

# GMO's: Past, present, and future

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Entomology, Plant Pathology, and Weed Science



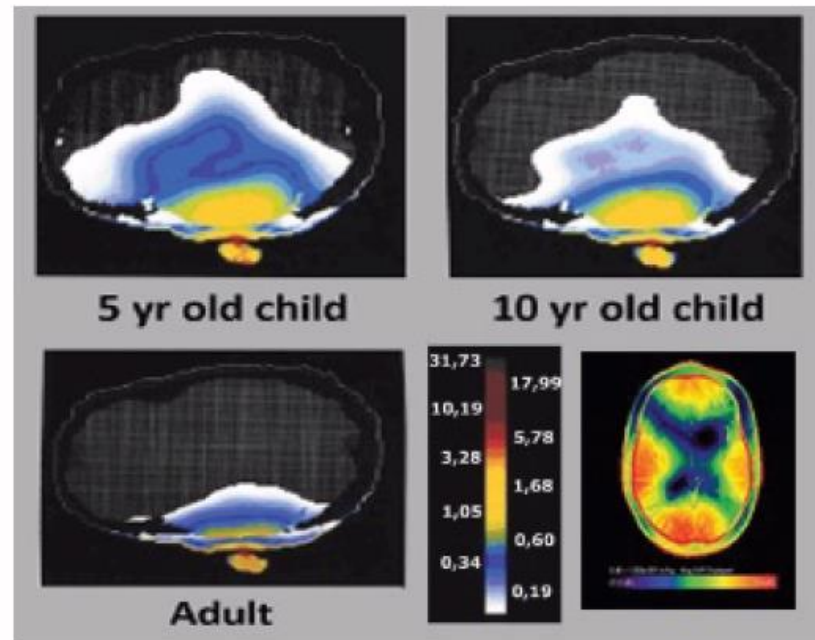
# Facts vs fiction:



Are we all really gullible  
-or-  
Is some of it pretty well packaged?  
-and-  
What is the truth?

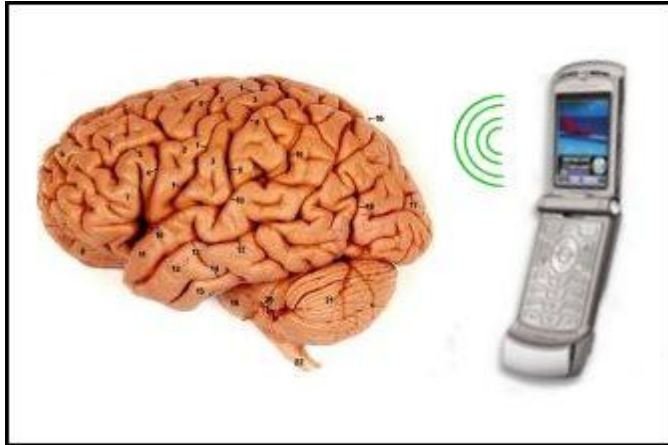
# Cell phones and cancer risk

## Brain Absorption of Cell Phone RF



News: -Cell phone irradiate our brains!  
-Should we be worried?

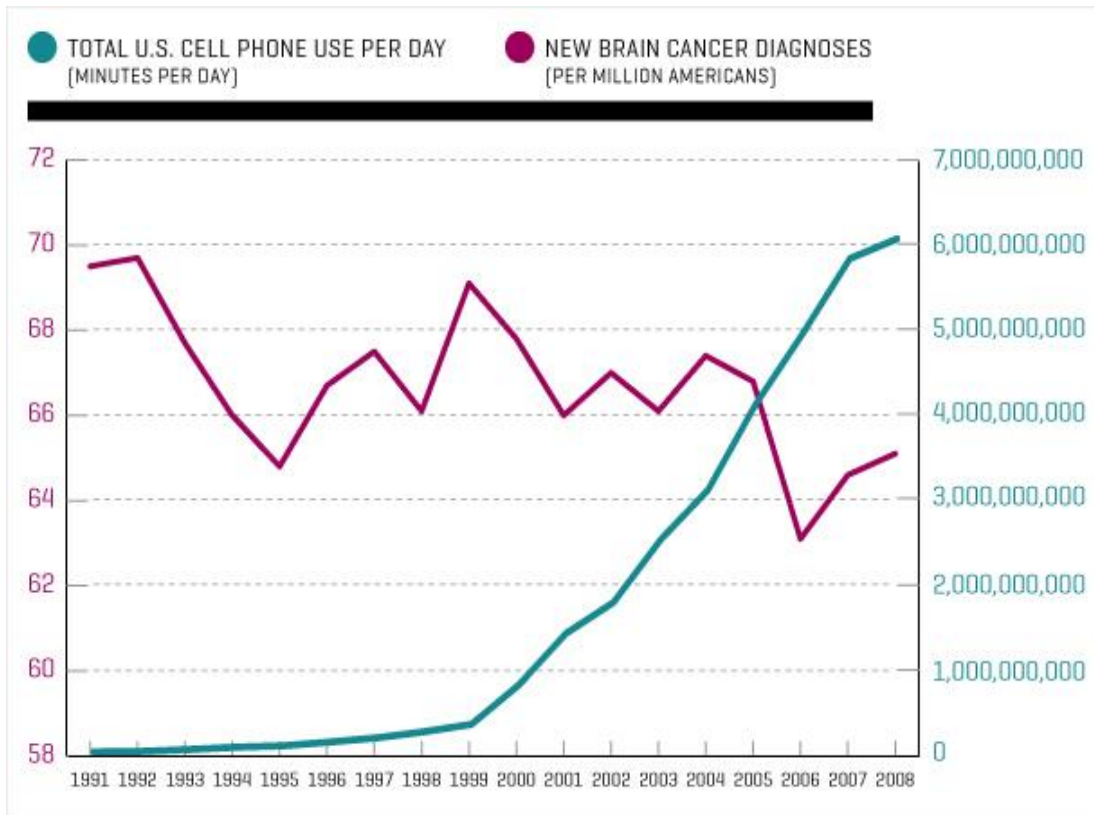
# Can healthy skepticism go to far?



# Cell phone radiation research questions

- Assume radiation is bad so cell phones must be giving us brain cancer?
- Or, ask questions?
- Any difference in brain cancer rates before / after cell phones became widely used?
- Any shift in age of people getting brain cancer?
  - Kids getting more than adults?
- Tumors more common on side of head that phone is held on?

# Cell phones, science and common sense



## Common sense:

If cell phones were causing a brain cancer epidemic we would probably have noticed by now.

# Risks of radiation: tested?

- TV and radio
  - Blocked by mountains, highway overpasses
  - Penetrate house walls
  - No link to human disease found

# Scientists are good at asking questions

- And yet, still some skeptics





# GMO food safety, real concern or hysteria?

**Shock findings in new GMO study: Rats fed lifetime of GM corn grow horrifying tumors, 70% of females die early**

[http://www.naturalnews.com/037249\\_gmo\\_study\\_cancer\\_tumors\\_organ\\_damage.html#ixzz2JyipfUjm](http://www.naturalnews.com/037249_gmo_study_cancer_tumors_organ_damage.html#ixzz2JyipfUjm)



Wednesday, September 19, 2012  
by [Mike Adams](#), the Health Ranger, Editor of  
NaturalNews.com



# Real science or fake news?

- Study done with strain of rat that has high rate of spontaneous cancer, especially breast cancer.
- Control groups had more cancer than GMO groups in high dose GMO group.
  - Eating a small amount of GMO causes cancer but higher amounts protects against cancer?
  - Sample size too small, statistically non-significant differences.
- Study claimed to be first comprehensive feeding study.
  - Simply not true, hundreds done.
- “Study” was retracted by journal shortly after publication (2012).

Article remains on Natural News web site to date.



# GMO food safety- real life experiment / experience

- If roundup ready crops really caused breast cancer in 70+% of mammals....
  - Maybe somebody would have noticed by now?
  - Could the dairy and cattle industries survive if GMO caused breast cancer in most of the animals that ate it?



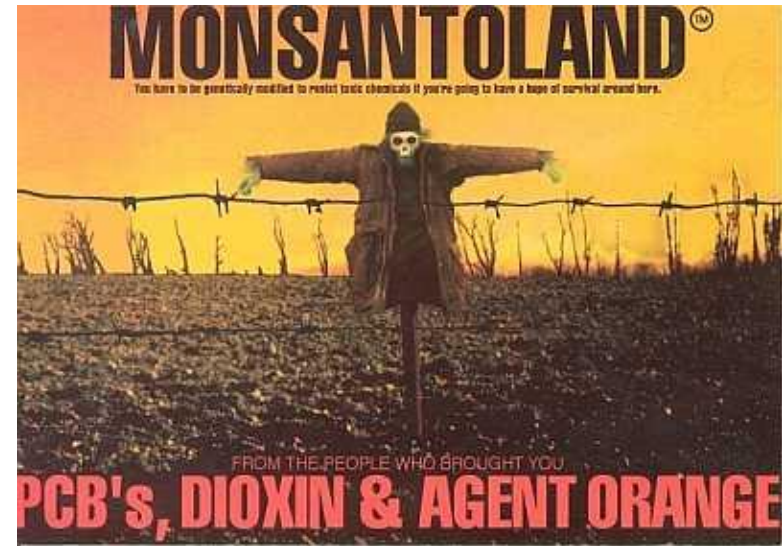
# The “trillion meal” study- real world experience

- Prevalence and impacts of genetically engineered feedstuffs on livestock populations..
  - A. L. Van Eenennaam and A. E. Young, UC-Davis Dept of Animal Sci.
  - J. Anim. Sci., 2014
- Studied livestock health and productivity
  - 1983-1996 = NO GM livestock feed.
  - Compared to recent records where >95% of livestock consume GM feed.
  - 100 billion animals represented in studies reviewed
    - Slaughter weight, milk production
    - % mortality
    - Disease rates, miscarriage rates, health issues,.....

**No “unfavorable trends in livestock health or productivity” associated with GM feed.**



# Public representation of GMO's / biotechnology



# Are we are being presented with a complete and accurate story?

**Agent Orange Ready Corn!**

**Meet the New Monsanto: Dow Chemical... and Their New 'Agent Orange' Crops.**



Public acceptance still less than 100%



Is genetic modification of our  
crops new?





# Genetic modification of crops since domestication:



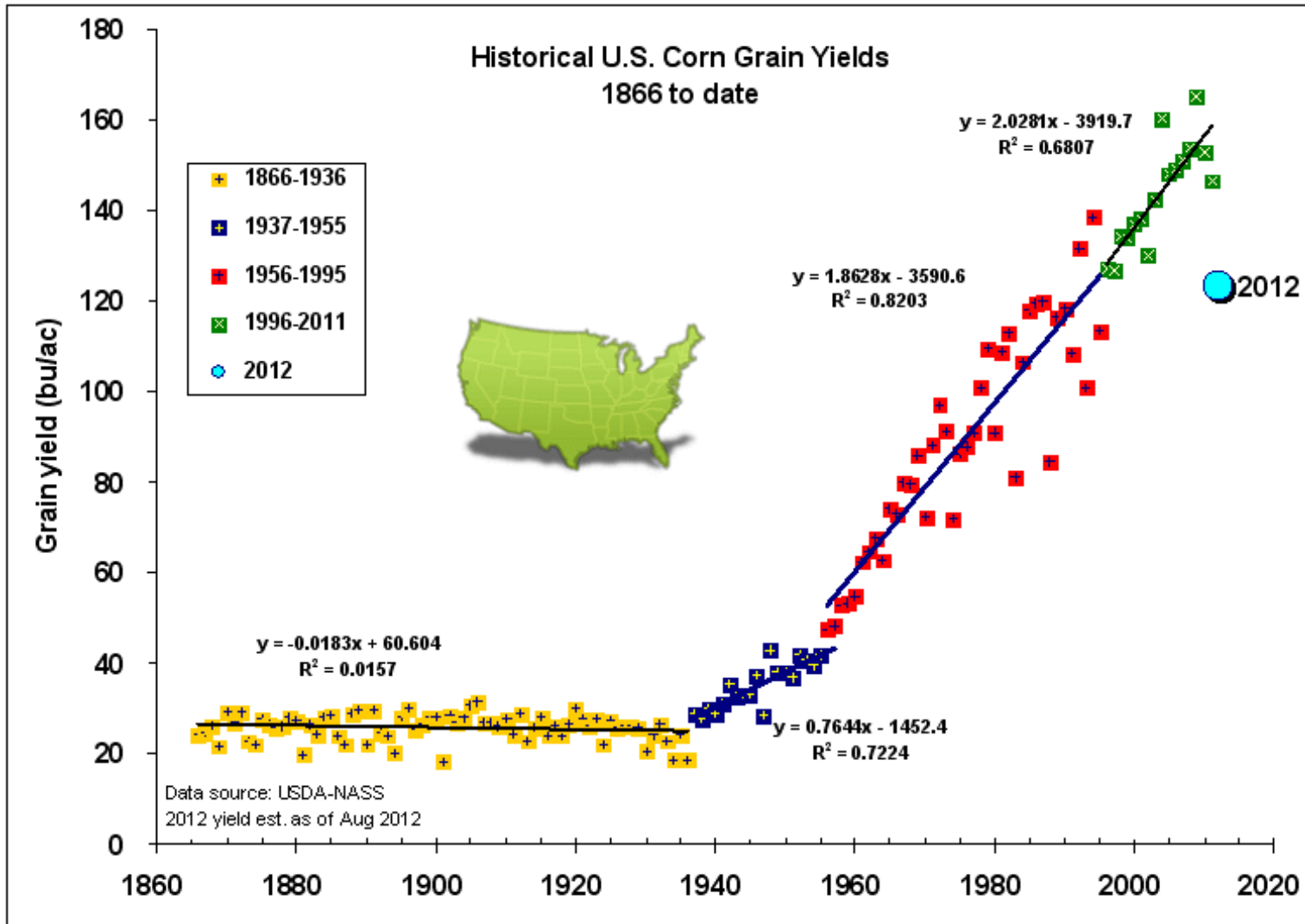
Teosinte

10,000 yrs



Corn

# Crop yield improvements



# Genetic modification of crops during domestication:



# Natural variation, mutation, and human guided selection



# Chiles



Chiltepin



# What is a genetically modified organism?

- “Genetically modified” is unfortunate terminology
- Most crops and livestock are highly modified from nearest wild ancestor
- Genetic engineering = moving DNA (traits) using gene transfer technology instead of sexual crossing.
  - No species barrier
  - Can create new traits in the lab
- Is it unnatural and dangerous?
- Do we really understand what it is, how it works, what kinds of manipulations are being done?



# How are GE crops produced?



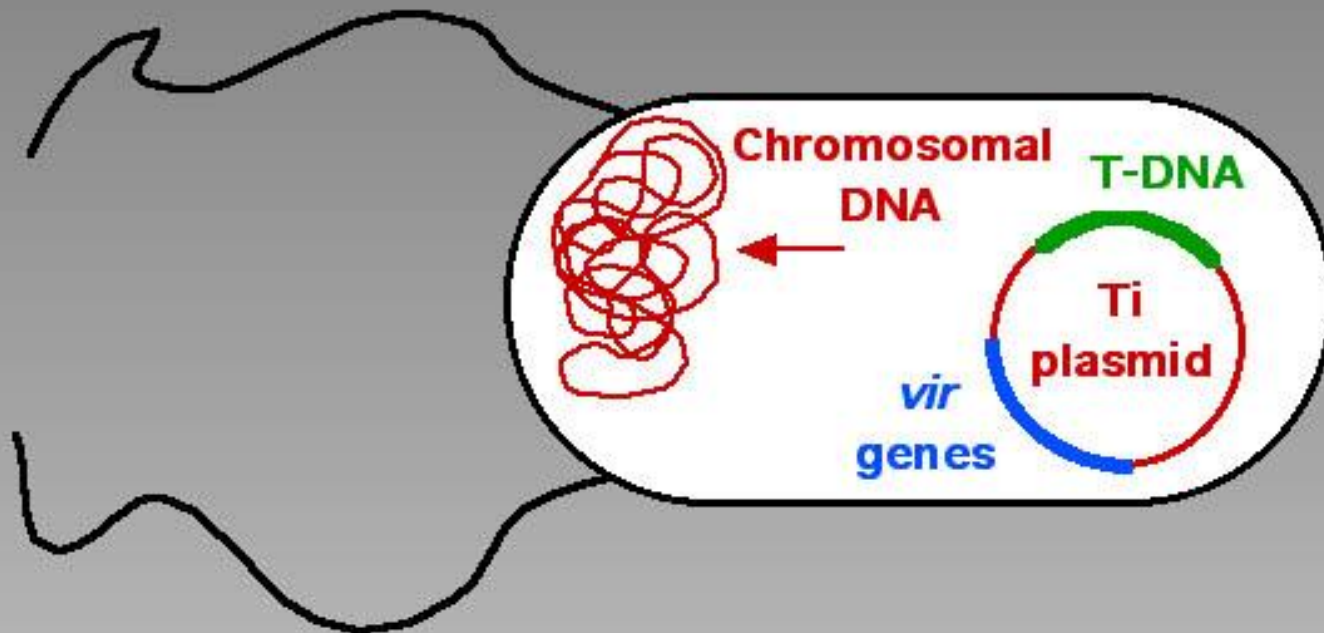
# Blame the Plant Pathologists!

- It all started with crown gall disease (*Agrobacterium tumefaciens*)

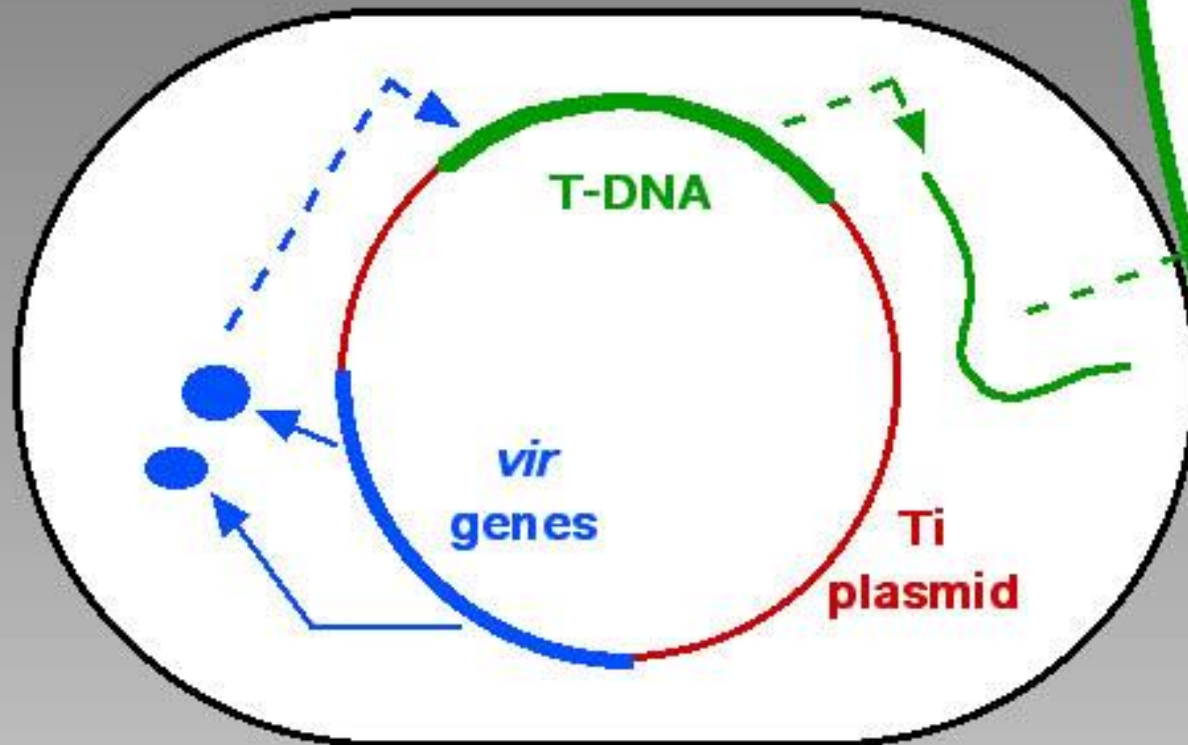




*Agrobacterium tumefaciens* is a naturally occurring soil bacterium. Most strains carry a plasmid (the **Ti plasmid**) which gives the bacterium the capacity to transfer part of the plasmid (the **T-DNA**) to a plant.



Proteins produced by the *vir* genes cause a strand of T-DNA to be copied and transferred to the plant cell.



PLANT  
CELL

T-DNA  
integrates  
into plant  
genome

# Genetic engineering based on well understood natural process

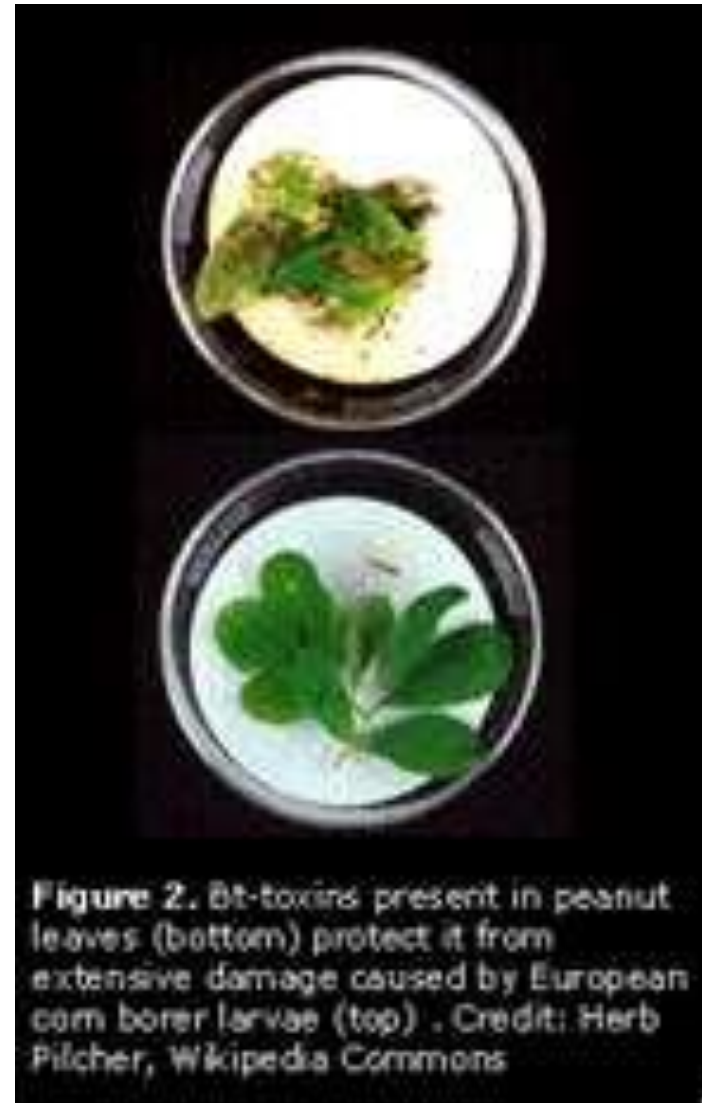
- Crown gall disease = *Agrobacterium* genetically engineering host plant to make food factory for *Agrobacterium*.
- Scientists learned how to delete disease causing genes and replace them with genes of interest.
- Use *Agrobacterium* to move genes into plants for us.

# GMO crops approved for use

- **Bt insect resistant crops**
- Herbicide tolerant crops
- **Papaya ringspot resistant papaya**
- **Arctic apple**
- Flavr-savr tomato
- Potatoes (virus, insect, fungus resistant)
- Squash (virus resistant)
- Sweet corn

# Development of insect resistant Bt crops

- Scientists knew *Bacillus thuringiensis* was toxic to certain insects. Dried bacteria can be dusted onto plants to protect from insects.
- Experiments identified “crystal protein” as the toxin.
- Petri dish tests:
  - Plant tissue plus insects
  - Can apply purified crystal protein to plant tissue and see protection
- Based on results like this scientists decided to engineer plants to express crystal protein.



# Testing of transgenic Bt crop plants

- Bt crops engineered to express (Bt toxin)
- Control of specific target insects without insecticides
  - Only insects eating plant are exposed, vs. spraying field
  - Bt toxins target specific groups of insects, not all insects (bees)



*Insect damage in normal and Bt-potato plants*

[http://www.biotechnews.gov.in/fullstory\\_1.html](http://www.biotechnews.gov.in/fullstory_1.html)



<http://www.biology.iupui.edu/biocourses/biol540/9agbiofullCSS.html>

# Benefits of Bt crops

- Proven to maintain yields with greatly reduced (50-90%) insecticide use.



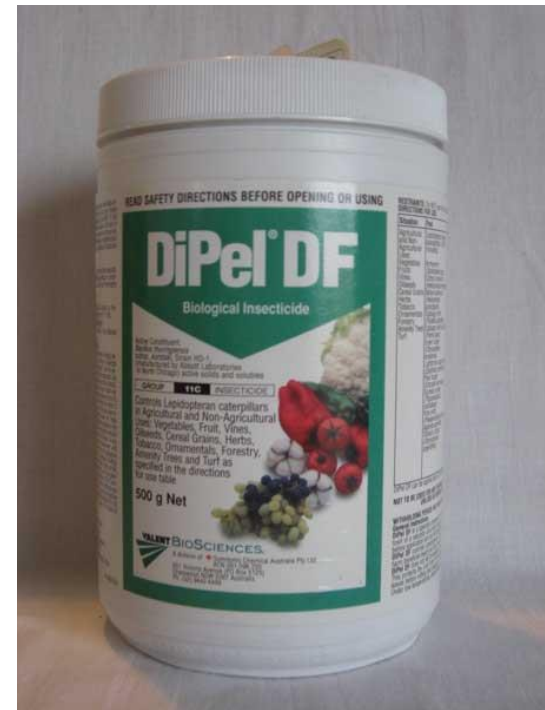
<http://cls.casa.colostate.edu/transgeniccrops/current.html>



<http://www.agbioforum.org/v7n12/v7n12a04-zehr.htm>

# Safety of Bt crops?

- Concerns expressed over dangers of consuming Bt expressing crops. Dangerous for humans to consume?
- Dipel?
- Dipel = organic approved insecticide
  - AI = powdered *Bacillus thuringiensis*
  - The whole bacterium
  - Not just the crystal protein.





# Benefits of Bt crops?

- Insect control with greatly reduced insecticide use
- Reduced insecticide use = less damage to beneficial insects, environment, etc.
- Highly targeted
  - Many different Bt genes with different specificities
  - All are very narrow spectrum
- How is a gene used for decades in organic agriculture dangerous when used in GMO crops?

# Safety testing of GMO (GE) crops

- Claim: GMO crops are released to field with no testing. The companies choose what they want to create and put into the fields.
- Truth: GMO crops MUST be approved by **3** different federal agencies prior to release (USDA / APHIS, EPA, FDA).
- Bt crops safety tested for toxicity, allergen city, rate of decay of Bt protein in digestive tract, etc..
  - Even after a 50+ year history of using Bt as an organically approved insecticide.

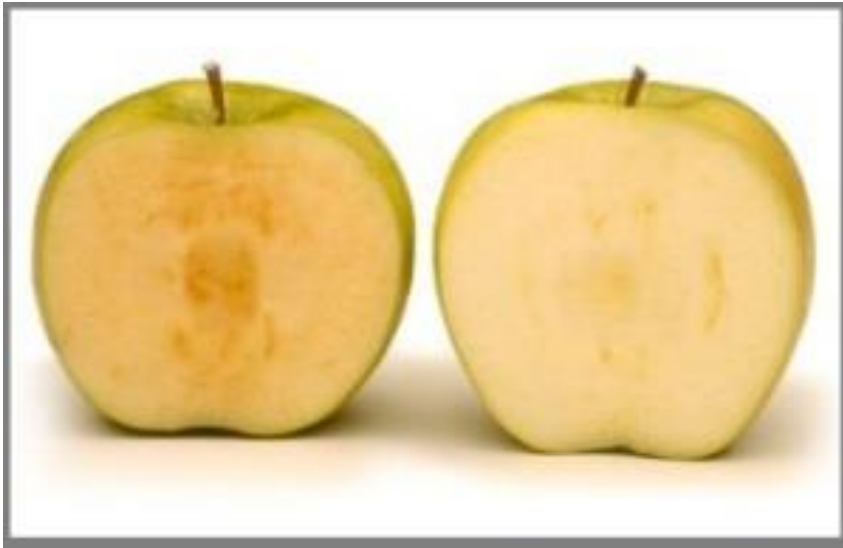
# Papaya ringspot virus resistance

- Researchers engineered PRSV coat protein gene into papaya plants, asked if it caused cross protection like resistance in engineered plants.



# “Removing” a gene

- Non-browning “Arctic” apple similar, to flav savr tomato
- Gene silencing used to down regulate enzyme that causes browning.
- No extra proteins, metabolites, etc..



How is an apple minus an apple gene  
more dangerous than an apple?

# Public perception of non-browning apples?

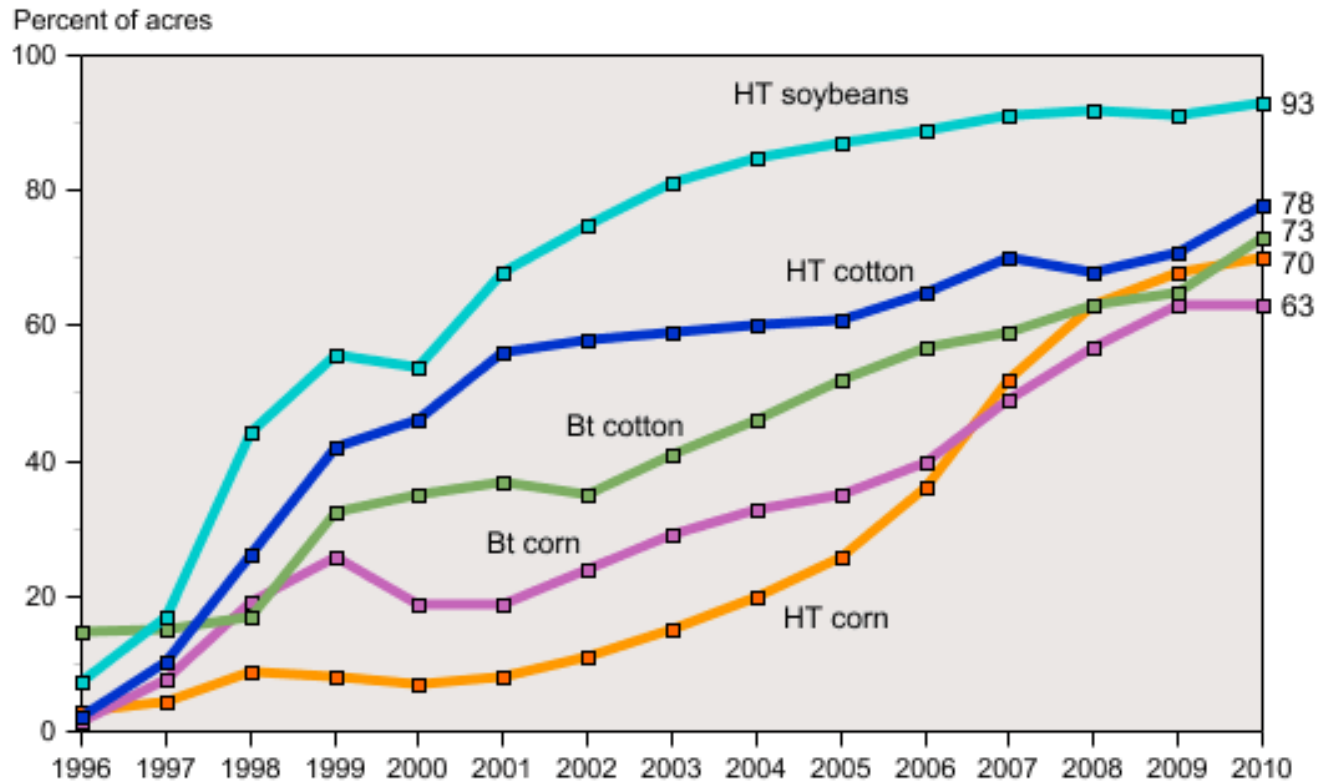


# The future of GMO crops?

- Widely used, likely to continue expanding
- Small but vocal minority will continue to oppose
  - More fear and greed than science based.
- Food labeling is a major current battle line
  - Information for consumers or fear mongering?

# Widely adopted by producers

## Rapid growth in adoption of genetically engineered crops continues in the U.S.



Data for each crop category include varieties with both HT and Bt (stacked) traits.

Sources: 1996-1999 data are from Fernandez-Cornejo and McBride (2002). Data for 2000-10 are available in the ERS data product, Adoption of Genetically Engineered Crops in the U.S., tables 1-3.



# Genetic modification of tree crops

- See Richard Heerema or Jennifer Randall!
- Lots of past work on breeding and non-GMO
  - Traditional breeding
  - Grafting
  - Radiation / mutation breeding
- Some current work on GMO tree crops
  - Disease resistance (PRSV, Sharka / PPV, citrus greening, crown gall, others).
  - Quality traits (color, nutrition, etc)
  - Trap crops
  - Fast track breeding

# FasTrack Breeding

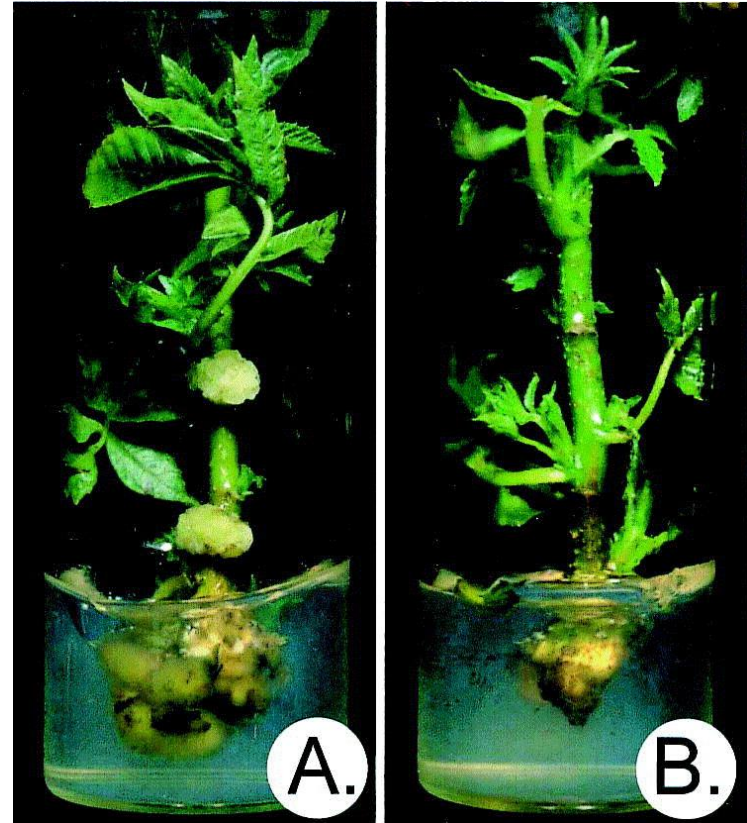


- Original genetic stock (with desired trait) transformed with poplar FT gene.
- Causes seedlings to bloom early and continuously.
  - Speeds up breeding process by many, many years!
- Crosses made until a high quality tree with desired trait is achieved.
- Finally, non-FT (and non transgenic) types are selected for release.

# Transgenic Rootstocks



Crown gall in walnut.



Escobar MA, Leslie CA, McGranahan GH, Dandekar AM.  
2002. Silencing crown gall disease in walnut (*Juglans regia*  
L.). *Plant Sci* 163:591–7.

# Plum Pox Virus

- Causes Sharka disease in stone fruit
- Spread by aphids and infected budwood.
- Causes deformed fruits, fruit drop, leaf chlorosis, and tree decline.
- First discovered in US (PA) in 1999– eradicated
- Discovered in Canada in 2000– not eradicated.
- Discovered again in the US (MI and NY) in 2006– eradicated again.



# Citrus greening (HLB)

**Growing Produce** | Vegetables | Fruits | Nuts | Citrus | Farm Marketing

Register Now For Biocontrols USA 2016 Conference & Expo

California Technology Summit Targeting Early Detection Of Deadly Citrus Disease Slated | New Citrus Greening Nutritional Mix Enters The Market

November 25, 2015

## Scientists Find Success Fighting Citrus Greening With GMOs

Posted By Paul Russak | Email | Print | Facebook | Google+ | LinkedIn | Twitter

UFIFAS researchers say they have developed genetically modified citrus trees that show enhanced resistance to greening, and have the potential to resist canker and black spot, too.

Jude Grosser, a professor of plant cell genetics at the UFIFAS Citrus Research and Education Center in Lake Alfred, and Manjaj Dutt, a research assistant scientist, used a gene isolated from *Arabidopsis thaliana*, a member of the mustard family, to create the new trees. Their experiment resulted in trees that exhibited enhanced resistance to greening, reduced disease severity, and even several lines that remained disease-free after 36 months of planting in a field with a high number of diseased trees.

Grosser and Dutt's research team used sweet orange cultivars Hamlin and Valencia and created plants that defend themselves against pathogens utilizing a process called systemic acquired resistance (SAR). SAR provides protection against a broad spectrum of microorganisms and is associated with the production of anti-pathogen proteins.

Disease resistance to HLB in this study was evaluated in two ways:

- First, in a greenhouse study conducted with Southern Gardens Citrus in Clewiston, several hundred trees (clones from several independent transgenic plant lines) were exposed continuously for two years to free-flying, greening-positive psyllids. Trees were routinely pruned and fertilized to stimulate new leaf production. These trees were evaluated every six months for two years for the presence of greening. The insects were also randomly evaluated during this study for the presence of the greening bacterium. Approximately 45% of the trees expressing the *Arabidopsis* gene tested negative for greening. In three of the transgenic lines, the greening bacterium was not detected at all. Control trees tested positive for the presence of greening within six months and remained positive for the entire duration of the study.
- In the second concurrent study, selected transgenic trees and controls were cloned, grown, and planted in fields with a 90% percent HLB infection rate. These trees were similarly evaluated every six months for three years for the presence of the greening bacterium. In this study, one transgenic line remained greening-free for the duration of the study, except for the 24-month sampling period when it tested positive. A second line tested positive at the 30-month sampling period while a third line tested positive at 36 months, but was greening-free at 36 months. Neither of these lines declined in health, and both allowed continued growth with periodic flushes.

*Photo courtesy of UFIFAS*

“Transgenic trees exhibited reduced disease severity and a few lines remained disease-free even after 36 months of planting in a high-disease pressure field site.” Dutt et al. (2015)

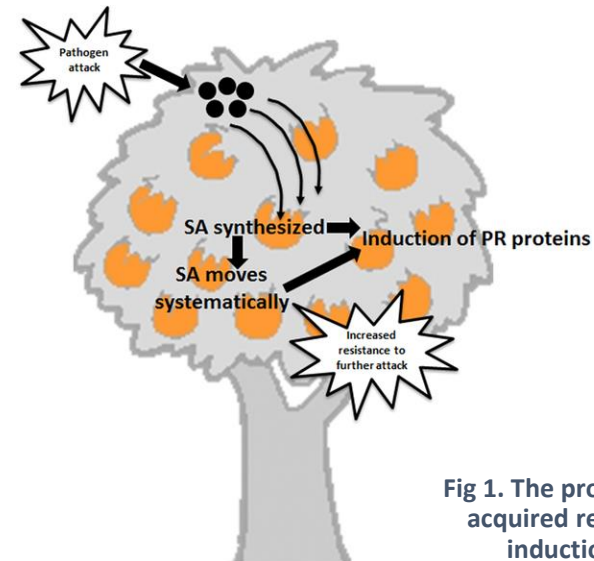


Fig 1. The process of systemic acquired resistance (SAR) induction in citrus.

<http://www.growingproduce.com/citrus/insect-disease-update/scientists-find-success-fighting-citrus-greening-with-gmos/>

Dutt M, Barthe G, Irej M, Grosser J (2015) Transgenic Citrus Expressing an Arabidopsis NPR1 Gene Exhibit Enhanced Resistance against Huanglongbing (HLB; Citrus Greening). PLoS ONE 10(9): e0137134. doi:10.1371/journal.pone.0137134  
<http://journals.plos.org/plosone/article?id=info:doi/10.1371/journal.pone.0137134>

# Quiz time!



Answer: Picture is not of a GMO field. Respirators used for pesticide Sprays which can be greatly reduced with GMO crops

# THANK YOU!

- NMSU GMO fact sheet, CR-682
- Questions?



# Questions

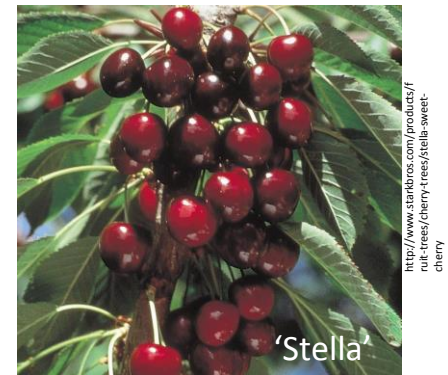
Q: Is Roundup<sup>®</sup> associated with cancer?

A: No evidence that it is. The trillion meal study would probably have seen a link if it was there.



# Radiation-Induced Mutations (“GMOs”?)

- Some important older fruit varieties:
  - ‘Stella’ cherry (Canada, 1968)– self fertile flowers
  - ‘Star Ruby’ grapefruit (USA, 1970)– nearly seedless
  - ‘Rio Red’ grapefruit (USA, 1984)– deeper red fruit and juice
- Some recently released fruit varieties:
  - ‘Nero’ clementine (Spain, 2006)– earlier fruit ripening
  - ‘Clemenverd’ clementine (Spain, 2010)– delayed fruit maturation
  - ‘Aldamla’ cherry (Turkey, 2014)– compact growth habit
  - ‘Burak’ cherry (Turkey, 2014)– high yields, large fruit



Source: <https://mvd.iaea.org/>

# 'HoneySweet' Plum

- Developed at USDA-ARS Appalachian Fruit Research Station.
- Resistant to Plum Pox Virus (PPV).
- Gene silencing or RNA interference (RNAi).
- Gene for PPV virus coat protein inserted into plant genome .
- By 2009 had been approved by APHIS, FDA, and EPA.
- No commercial production in US as of 2015.



# “Ornacidrus”

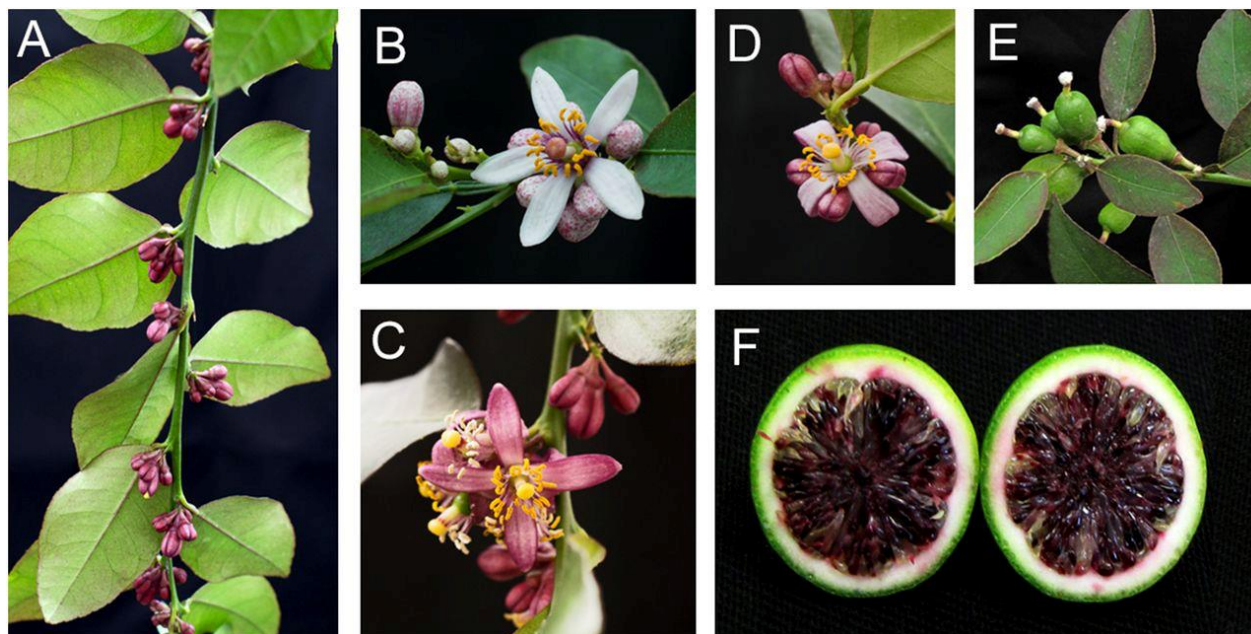


Fig. 2.  
(A) Flower clusters on a VvmybA1 overexpressing 'Mexican' lime transgenic line. (B and C) Close-up of flowers on two independent VvmybA1 overexpressing lines. (D) Close-up of flowers on a Ruby overexpressing line. (E) A fruit cluster on a VvmybA1 overexpressing 'Mexican' lime line. (F) A cross-section of a fruit from a VvmybA1 overexpressing 'Mexican' lime line demonstrating the production of anthocyanin in the pulp.



Fig. 3.  
Cross-sections of a transgenic Ruby overexpressing 'Mexican' lime fruit with a control nontransgenic fruit for comparison.

Dutt et al., 2016.