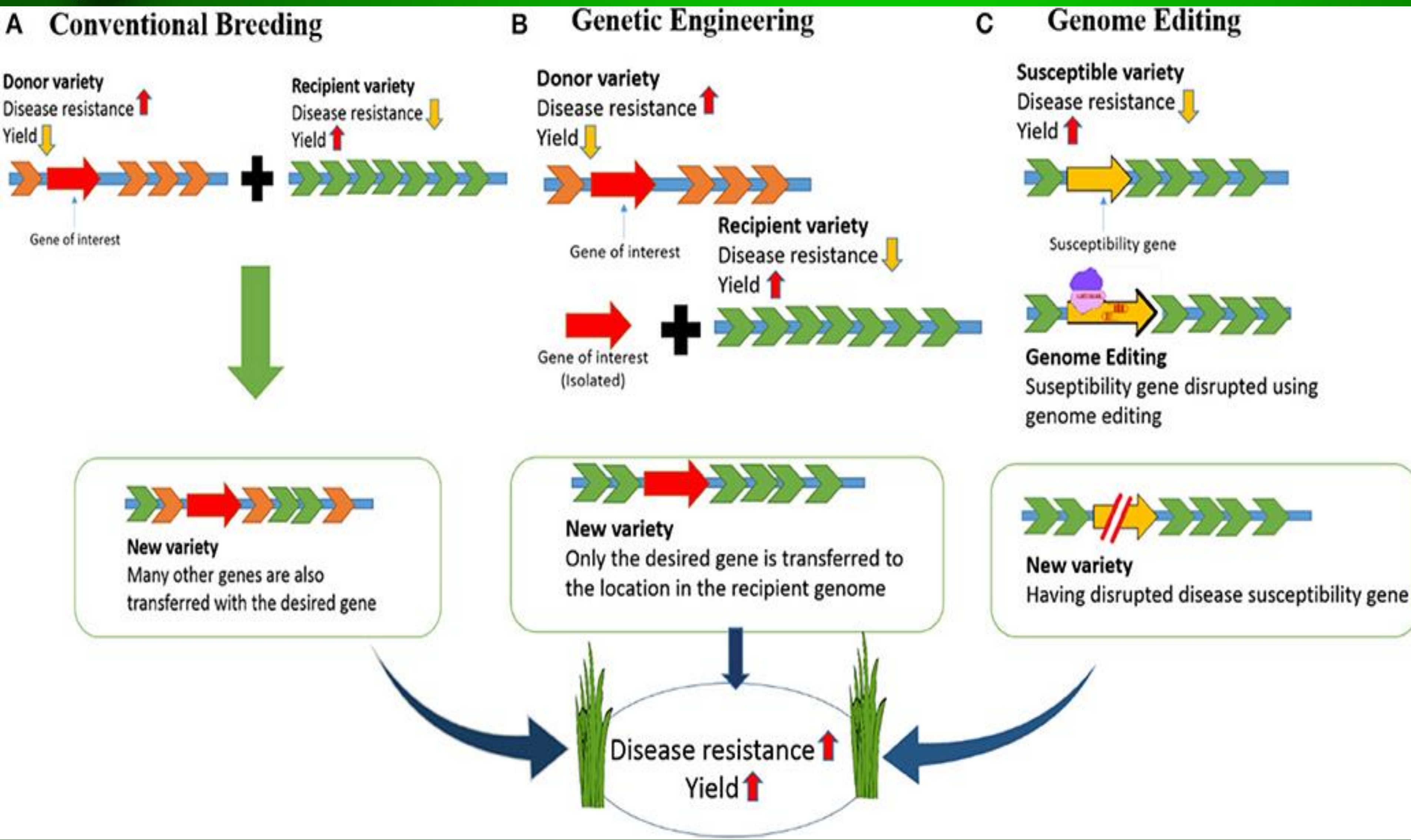
aubergine / eggplant



carrot

cabbage, kale, broccoli, etc.

gmo answers Open to Your Questions About How Our Food Is Grown


A Conventional Breeding
B Genetic Engineering
C Genome Editing
Donor variety
Disease resistance
Yield
Recipient variety
Disease resistance
Yield
Gene of interest
New variety
Many other genes are also transferred with the desired gene
Donor variety
Disease resistance
Yield
Gene of interest
Recipient variety
Disease resistance
Yield
Gene of interest (Isolated)
New variety
Only the desired gene is transferred to the location in the recipient genome
Susceptible variety
Disease resistance
Yield
Susceptibility gene
Genome Editing
Suseptibility gene disrupted using genome editing
New variety
Having disrupted disease susceptibility gene
Disease resistance
Yield

Transformasi

- Memperkenalkan DNA ke dalam host sel lain sedemikian rupa, sehingga gen tersebut dapat diekspresikan

- Gen pada DNA yang ditransformasikan harus mampu:
  a. Transkripsi dan translasi untuk membentuk molekul protein
  b. Replikasi dan dapat diturunkan ke generasi berikutnya

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Transformasi

- Untuk mengontrol replikasi dan ekspresi DNA asing yang telah disisipkan kedalamnya dapat digunakan Vektor ,plasmid maupun virus

- Transformasi dapat didefinisikan: Perubahan keadaan/sifat satu strain oleh DNA asing
- Dapat dilakukan dengan memasukan DNA donor ke dalam sel inang
- DNA donor bisa utuh ataupun rekombinan

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Sejarah Organisme Rekayasa Genetika (GMO)

- 1982 1st transgenic plant produced (antibiotic resistance tobacco)
- 1984 1st transgenic plant produced using Caulimovirus vector (CaMV)
- 1994 1st GMO approved for sale in US (Flavr-Savr tomato)

  The EU approved GMO herbicide-resistance tobacco → 1st commercially marketed in Europe
- 1995 US-EPA approved Bt-potato (insecticide-producing potato)

Sejarah GMO

- 1996 1st GM flower introduced (Moondust-bluish colored carnation)

- 2000 Rice containing β-carotene (Golden rice)

Syarat Dasar Transformasi Genetik

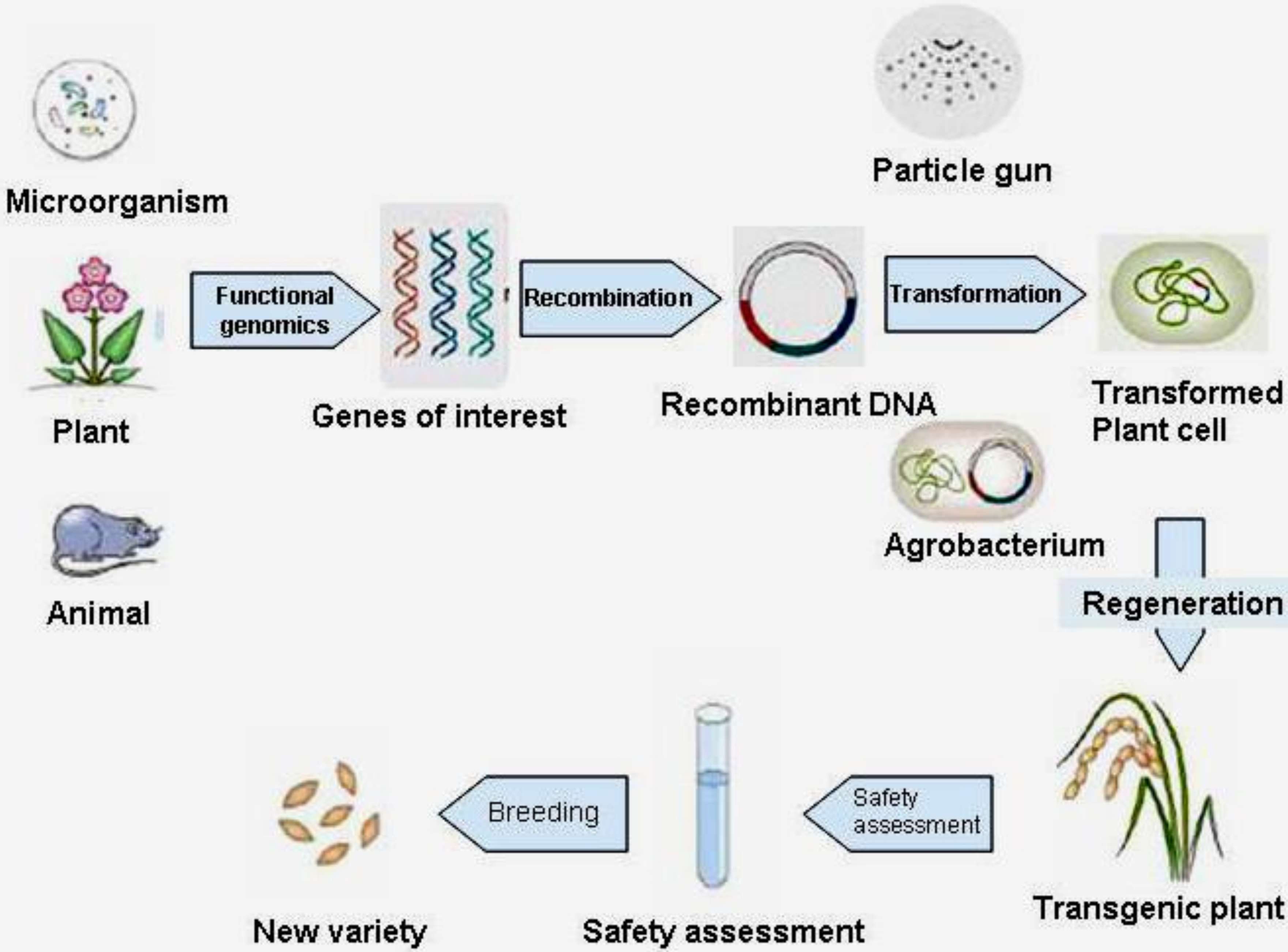
1. Gen target
2. Vector pembawa gen
3. Modifikasi DNA asing untuk meningkatkan tingkat ekspresi gen
4. Metode pengiriman plasmid DNA ke dalam sel
5. Metode identifikasi *transformed cell*
6. Kuljar untuk memulihkan tanaman yang layak dari sel yang diubah

Prinsip Dasar Rekayasa Genetika

1. Identify required gene and isolate it.
2. Make multiple copies of the gene.
3. Insert the gene into the cells of the host organism.
4. Identify the cells that have the gene and clone it.

Genetic engineer's toolkit:

a. Enzymes
b. Vectors
c. Marker genes


Particle gun
Microorganism
Functional genomics
Recombination
Transformation
Plant
Genes of interest
Recombinant DNA
Transformed Plant cell
Agrobacterium
Animal
Regeneration
Breeding
Safety assessment
New variety
Safety assessment
Transgenic plant

Aplikasi Rekayasa Genetika Tanaman

- Toleran terhadap zat kimia tertentu (missal herbisida)
- Tahan terhadap hama dan penyakit tertentu
- Memiliki sifat khusus, misalnya longer-lasting tomato dan padi yang mengandung β-carroten & vitamin A.
- Dapat mengambil nitrogen langsung dari udara.
- Tahan terhadap lingkungan ekstrim, misalnya kekeringan, cuaca dingin, dan tanah bergaram tinggi.

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Keilmuan yang Mendasari Rekayasa Genetika

- Restriction Enzymes & Recombinant DNA
- Gene Discovery, Isolation and Cloning
- Move Foreign Gene or Transgene from Any Organism to Any Other Organism

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Metode Rekayasa Genetika Tanaman

Mediasi Vektor

Biologi

- Mediasi bakteri *Agrobacterium tumefaciens* & *A. rhizogenes*
- Mediasi virus

Tanpa Mediasi Vektor

Fisik

- Microinjection
- Pressure
- Biolistic
- Electroporation
- Silica carbide fibers

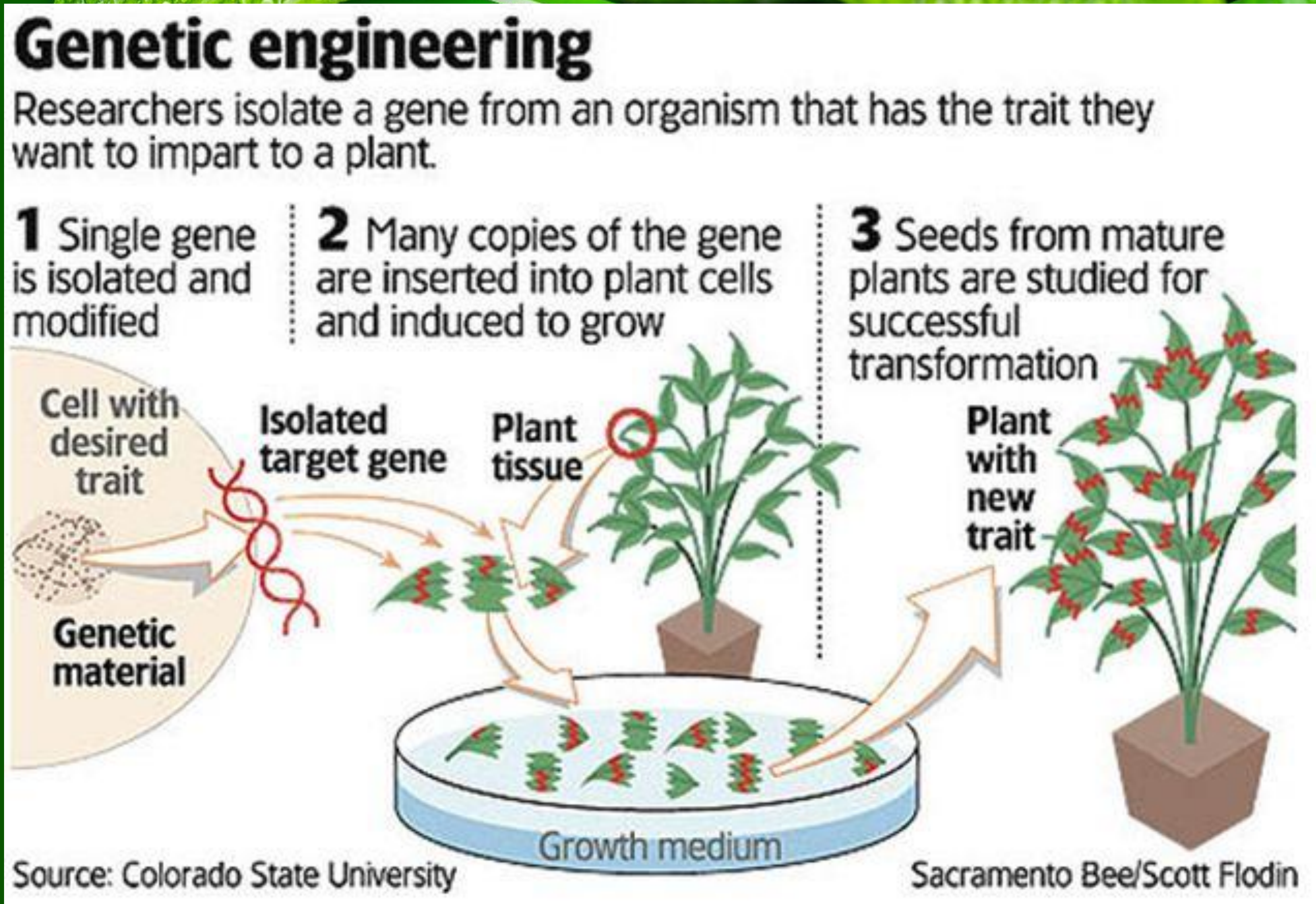
Kimia

- PEG
- DEAE-dextran
- Calcium phosphate
- Artificial lipids
- Proteins

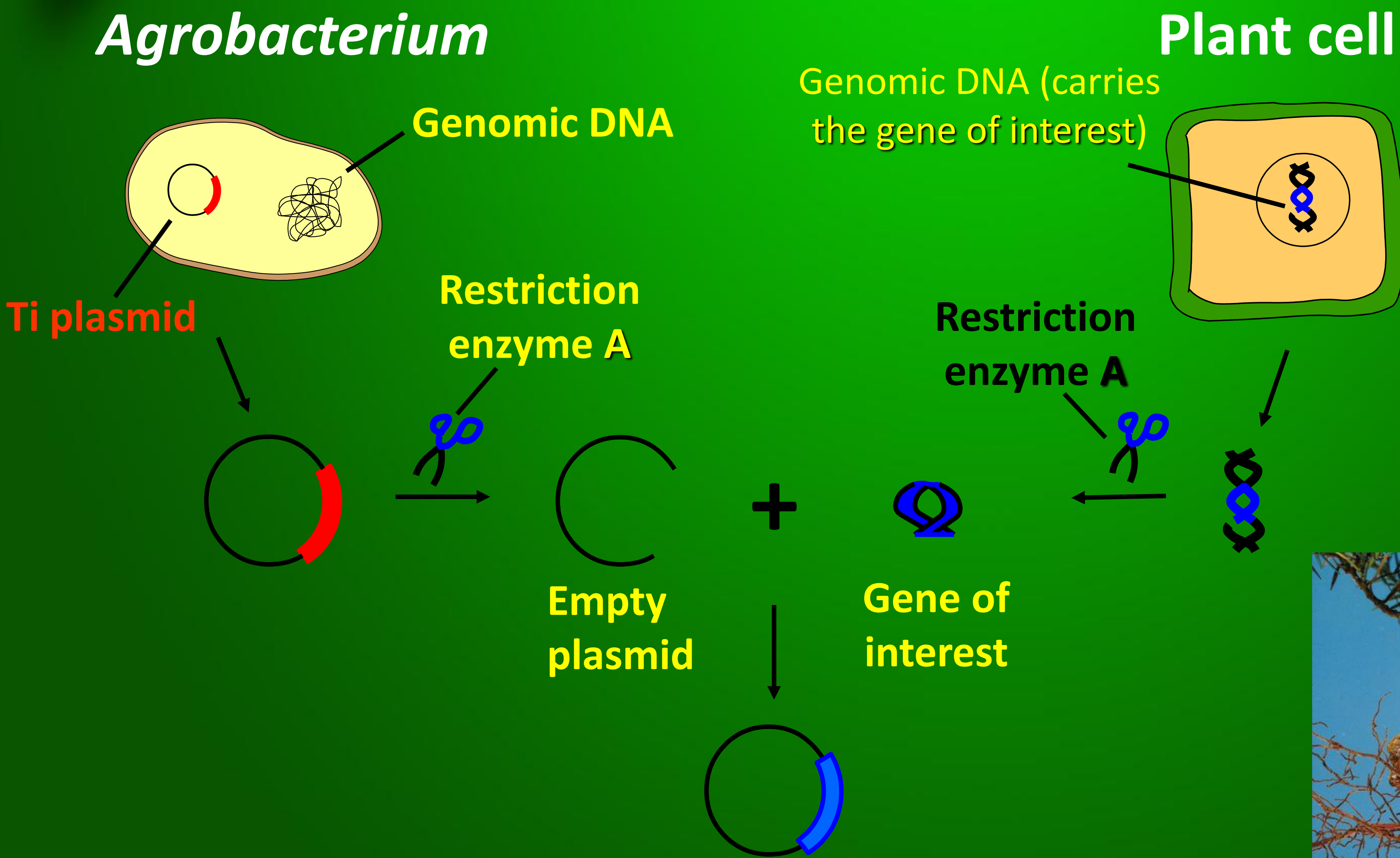
Metode Rekayasa Genetika Tanaman

Table 49.1 Gene transfer (DNA delivery) methods in plants

Method	*Salient features*
I. Vector–mediated gene transfer	
Agrobacterium (Ti plasmid)-mediated gene transfer	Very efficient, but limited to a selected group of plants
Plant viral vectors	Ineffective method, hence not widely used
II. Direct or vectorless DNA transfer	
(A) Physical methods	
Electroporation	Mostly confined to protoplasts that can be regenerated to viable plants. Many cereal crops developed.
Microprojectile (particle bombardment)	Very successful method used for a wide range of plants/ tissues. Risk of gene rearrangement high.
Microinjection	Limited use since only one cell can be microinjected at a time. Technical personnel should be highly skilled.
Liposome fusion	Confined to protoplasts that can be regenerated into viable whole plants.
Silicon carbide fibres	Requires regenerable cell suspensions. The fibres, however, require careful handling.
(B) Chemical methods	
Polyethylene glycol (PEG)-mediated	Confined to protoplasts. Regeneration of fertile plants is frequently problematical.
Diethylaminoethyl (DEAE) dextran-mediated	Does not result in stable transformants.

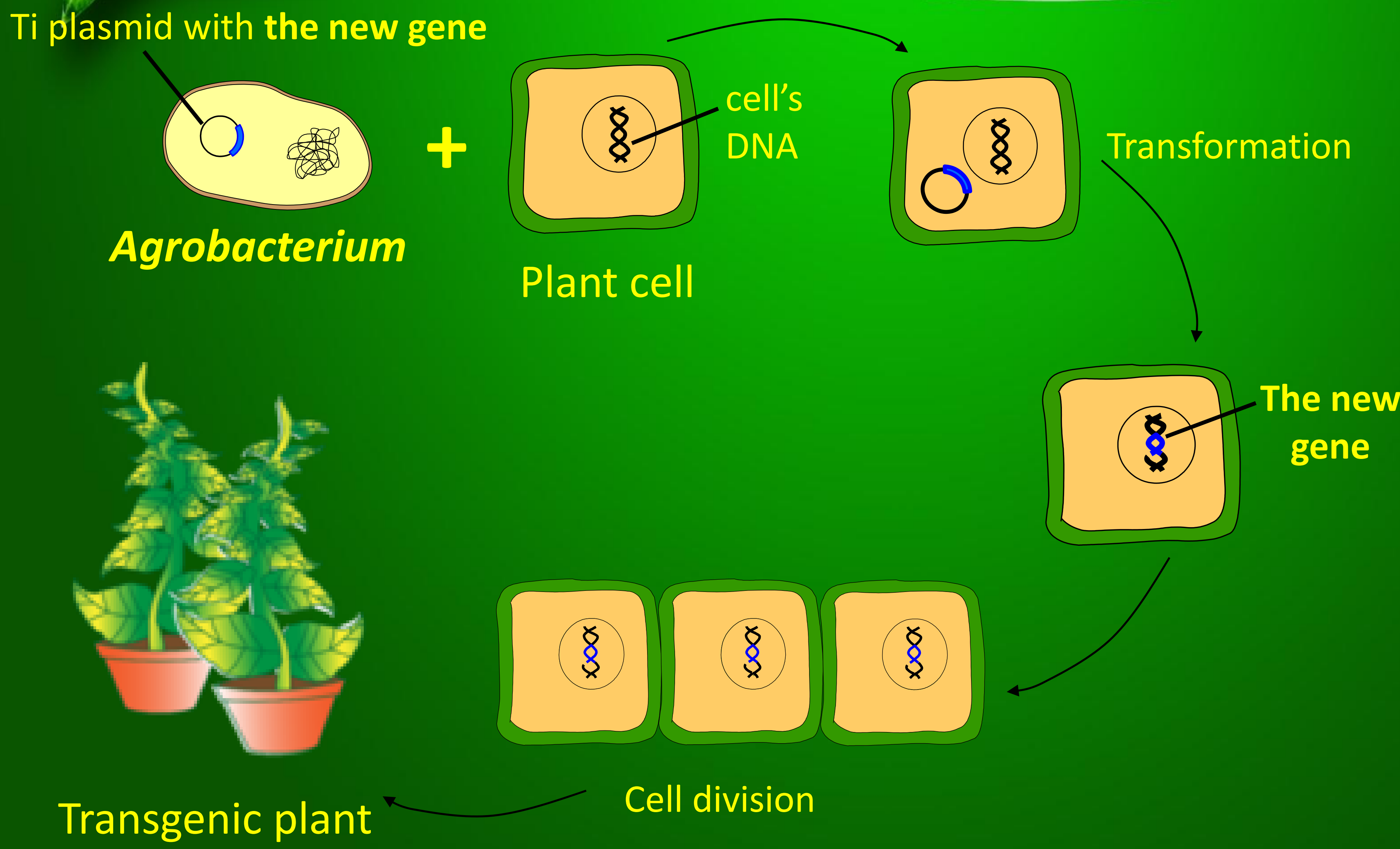

Genetic engineering
Researchers isolate a gene from an organism that has the trait they want to impart to a plant.
1 Single gene is isolated and modified
2 Many copies of the gene are inserted into plant cells and induced to grow
3 Seeds from mature plants are studied for successful transformation
Cell with desired trait
Genetic material
Isolated target gene
Plant tissue
Growth medium
Plant with new trait
Source: Colorado State University
Sacramento Bee/Scott Flodin

Agrobacterium tumefaciens



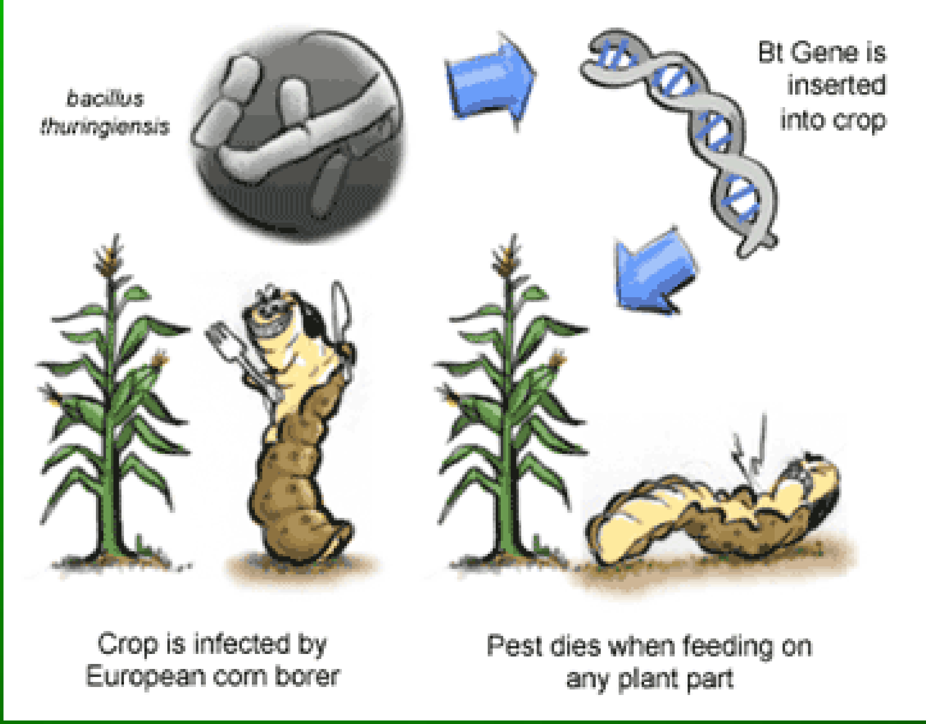
Ti plasmid with the gene of interest

Agrobacterium tumefaciens



Gen yang disisipkan pada tanaman GM

- Endo-toxin dari Bt
- Protease inhibitors
- Alpha amylase inhibitors
- Lectins
- Enzymes
- Pyramiding genes



Gen yang disisipkan pada tanaman GM

- Protease inhibitors (PI)

  Menghambat protease pada pencernaan serangga.

  Contoh: Gen trypsin inhibitor (CpTi) dari Cowpea disisipkan pada tembakau untuk mencegah serangan *Helicoverpa*

Gen yang disisipkan pada tanaman GM

- Alpha Amylase Inhibitors (AAI)

  Menghambat digesti karbohidrat pada serangga.

  Contoh: Tomat & kentang dengan gen AAI resisten terhadap serangan hama Lepidopteran

- Lectin genes

  Lectin mengikat karbohidrat, termasuk kitin pada saluran cerna serangga. Sehingga mengganggu penyerapan nutrisi

  Contoh: Gen pea lectin (P-Lec) disisipkan pada tembakau untuk mencegah serangan *Helicoverpa*

Gen yang disisipkan pada tanaman GM

- Enzymes

  Gen chitinase, cholesterol oxidase, dan lipo-oygenase disisipkan pada tanaman untuk memunculkan sifat insektisida

  Contoh: Gen bean chitinase (BCH) disisipkan ke tembakau untuk mecegah serangan Aphid

- Pyramiding Genes

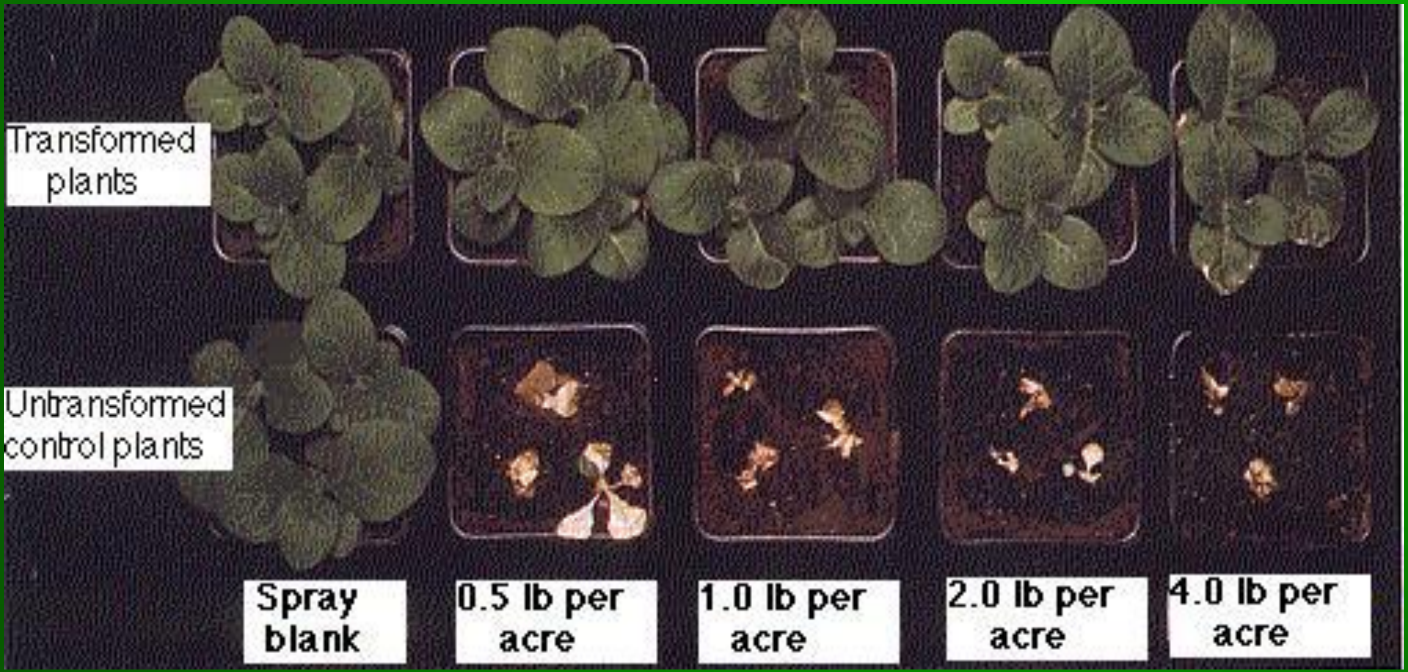
  Penyisipan > 1 gen untuk memperoleh banyak mekanisme pertahanan

  Contoh: CpTi + P-Lec disisipkan pada tembakau

C5 Plum pox resistant plums

Plums that have been genetically engineered to be resistant to the plum pox virus

Pesticide resistance

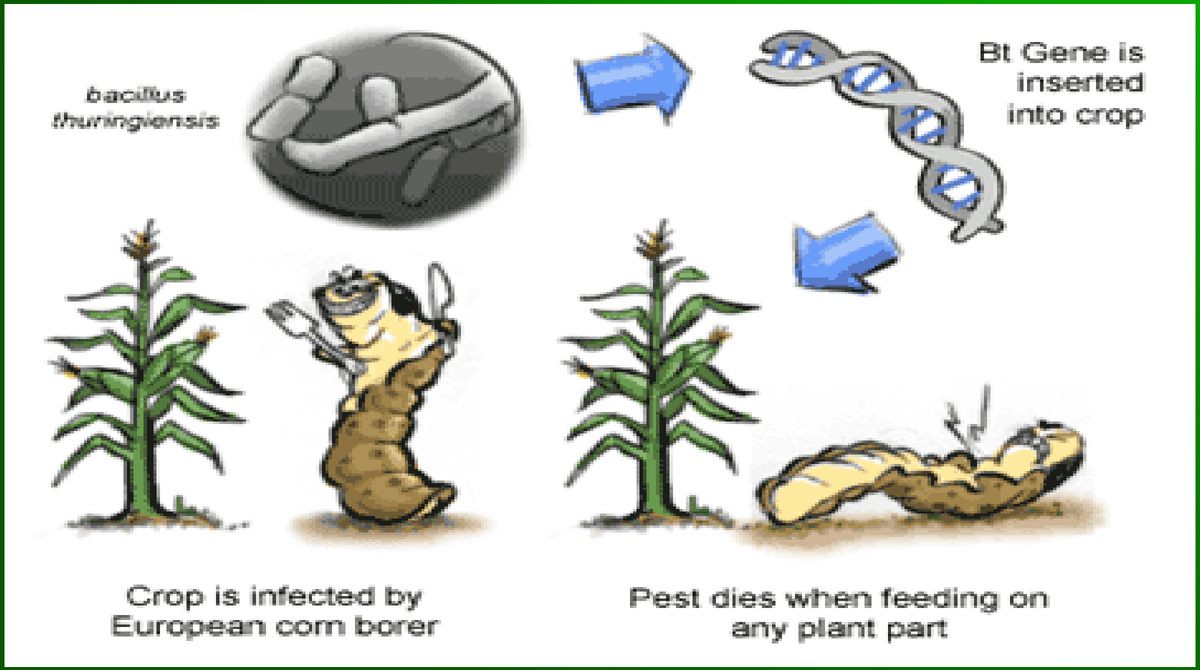


(Courtesy of Calgene, Davis, CA.)

Effect of the herbicide bromoxynil on tobacco plants transformed with a bacterial gene of which a product breaks down bromoxynil (top row) and control plants (bottom row). "Spray blank" plants were treated with the same spray mixture as the others except the bromoxynil was left out.

Bt Corn

Bt corn is a variant of maize, genetically altered to express the bacterial Bt toxin, which is poisonous to insect pests. The pest is the European Corn Borer.



Bt Cotton

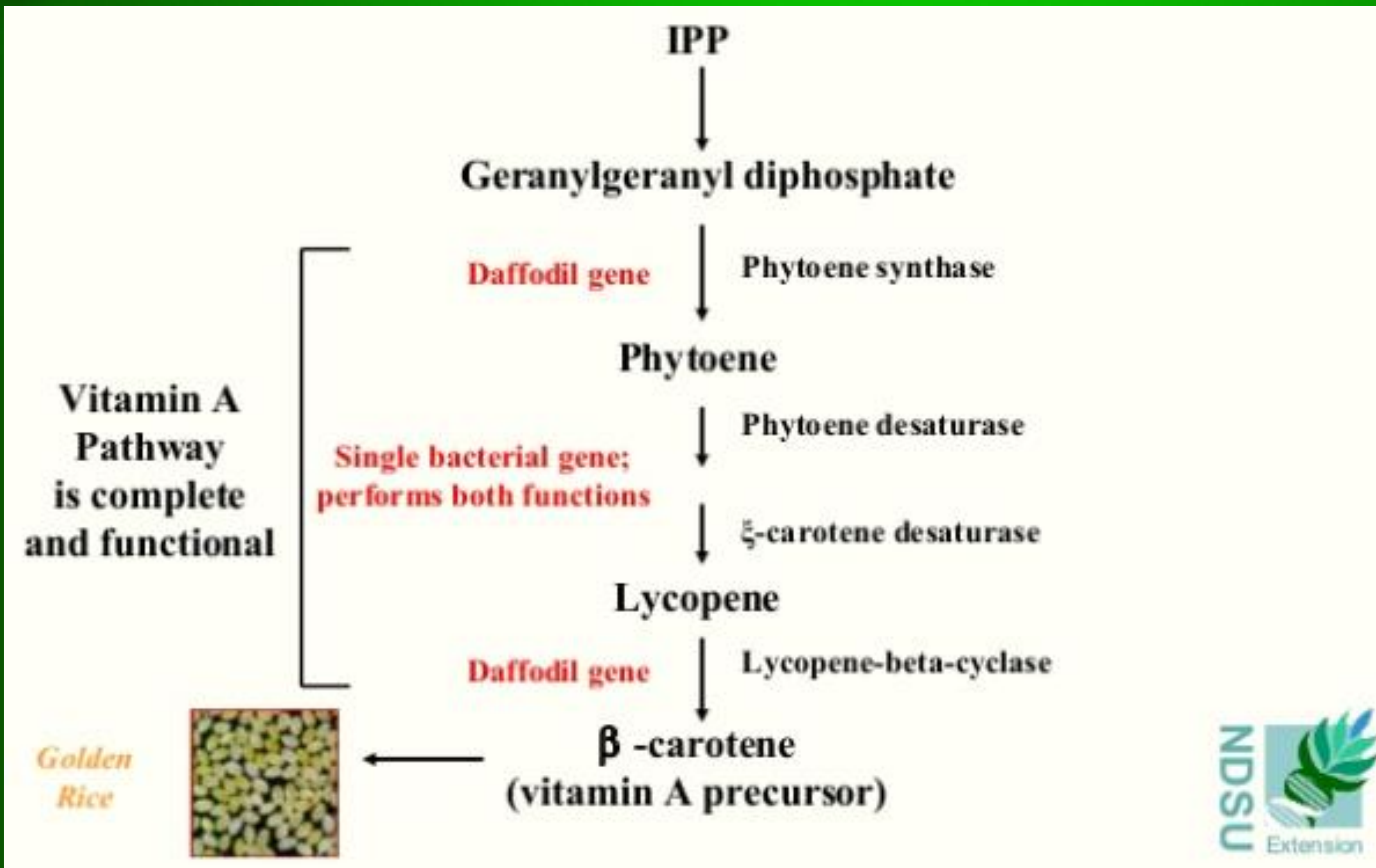
Manufacturing	Distribution	Application	Financial Benefit	Stewardship	Consumer Benefit
- Saves 3.46 M lb raw material - Conserves 1.48 Mgal fuel oil - Eliminates 2.16 M lb industrial waste	- Transports and stores 416,000 gal insecticide less - Conserves 604k gal fuel oil	- Fewer insecticide use and storage - Saves workdays for insecticide application - Conserves 2.41 Mgal fuel and 93.7 Mgal water	Accrues $168 million benefits from lower production costs and increased cotton yield	- Reduces pesticide exposure risk - Preserves beneficial insect populations - Creates wildlife benefits - Gives cotton producers more time for family and community activities - Gives cotton producers peace of mind	Produces fiber equivalent to that found in all consumer products derived from cotton

Golden rice

Production of transgenic cereals for developing countries

- Introduction of genes that produce β-carotene in the rice grain.
- Beta-carotene is present in the leaves of the rice plant, but conventional plant breeding has been unable to put it into the grain.
- Dr. Ingo Potrykus of the Swiss Institute of Plant Sciences in Zurich, with Rockefeller funding, transferred one bacterial and two daffodil genes.
- The transgenic rice grain has a light golden-yellow color and contains sufficient beta-carotene to meet human vitamin A requirements from rice alone.
- Potrykus has also added a gene from the French bean to rice that increases its iron content over threefold.

β-Carotene Pathway in Golden Rice



New Ways to Protect Drought-Stricken Plants

Anne Simon Moffat. Science 296:1226-1229, May 17 2002.

With drought an ever-present threat, researchers are identifying genes that can help plants tolerate arid conditions in hopes of using them to produce hardier crops.

Tomato plants carrying a foreign gene that protects their cells from salt-induced dehydration thrive in a 200-mM salt solution, whereas unaltered plants wither.

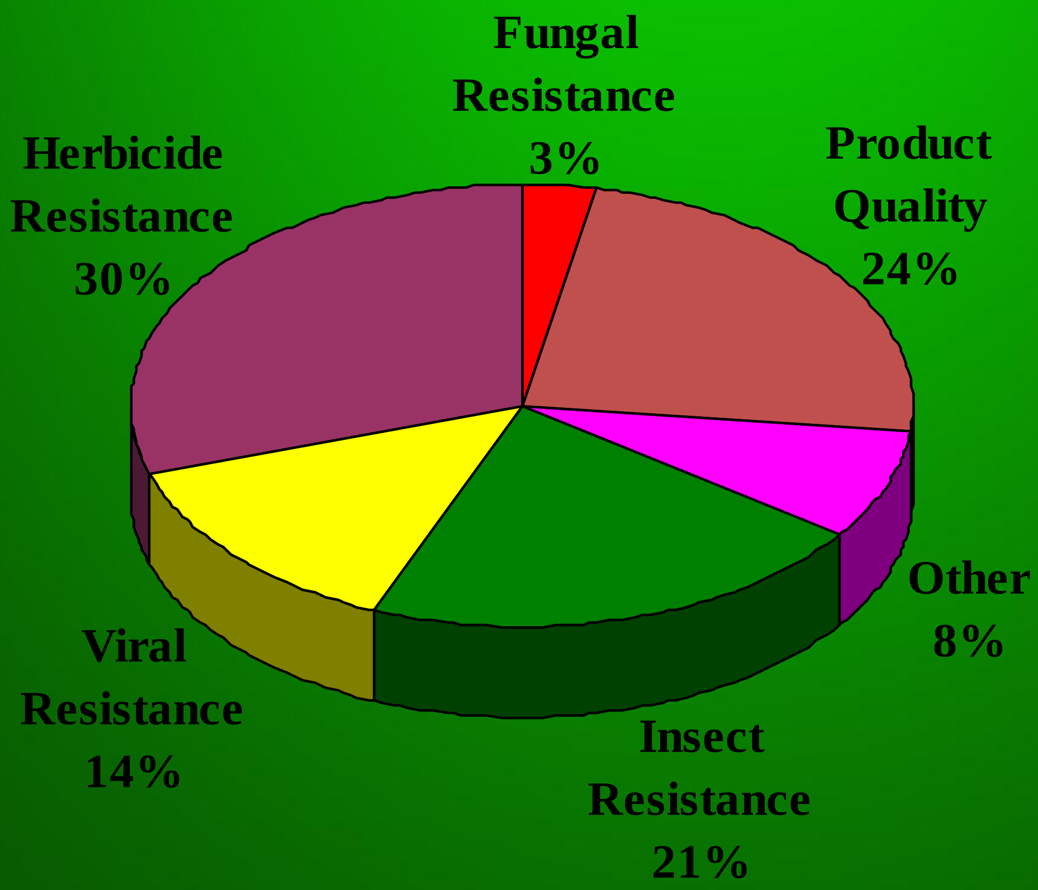
Credits: E. Blumwald/university of california, davis

Improving the drought tolerance of corn could make dried-out crops like this one a thing of the past.

Credit: Richard Hamilton Smith/Corbiss

What's Being Tested

(US field releases, cumulative since 1987-2015)



SOURCE: US DEPARTMENT OF AGRICULTURE

From Collins lab

Genetic traits expressed in GMOs in the US

RAINBOW PAPAYA

Genetic Traits
Disease resistance
Uses
- Table fruit

FIELD CORN

Genetic Traits
Insect Resistance
Herbicide Tolerance
Uses
- Livestock and poultry feed
- Fuel ethanol
- High-fructose corn syrup and other sweeteners
- Corn oil
- Starch
- Cereal and other food ingredients
- Alcohol
- Industrial uses

CANOLA

Genetic Traits
Herbicide Tolerance
Uses
- Cooking oil
- Animal feed

SOYBEAN

Genetic Traits
Insect Resistance Herbicide Tolerance
Uses

- Livestock and poultry feed
- Aquaculture
- Soybean oil (vegetable oil)
- High oleic acid (monounsaturated fatty acid)
- Biodiesel fuel
- Soymilk, soy sauce, tofu, other food uses
- Lecithin
- Pet food
- Adhesives and building materials
- Printing ink
- Other industrial uses

ALFALFA

Genetic Traits
Herbicide Tolerance
Uses
- Animal feed

COTTON

Genetic Traits
Insect Resistance
Herbicide Tolerance
Uses: Fiber, Animal feed, Cottonseed oil

SUGAR BEETS

Genetic Traits
Herbicide Tolerance
Uses: Sugar, Animal feed

SWEET CORN

Genetic Traits
Insect Resistance
Herbicide Tolerance
Uses: Food

SUMMER SQUASH

Genetic Traits
Disease resistance
Uses: Food

GET TO KNOW

GMO BASICS

How We Got Here

THE HISTORY OF GENETIC MODIFICATION IN CROPS

10,000 years ago

Humans begin crop domestication using selective breeding.

1700s

Farmers and scientists begin cross-breeding plants within a species.

1940s and 1950s

Breeders and researchers seek out additional means to introduce genetic variation into the gene pool of plants.

1980s

Researchers develop the more precise and controllable methods of genetic engineering to create plants with desirable traits.

1990s

The first GMOs are introduced to the marketplace.

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Why GMO? SEED IMPROVEMENT

SEED IMPROVEMENT TECHNIQUE	SELECTIVE BREEDING 10,000 years ago to today	INTERSPECIES CROSSES late 1800s to today	MUTAGENESIS 1930s to today	TRANSGENESIS (GMOs) 1990s to today
What is it?	Combining traits from similar and dissimilar plants by crossing into one genetic background with improved traits	Breeding and tissue culture techniques that permit genetic exchange between plants not crossing naturally	Using chemicals or radiation on seeds to change DNA and occasionally induce a favorable trait	Adding a specific, well-characterized gene to a new seed to transfer a specific trait
Examples	 Almost everything we eat	 Pluots, tangelos, some apples, rice and wheat	 Many plants and fruits including pears, apples, rice, yams, mint, some bananas	 Alfalfa, canola, corn (field and sweet), cotton, papaya, potatoes, soybeans, squash, sugar beets. Apples approved and coming to market soon.
Improved by breeding?	YES	YES	YES	YES
How many genes are affected?	10,000 to 300,000+	10,000 to 300,000	Random and unknown, likely thousands	1 to 3
Do we know which genes in the seed are affected?	NO	NO	NO	YES
Research and development time?	5 to 30 years	5 to 30 years	5+ years	5 to 10 years
Tested by regulatory agencies to ensure safety for people, animals and the environment?	NO	NO	NO	YES
Can the seeds be patented?	YES	YES	YES	YES
Approved for non-GMO and organic farming?	YES	YES	YES	NO
Are people asking for labeling?	NO	NO	NO	YES

THIS CHART COMPARES AND CONTRASTS MODERN METHODS OF SEED IMPROVEMENT.

How do we create new and improved varieties of plants? It starts with the seed. Plant breeders and scientists work together to create new varieties to address evolving challenges to farming and changing consumer preferences. Humans have been central in seed improvement for over 10,000 years, and in the last 100 years our understanding of genetics has accelerated and enabled new seed improvement techniques. Compared to earlier methods, breeders can now make improvements to seeds by moving more precisely one or a few genes into a seed.

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Sourced by Dr. Kevin M. Folta, Professor and Chairman, Horticulture Sciences Department, University of Florida, GMOAnswers.com and Scitable by Nature Education. Visit GMOAnswers.com for more information.

GMO MISCONCEPTIONS

The top five misconceptions see across social media are:

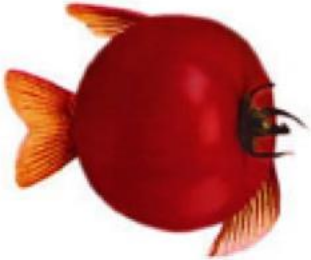
#1. If it’s extra-large, seedless, looks weird, tastes bad and feels squishy – it must be a GMO.

#2. GMOs aren’t safe and they’re only tested by the companies making them.

#3. There is animal DNA in GMOs.

#4. GMOs have pesticides injected into them.

#5. GMO companies force farmers to grow their crops, or sue farmers if GMO seeds or pollen blow into their fields.



GET TO KNOW

GMO BASICS

How do we ensure that GMOs are safe for use and consumption?

- GMO crops are studied extensively to make sure they are safe for people, animals and the environment
- GM seeds take an average of $136 million and 13 years to bring to market because of research, testing and regulatory approvals conducted by government agencies in the United States and around the world.[1]

USDA > safe to grow

EPA > safe for the environment

FDA > safe to eat

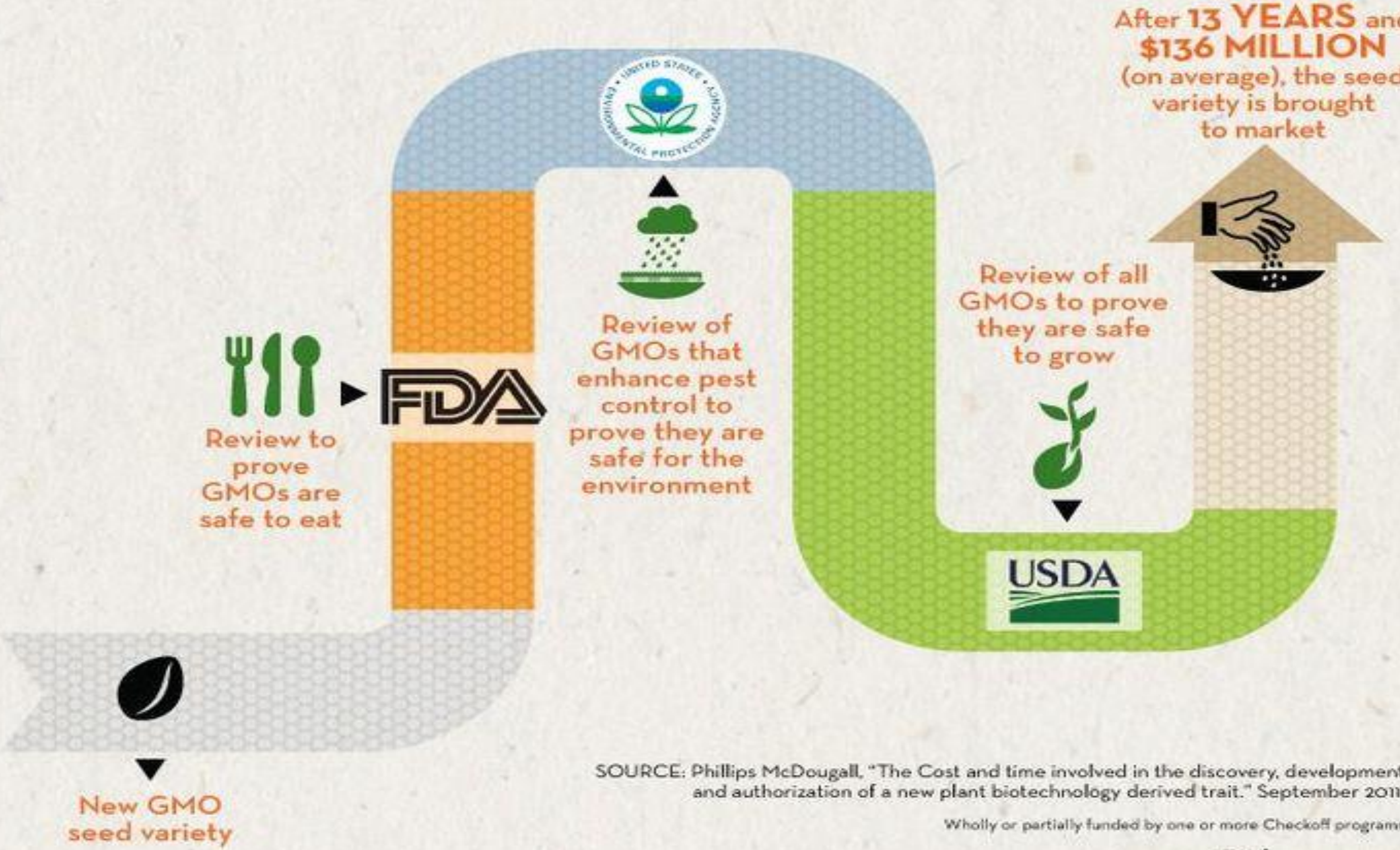
gmo answers Open to Your Questions About How Our Food Is Grown

1 McDougall,P. (2011). The Cost and Time Involved in the Discovery, Development and Authorization of a New Plant Biotechnology Derived Trait

HOW A GM SEED GETS TO MARKET

No other type of new seed that comes to market from other breeding methods goes through regulatory approval, including the thousands of conventional and organic seeds developed from mutagenesis*. Only GMOs are required to be reviewed. Even before the new seed goes through the review process, years of testing and research take place.

*Deliberately engineered DNA mutations



SOURCE: Phillips McDougall, "The Cost and time involved in the discovery, development and authorization of a new plant biotechnology derived trait." September 2011.

Wholly or partially funded by one or more Checkoff programs

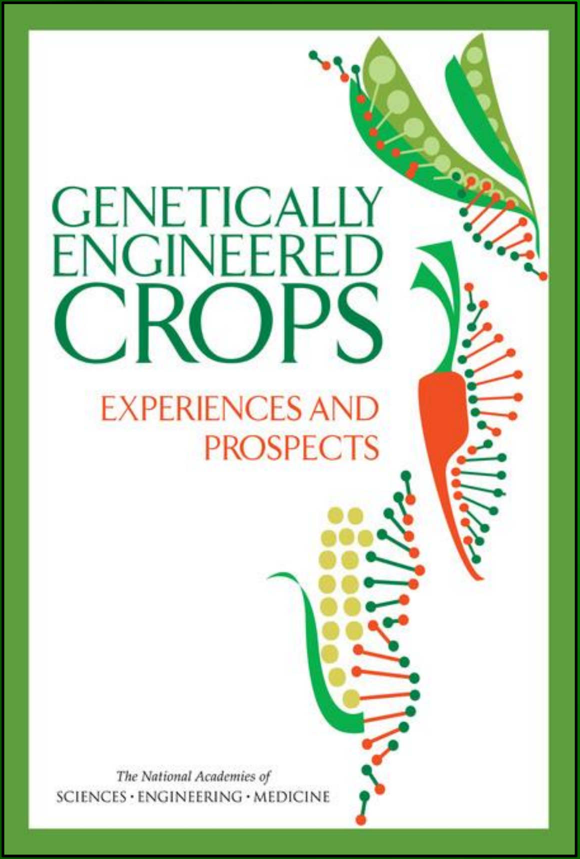
• U.S. Farmers & Ranchers Alliance •
www.FoodDialogues.com

Januari 2022

Label pada produk yang mengandung GMOs

DERIVED FROM BIOENGINEERING

National Academy of Science Report on GE Crops - May 2016



Tidak menemukan bukti nyata tentang perbedaan risiko terhadap kesehatan manusia antara tanaman rekayasa genetika (RG) yang saat ini dikomersialkan dan tanaman yang dibiakkan secara konvensional, juga tidak menemukan bukti sebab-akibat yang meyakinkan tentang masalah lingkungan dari tanaman RG.

http://nas-sites.org/ge-crops/ FREE: full report; short report; slides from news release