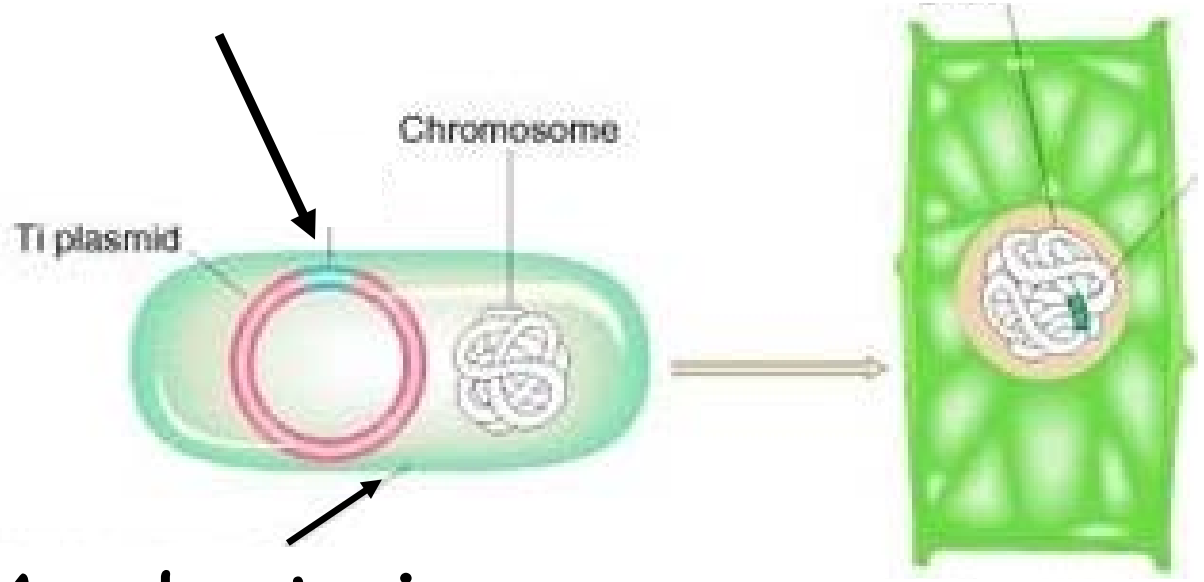
Using Agrobacterium to make "Transgenic" Plants

We insert DNA with Our Favorite Gene into the bacterium

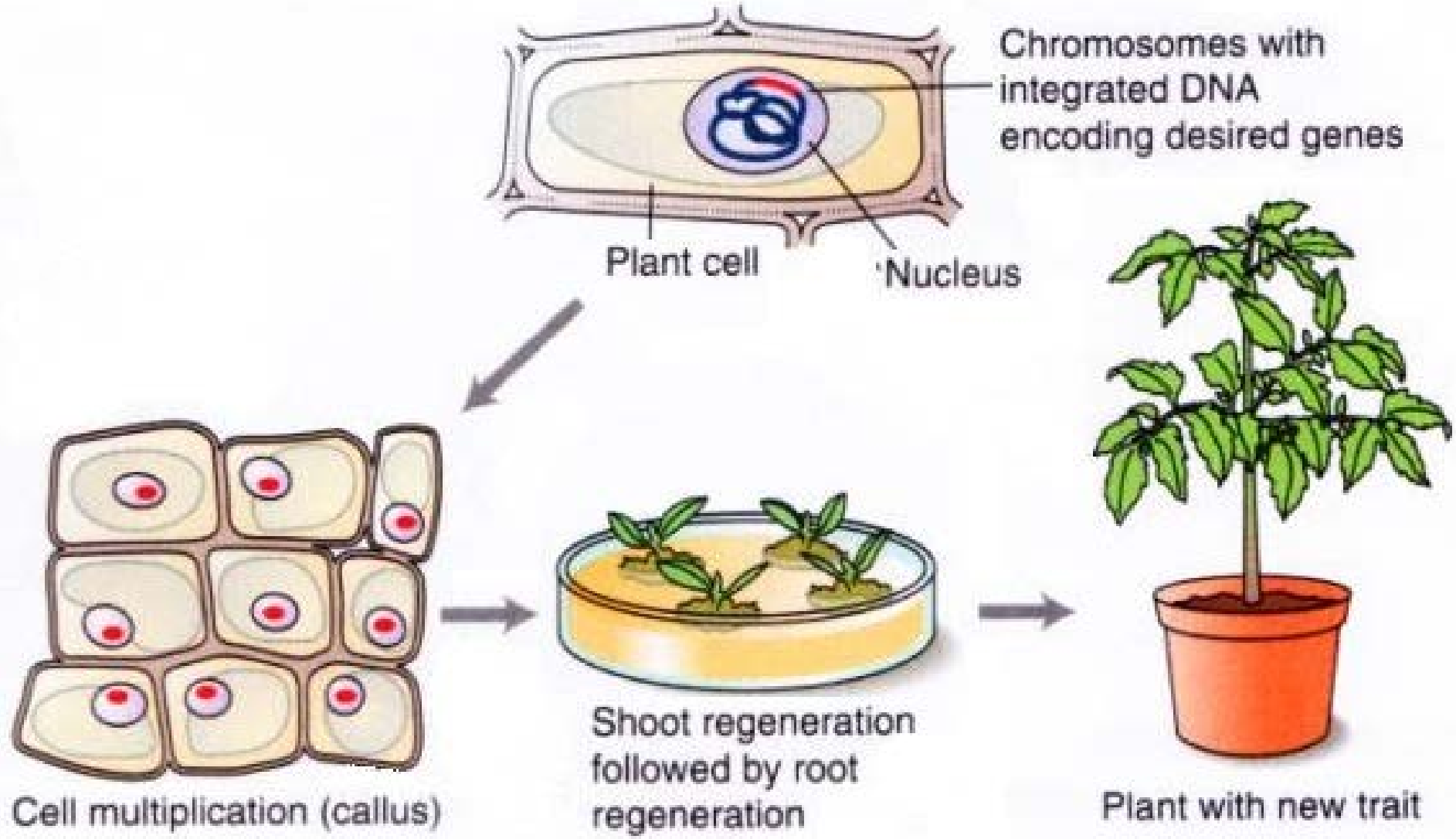
The bacterium puts it into the plant for us!



Agrobacterium

Plant Cell

We can introduce a gene into a plant cell and the "regenerate" a whole plant



Making Plants Herbicide or Insect Resistant

"RoundUp ready"

The active ingredient of RoundUp is glyphosate

Glyphosate Inhibits A Protein Called:

"EPSP Synthase"

This protein is found in bacteria, fungi, algae, some parasites and plants

EPSP Synthase is NOT found in animals including humans.

Its job is to make essential amino acids that must be obtained from an animal's diet.

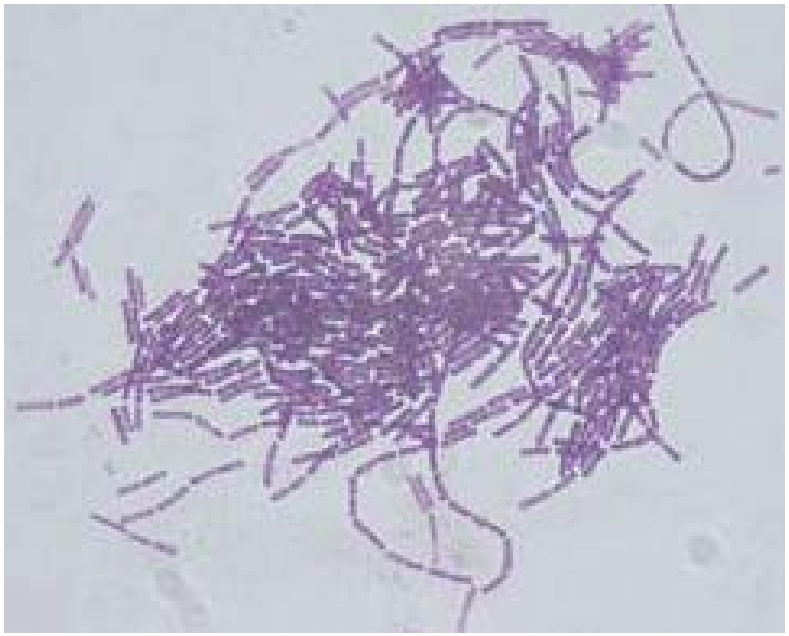
Why I am perfectly happy eating herbicide tolerant plants!

The gene used specifies a protein found in all plants. We eat it all the time!

The change that makes the protein "herbicide tolerant" involves a few amino acids – less difference than there is between two different plants.

Insect Resistance

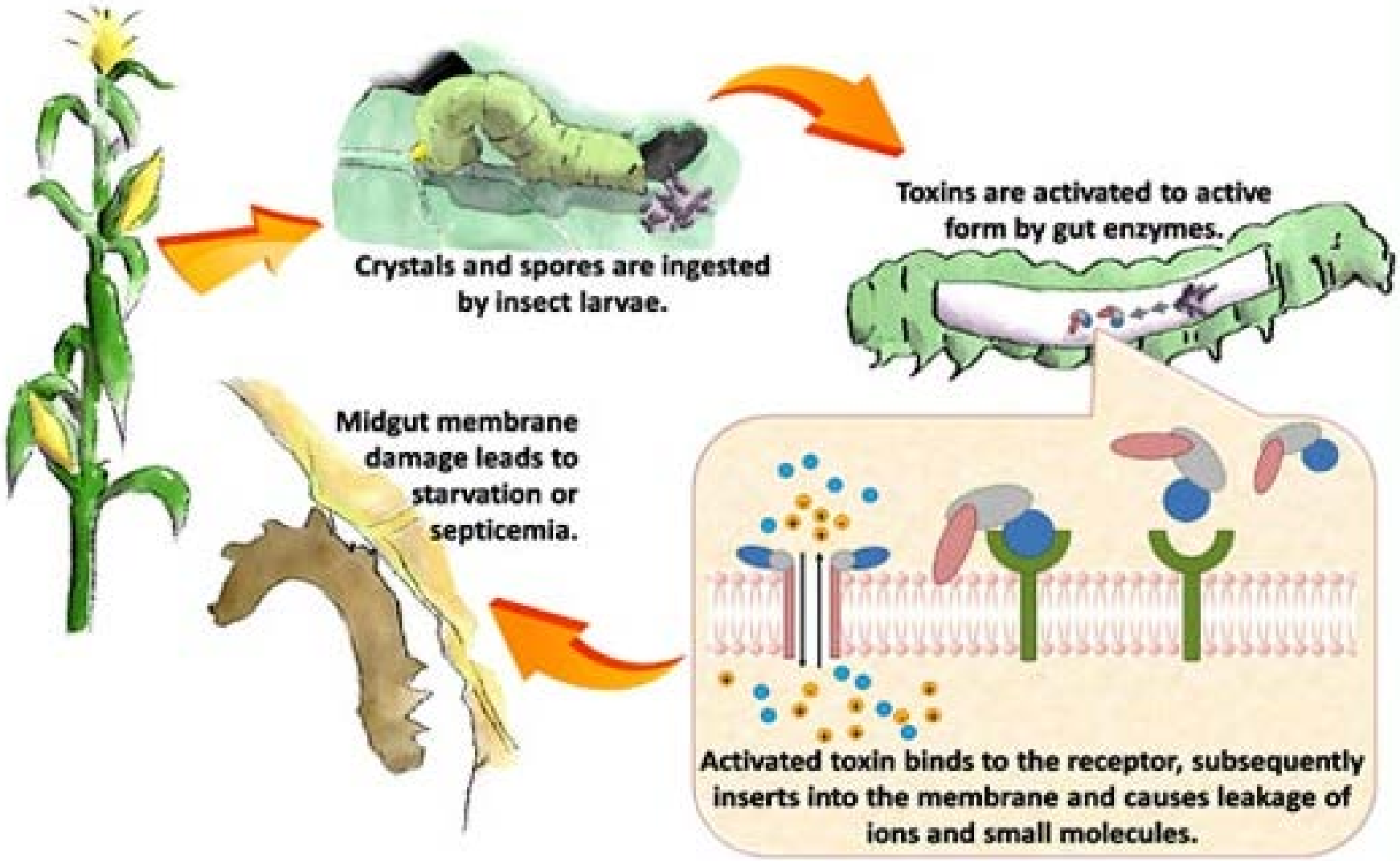
Bacillus thuringiensis (Bt)



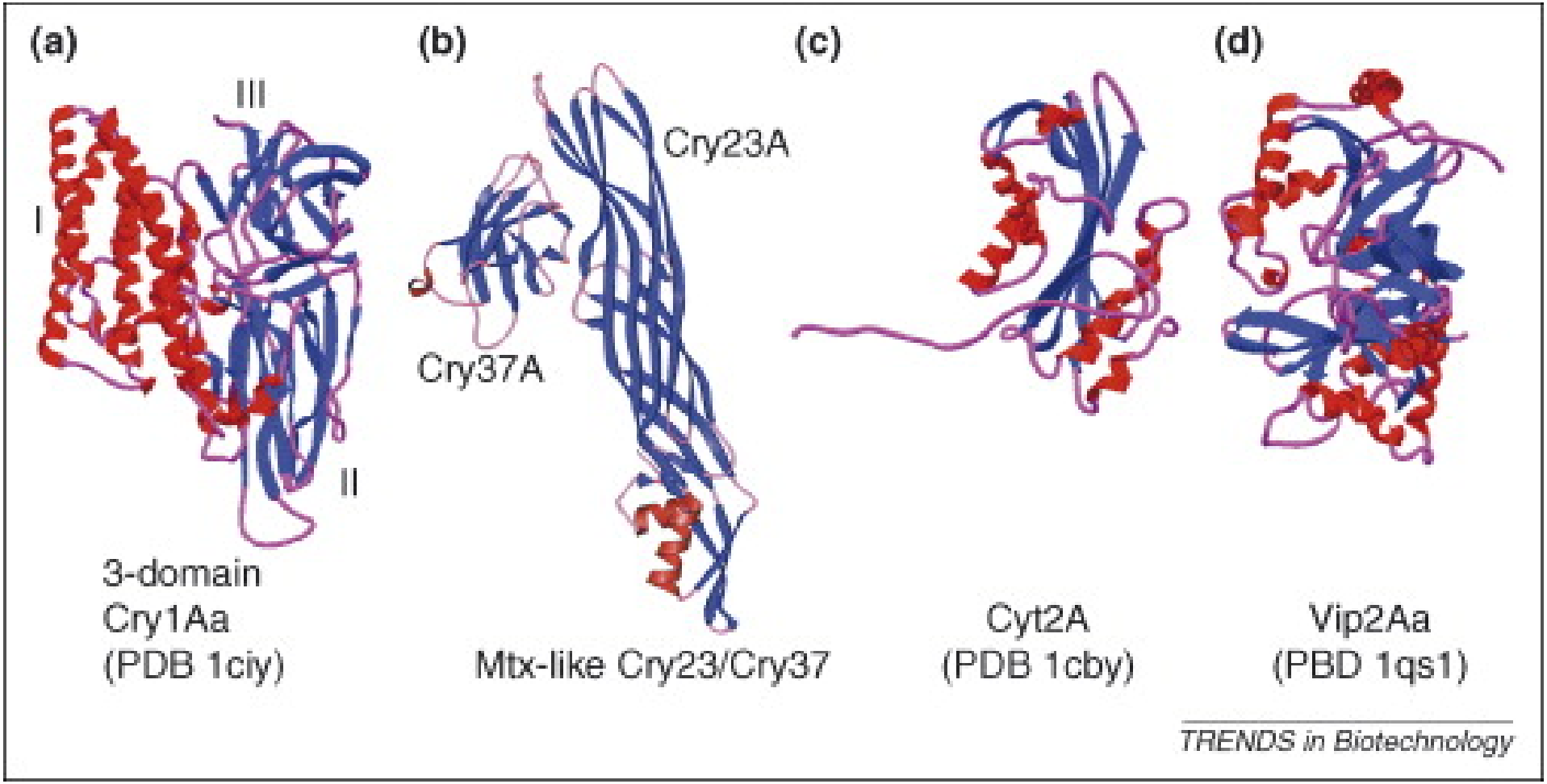
A gram positive soil bacterium

Bt bacteria are insect pathogens that produce insecticidal pore forming proteins, the Cry toxins, that kill their insect larval hosts.

Bt toxin is very INSECT SPECIFIC, specific types affect only certain insects

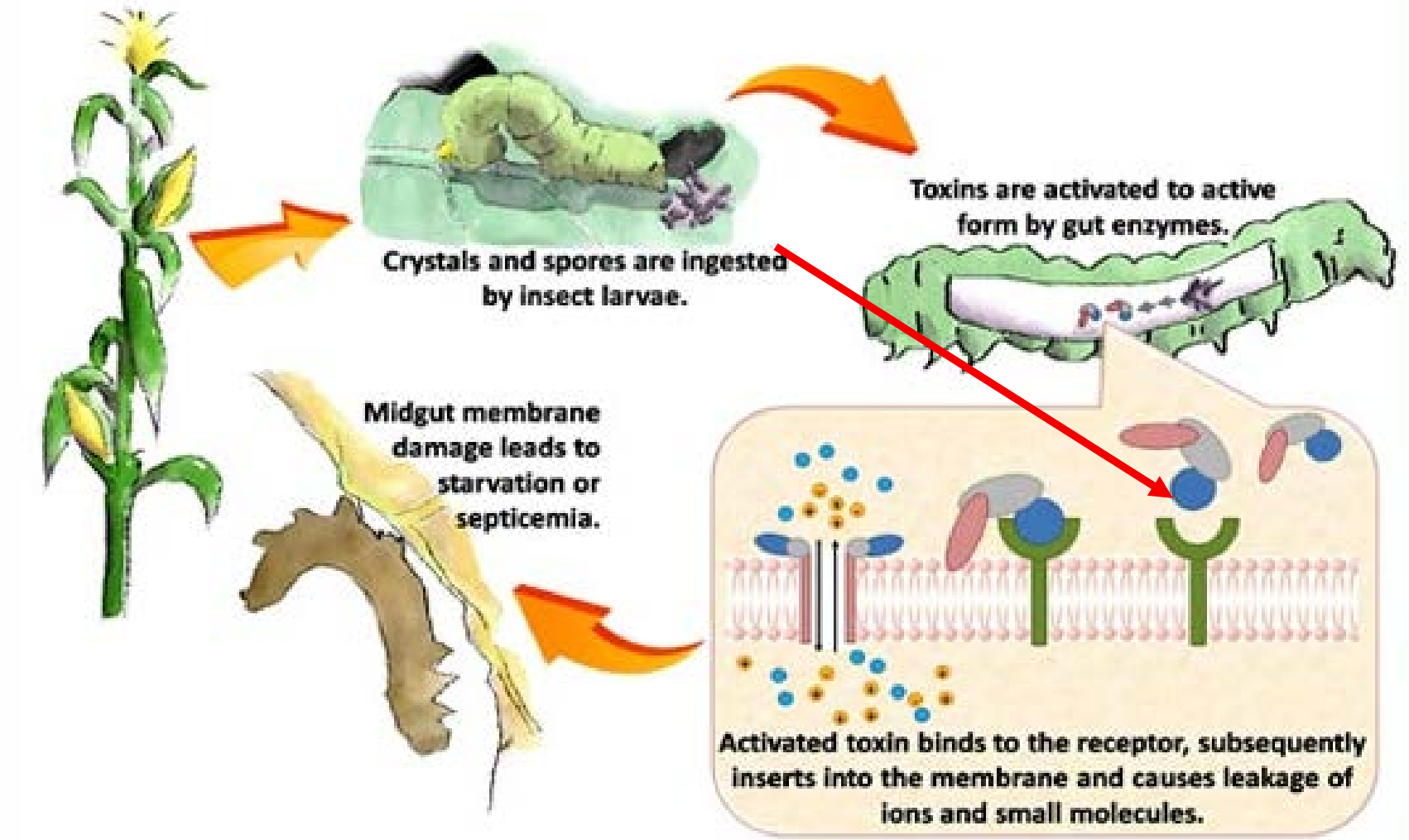


There are many different Cry toxins



Bt toxin is very INSECT SPECIFIC, specific types affect only certain insects

In order to kill the insect, the Bt protein must be attached to a specific receptor found only in insects



Why I am perfectly happy eating insect resistant plants!

The gene used (Bt toxin) specifies a protein that is digested in our stomach.

It is not digested by the insect, because, not surprisingly, they have very different "guts".

The four major Macromolecules of life:

(i.e. big stuff, e.g. relative to an atom)

Nucleic acids: DNA-Deoxyribonucleic acid

RNA-Ribonucleic acid

Store and transmit information

Proteins: Made of Amino acids (20 kinds) -
Workhorses of our cells/bodies

Lipids: Store energy (fat),lots of other functions

Carbohydrates: Store energy, other stuff too

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To begin the Product Verification Program, please complete the form below. An enrollment specialist will contact you to get started with your free GMO-assessment and cost estimate for verification.

- **There is a lot of disagreement about the effects of existing GMOs on human health – FALSE!!!**

- **"No negative effects on human health"**
  - World Health Assoc.
  - National Academy of Sciences
  - American Assoc. Advancement of Sciences
  - American Medical Assoc.
  - European Food Safety Authority
  - US EPA, US FDA, USDA
  - Scientific Societies of UK, France, Brazil, etc.

INTERNATIONAL SCIENCE ORGANIZATIONS ON CROP BIOTECHNOLOGY SAFETY

GENETIC LITERACY PROJECT

WHERE SCIENCE TRUMPS IDEOLOGY

www.geneticliteracyproject.org

1 THE AMERICAN MEDICAL ASSOCIATION

(Chicago)

"There is no scientific justification for special labeling of genetically modified foods. Bioengineered foods have been consumed for close to 20 years, and during that time, no overt consequences on human health have been reported and/or substantiated in the peer-reviewed literature."

2 THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

(Washington, D.C.)

"The science is quite clear: crop improvement by the modern molecular techniques of biotechnology is safe."

3 THE NATIONAL ACADEMY OF SCIENCES

(Washington, D.C.)

"To date more than 98 million acres of genetically modified crops have been grown worldwide. No evidence of human health problems associated with the ingestion of these crops or resulting food products have been identified."

4 FOOD STANDARDS AUSTRALIA NEW ZEALAND

(Australia & New Zealand)

"Gene technology has not been shown to introduce any new or altered hazards into the food supply, therefore the potential for long term risks associated with GM foods is considered to be no different to that for conventional foods already in the food supply."

5 THE FRENCH ACADEMY OF SCIENCE

(France)

"All criticisms against GMOs can be largely rejected on strictly scientific criteria."

6 THE ROYAL SOCIETY OF MEDICINE

(United Kingdom)

"Foods derived from GM crops have been consumed by hundreds of millions of people across the world for more than 15 years, with no reported ill effects (or legal cases related to human health), despite many of the consumers coming from that most litigious of countries, the USA."

7 THE EUROPEAN COMMISSION

(Belgium)

"The main conclusion to be drawn from the efforts of more than 130 research projects, covering a period of more than 25 years of research, and involving more than 500 independent research groups, is that biotechnology, and in particular GMOs, are no more risky than conventional plant breeding technologies."

8 THE UNION OF GERMAN ACADEMICS OF SCIENCES AND HUMANITIES

(Germany)

"In consuming food derived from GM plants approved in the EU and in the USA, the risk is in no way higher than in the consumption of food from conventionally grown plants. On the contrary, in some cases food from GM plants appears to be superior in respect to health."

9 SEVEN OF THE WORLD'S ACADEMIES OF SCIENCES

(Brazil, China, India, Mexico, the Third World Academy of Sciences, the Royal Society, and the National Academy of Sciences of the U.S.)

"Foods can be produced through the use of GM technology that are more nutritious, stable in storage and in principle, health promoting—bringing benefits to consumers in both industrialized and developing nations."

10 WORLD HEALTH ORGANIZATION

(Switzerland)

"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."

What I want to communicate

What is my bias?

What are the major "transgenic crops" today?

How do we put genes into plants?

Will new technologies "replace" GMO plants?

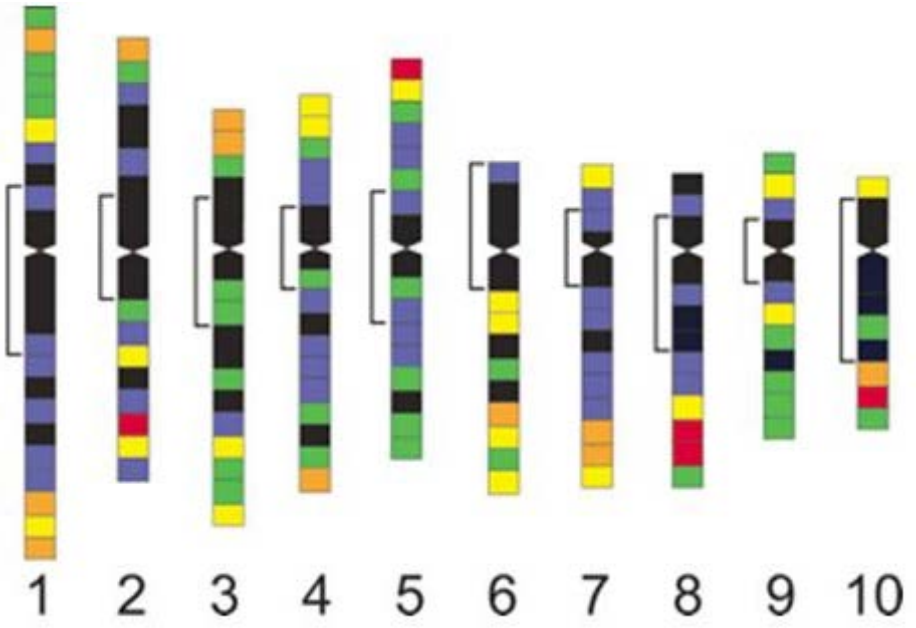
What do we need to do next?

New Technologies for Crop Improvement

- Marker Assisted Selection/Breeding
- CRISPR/Cas gene editing

Advances in genomics technologies facilitate breeding for complex traits

- Genome sequence data are available for more than 20 plant species
- Molecular breeding and mapping tools are developed for many species
- Genome-wide association studies help match genes to traits



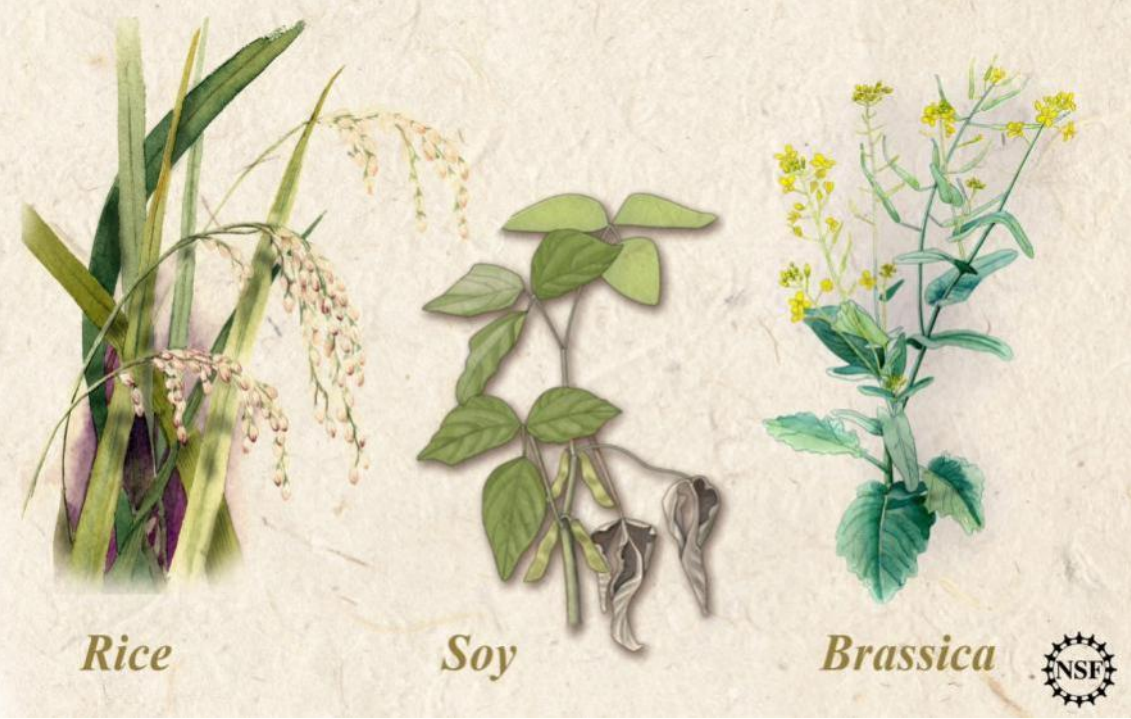
Anderson, L.K., Lai, A., Stack, S.M., Rizzon, C. and Gaut, B.S. (2006). Uneven distribution of expressed sequence tag loci on maize pachytene chromosomes. Genome Research. 16: 115-122.









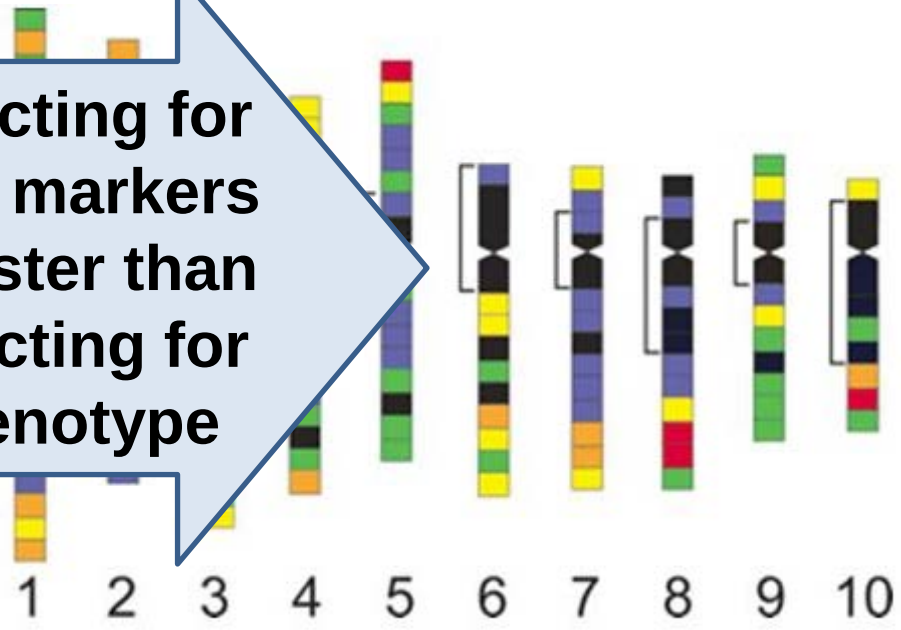



Genome sequence data are available for many crop plants

Marker Assisted Selection

Phenotype: physical expression of traits

Selecting for DNA markers is faster than selecting for phenotype



Genotype: sequence of all the genes in a genome

Photo credit LemnaTec; Anderson, L.K., Lai, A., Stack, S.M., Rizzon, C. and Gaut, B.S. (2006). Uneven distribution of expressed sequence tag loci on maize pachytene chromosomes. Genome Research. 16: 115-122.

MAS was used to produce of submergence tolerant rice (*Sub1*)

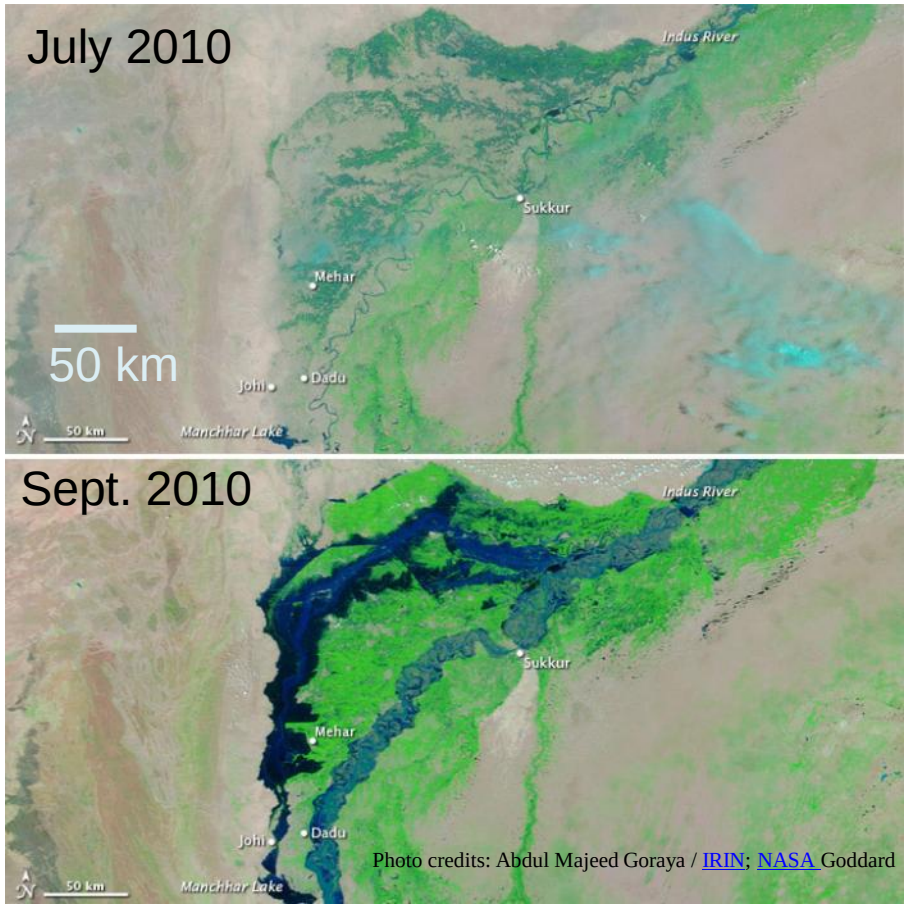


Photo credits: Abdul Majeed Goraya / IRIN; NASA Goddard

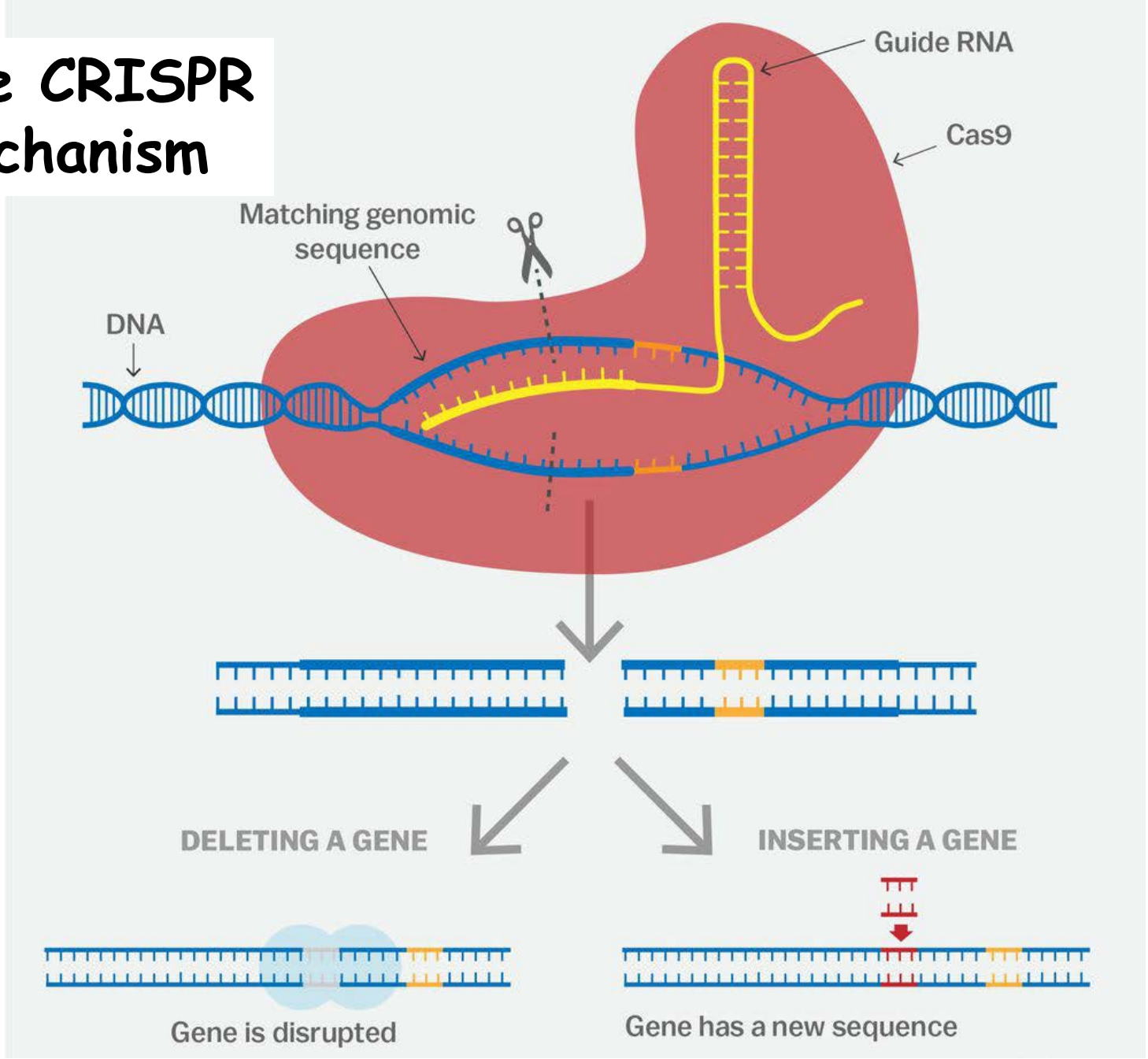
Many rice-growing regions are prone to flooding. In Pakistan a 2010 a huge flood submerged 17 million acres (69,000 km^2) and destroyed much of the harvest

CRISP/Cas

A technique for "Editing" a genome

Remove genes, change existing genes

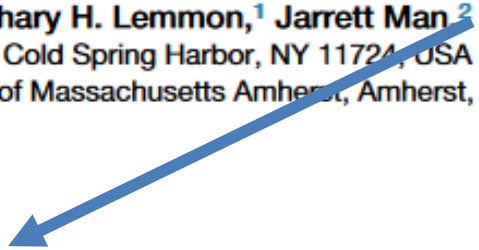
The CRISPR Mechanism



From the scientific journal **CELL – October, 2017**

Engineering Quantitative Trait Variation for Crop Improvement by Genome Editing

Daniel Rodríguez-Leal,[1] Zachary H. Lemmon,[1] Jarrett Man,[2] Madelaine E. Bartlett,[2] and Zachary B. Lippman[1,3,*]
[1]Cold Spring Harbor Laboratory, Cold Spring Harbor, NY 11724, USA
[2]Biology Department, University of Massachusetts Amherst, Amherst, MA 01003, USA



Jarrett Man,[2] Madelaine E. Bartlett,[2]
[2]Biology Department,
University of Massachusetts Amherst, Amherst, MA

They increased tomato size and yield.

What I want to communicate

What is my bias?

What are the major "transgenic crops" today?

How do we add to, or modify plant genes?

Will new technologies "replace" GMO plants?

What do we need to do next?

Worldwide, preharvest crop loss estimates:

- We need to use every tool at our disposal, including GMO technology, to solve agricultural and environmental problems to create food security and sustainability

Other losses due to stress:
drought, cold heat, salinization

Can we use Genetic Engineering to do "good things"???

Plant improvement that can't be done by conventional breeding.

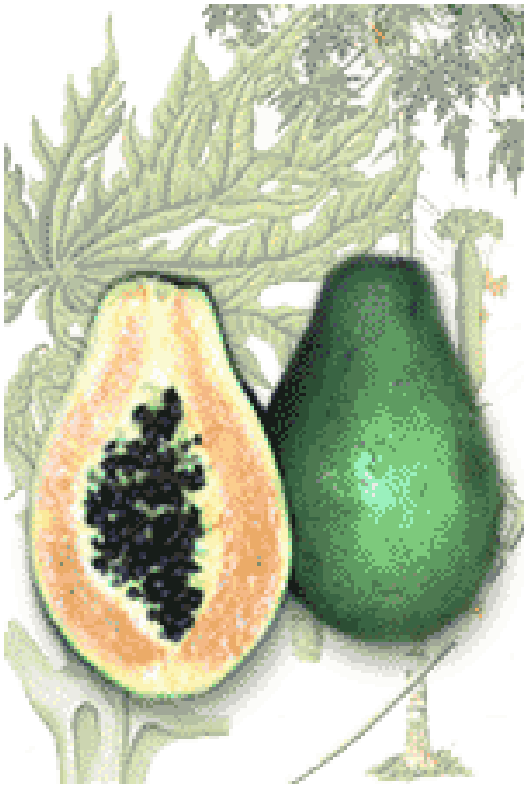
GM Disease Resistant Papaya has replaced 80% of the Hawaiian Papaya crop

GM Crop Database

Database Product Description | Show abstract | Print this page

UFL-X17CP-6 (X17-2)

Host Organism	*Carica papaya* L. (Papaya)
Trait	Resistance to viral infection, papaya ringspot virus (PRSV).
Trait Introduction	*Agrobacterium tumefaciens*-mediated plant transformation.
Proposed Use	Production of papaya for human consumption, either fresh or processed.
Company Information	University of Florida



http://cera-gmc.org/index.php?action=gm_crop_database

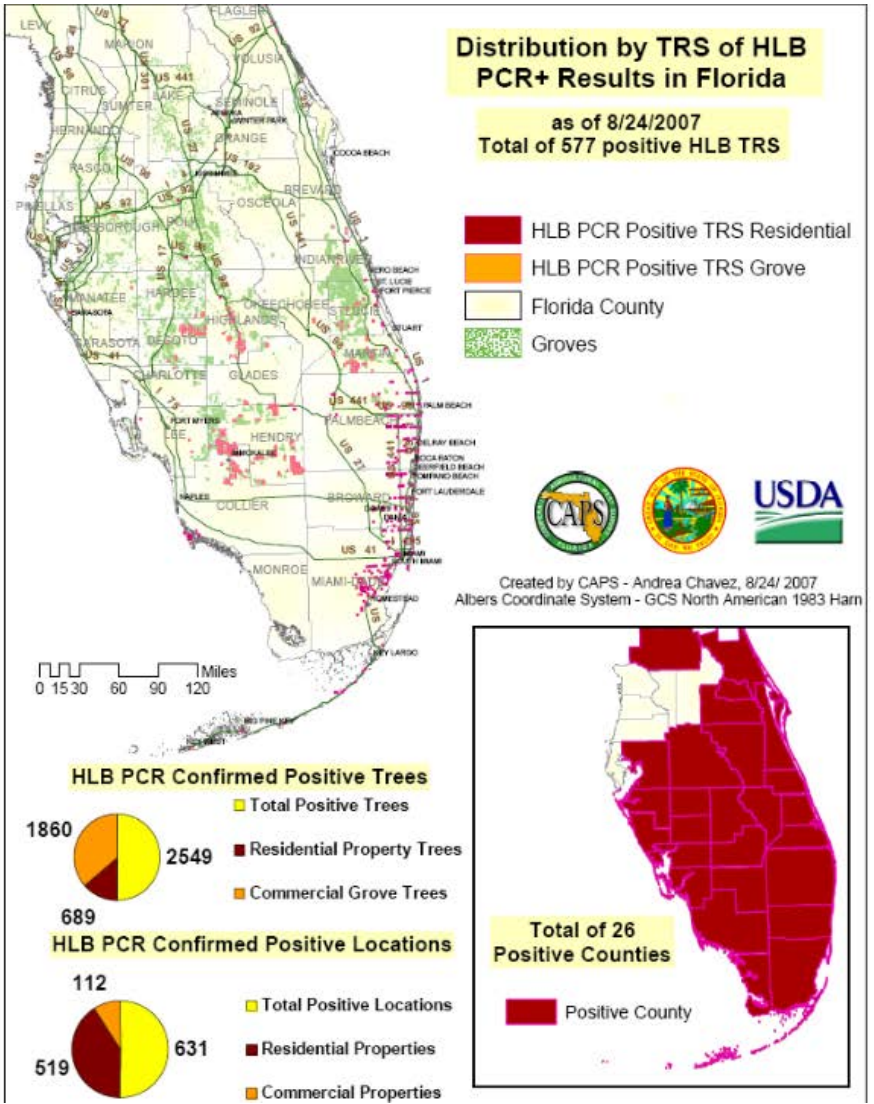
Ringspot Virus resistant Papaya

Developed by Dennis Gonsalves

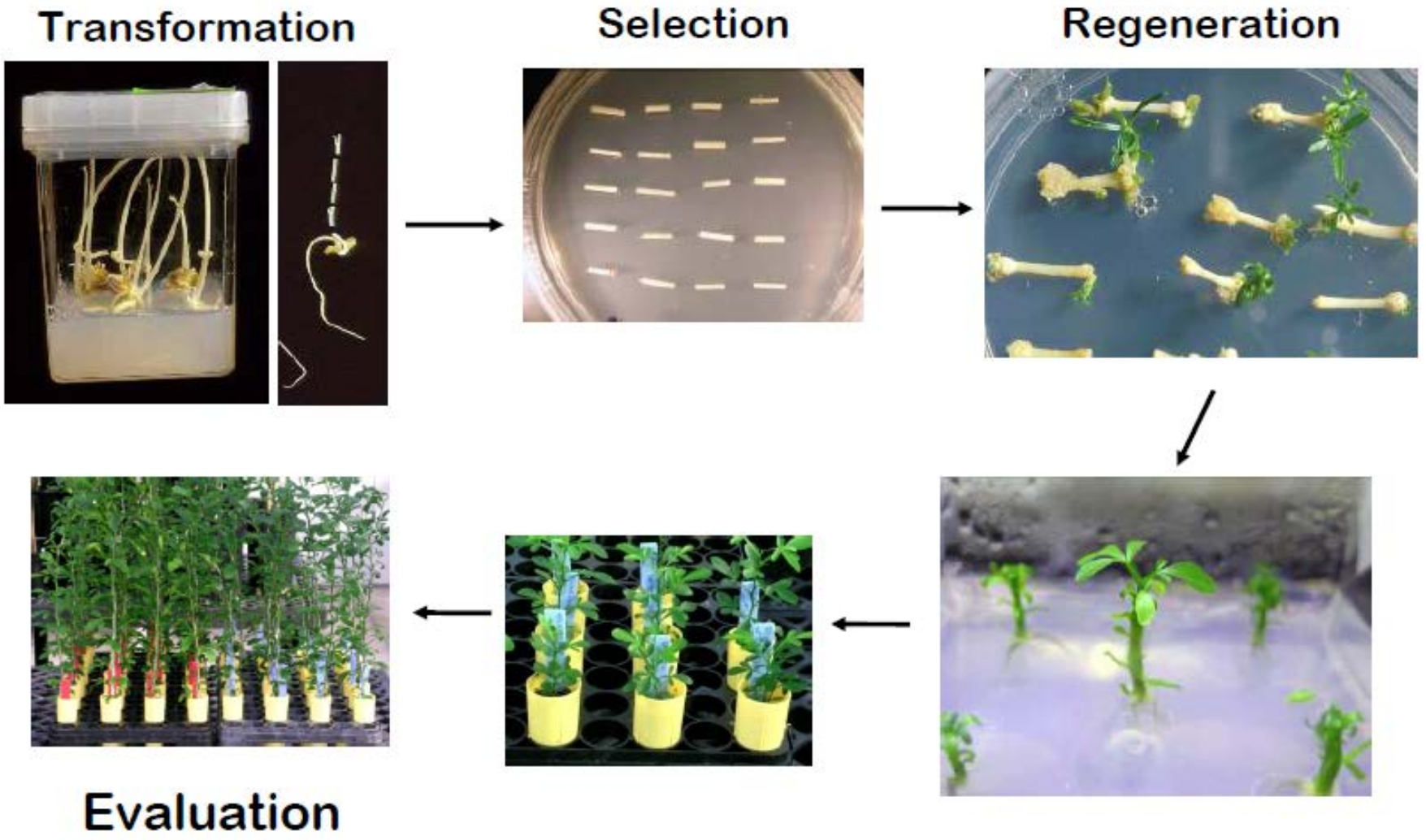
- An American phytopathologist, born in 1943.
- Grew up on a sugar plantation in Kohala, Hawaii
- Created virus-resistant Papayas at the University of Florida
- Funded by USAID, helped develop locally adapted papayas for Venezuala, Jamaica, Brazil, Africa and Bangladesh

The spread of Citrus Greening disease

We have no way to breed citrus for resistance to this disease, but it could be done with GMO technology



Citrus Transformation



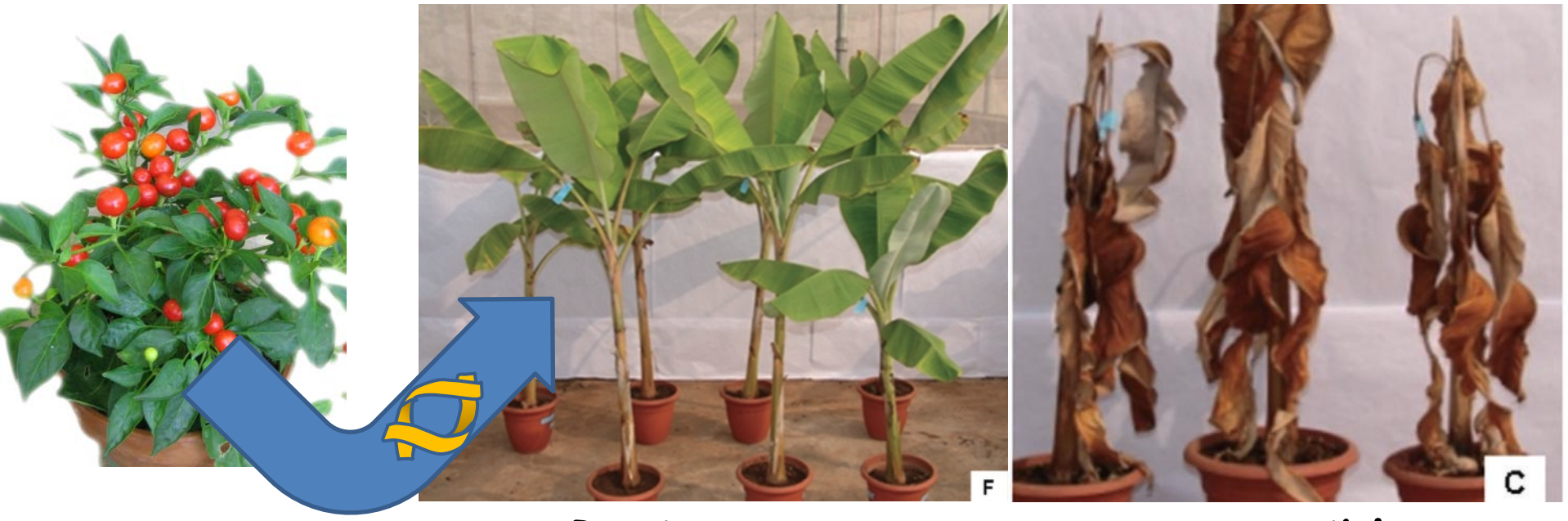
Transgenics have proven successful for other fruit crops

Papayas
Papaya ring spot
Viral disease

Apples
Fire blight
Bacterial disease

Plums
Plum pox
Viral disease

GM Example: Disease resistant banana by introduction of a gene from pepper



Resistant Susceptible

Banana bacterial wilt is destroying plants in Africa. Transgenic plants carrying a resistance gene from pepper are resistant to the disease

Tripathi, L., Mwaka, H., Tripathi, J.N., and Tushemereirwe, W.K. (2010). Expression of sweet pepper Hrap gene in banana enhances resistance to Xanthomonas campestris pv. musacearum. Molecular Plant Pathology 11: 721-731.