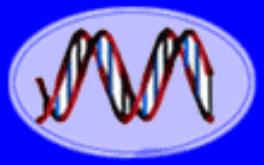
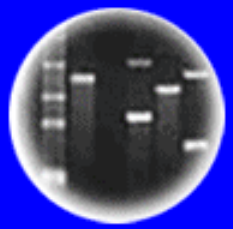


DNA
Genetic Code of Life

Entire Genetic Code of a Bacteria



DNA Fingerprinting

Cloning: Ethical Issues and Future Consequences

Plants of Tomorrow

HC70A, SAS70A
Winter 2016
Genetic Engineering in Medicine, Agriculture, and Law

Professors Bob Goldberg,
Channapatna Prakash, & John Harada

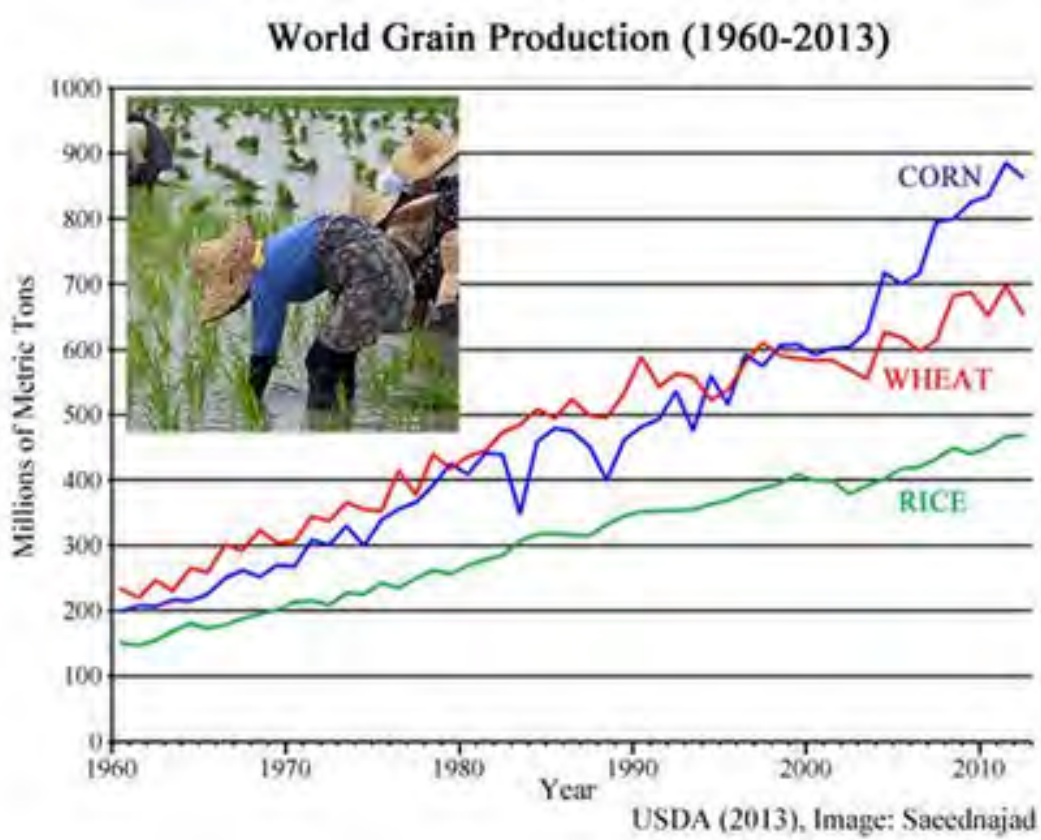
Crop domestication to gene editing – How genetics is shaping our farming

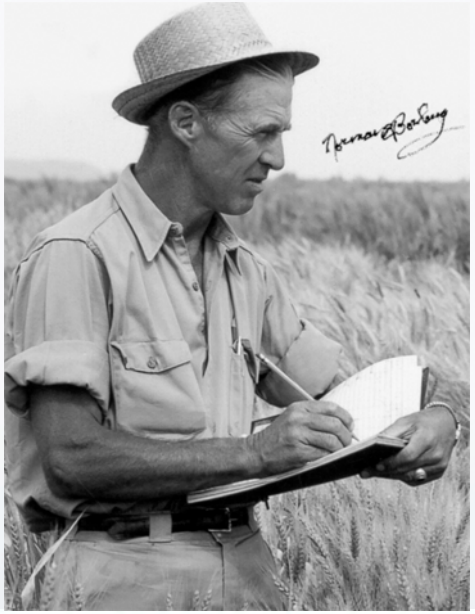
Please Turn Off Your Cell Phones!!

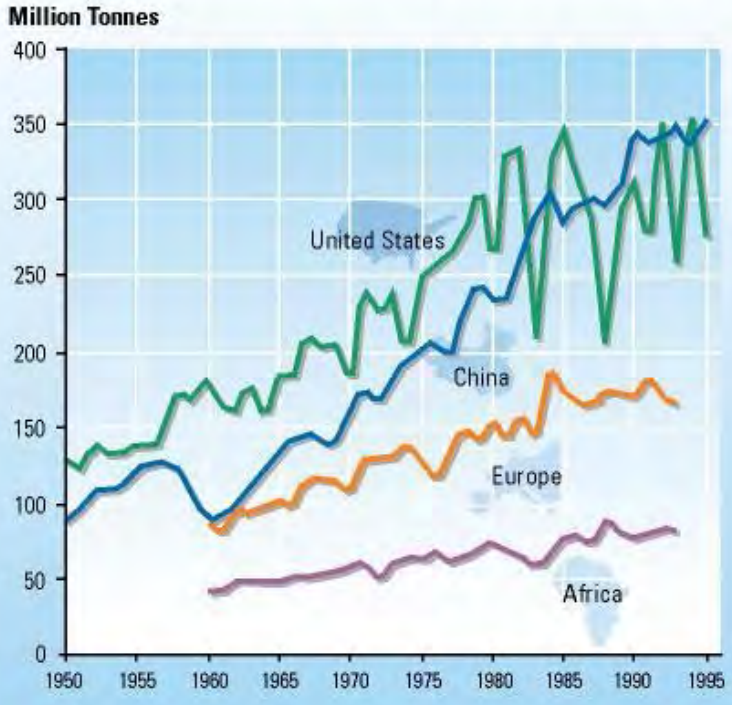
UCLA

TUSKEGEE UNIVERSITY

UCDAVIS
UNIVERSITY OF CALIFORNIA







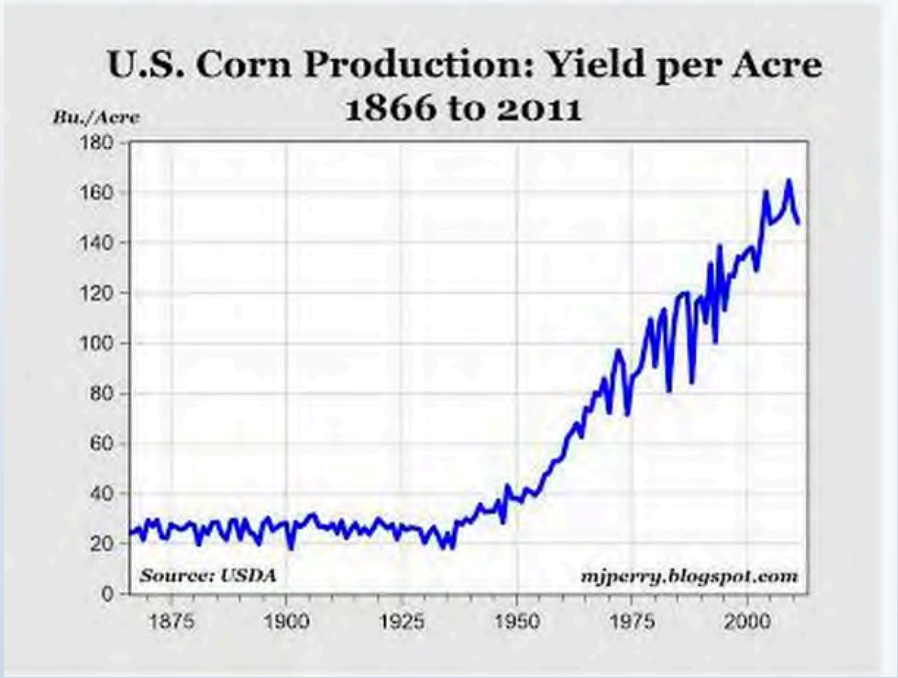
http://dailycaller.com/2013/11/27/world-agricultural-output-continues-to-rise-despite-dire-predictions-of-decl

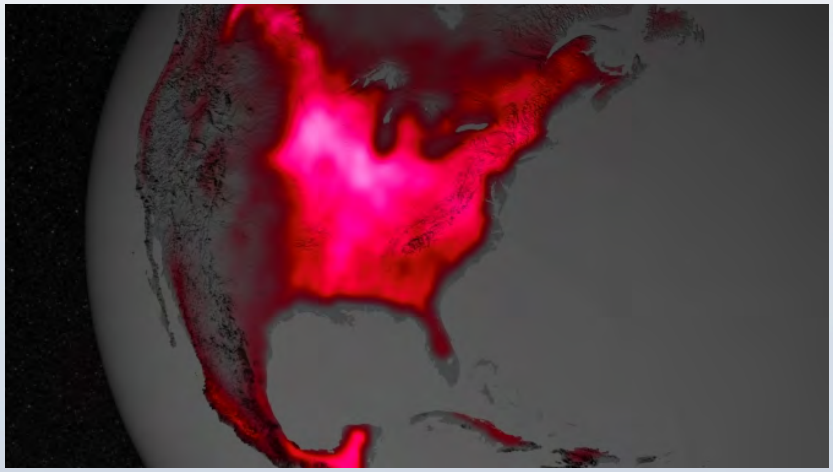
http://www.grida.no/graphicslib/detail/grain-production-in-selected-countries_daee

Corn yield trend; NASA Picture showing US Corn Belt

with the highest productivity on earth

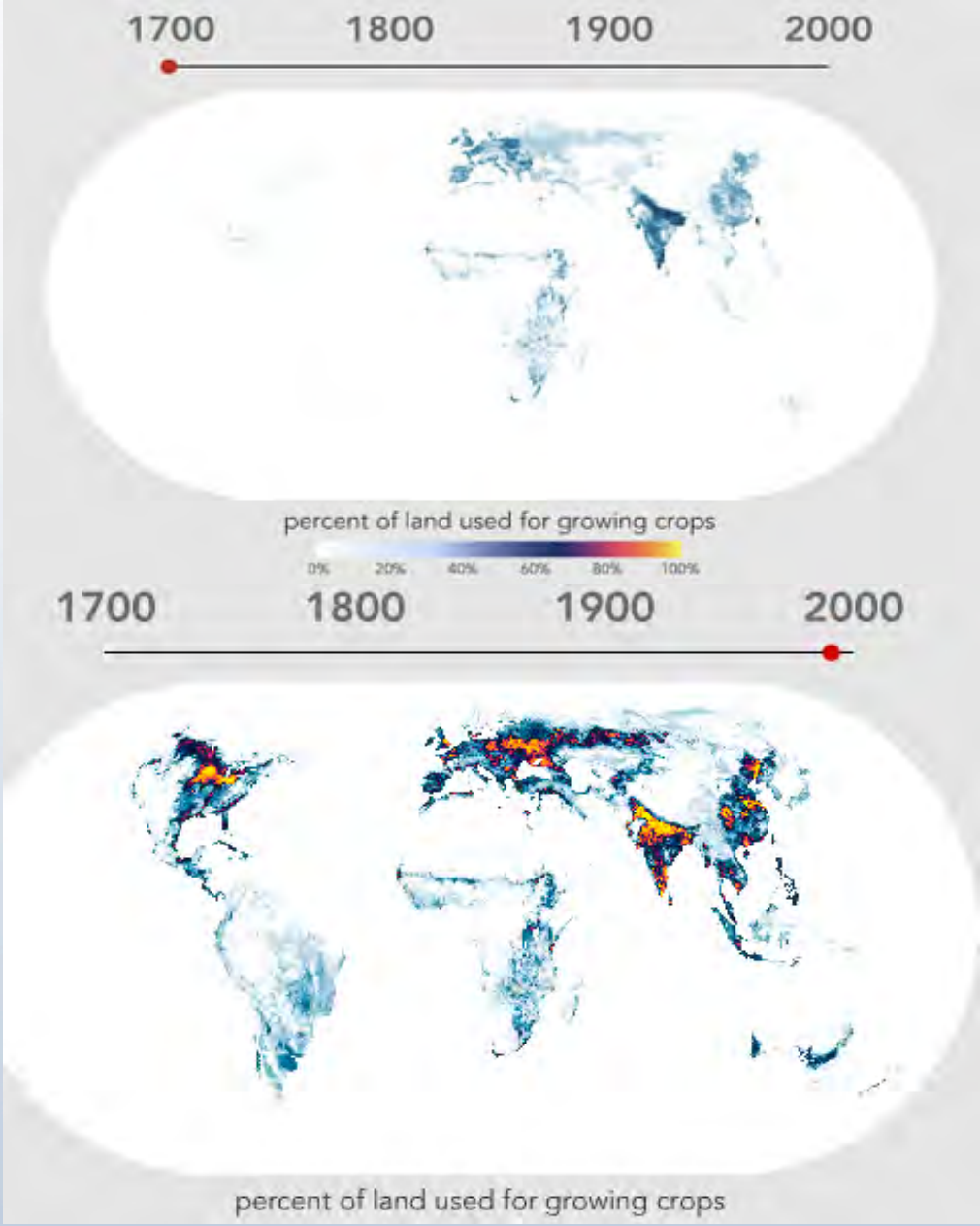
mjperry.blogspot.ch/2011/11/corn-y...





https://www.nasa.gov/press/goddard/2014/march/satellite-shows-high-productivity-from-us-corn-belt/#.VhBXHBNVhBc

Percent of Land under farming in 1700 vs. now!



California Drought

California just had its worst drought in over 1200 years, as temperatures and risks rise

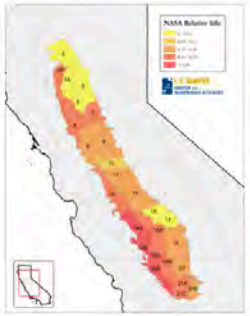
Global warming is playing havoc on extreme weather

Economic Analysis of the 2014 Drought for California Agriculture

Richard Howitt
Josué Medellín-Azuara
Duncan MacEwan
Jay Lund
Daniel Sumner

Center for Watershed Sciences
University of California, Davis
UC Agricultural Issues Center
ERA Economics, Davis, Calif.

July 23, 2014*



Funded by
California Department of Food and Agriculture
and
University of California, Davis
with assistance from
California Department of Water Resources

*Revision of original July 15, 2014 report. (See Erratum.)

Drought -- the third most severe on record – is responsible for the greatest water loss ever seen in California agriculture

Human civilization evolved in parallel with crop domestication and breeding

Image credits: P. Cos, Cacaphony, USDA, CIMMYT

The myth of natural food

The food we eat comes from plants already extensively modified from their original form. Even heritage varieties are extensively genetically modified.

Eat only 'natural' food just as God intended , not modified by man?
Then, one on the left is for you! . ---->

ndation

gists

Crop Modification Techniques

Cross Breeding

Combining two sexually compatible species to create a variety with the desired traits of the parents

The Honeycrisp Apple gets its famous texture and flavor by blending the traits of its parents.

Mutagenesis

Use of mutagens such as radioactivity to induce random mutations, creating the desired trait

Radiation was used to produce a deeper color in the red grapefruit.

Polyploidy

Multiplication of the number of chromosomes in a crop to impact its fertility

Seedless watermelons are created by crossing a plant with 2 sets of chromosomes with another that has 4 sets. The seedless fruit has 3 sets.

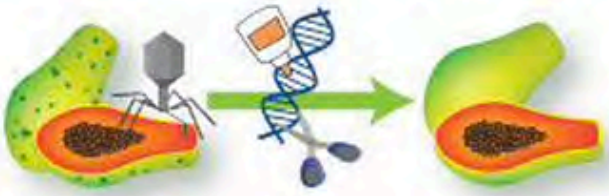
Protoplast Fusion

Fusion of cells or cell components to transfer traits between species

Male sterility is transferred from radishes to red cabbage by fusing their cells. Male sterility helps plant breeders make hybrid crops.

Transgenesis

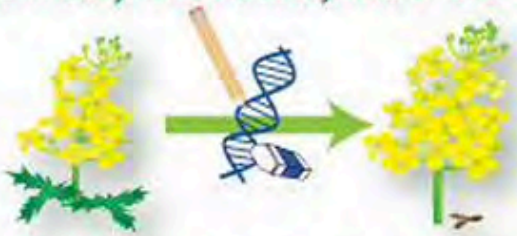
Addition of genes from any species to create a new variety with desired traits



The Rainbow Papaya is modified with a gene that gives it resistance to the Papaya Ringspot Virus.

Genome Editing

Use of an enzyme system to modify DNA directly within the cell



Genome editing was used to develop herbicide resistant canola to help farmers control weeds.

www.biofortified.org

Follow us on Twitter (@franknfoode) or join our Facebook Page

By Layla Katiraee (@BiochicaGMO) in collaboration with Karl Haro von Mogel (@kjhvm)

BIOLOGY FORTIFIED

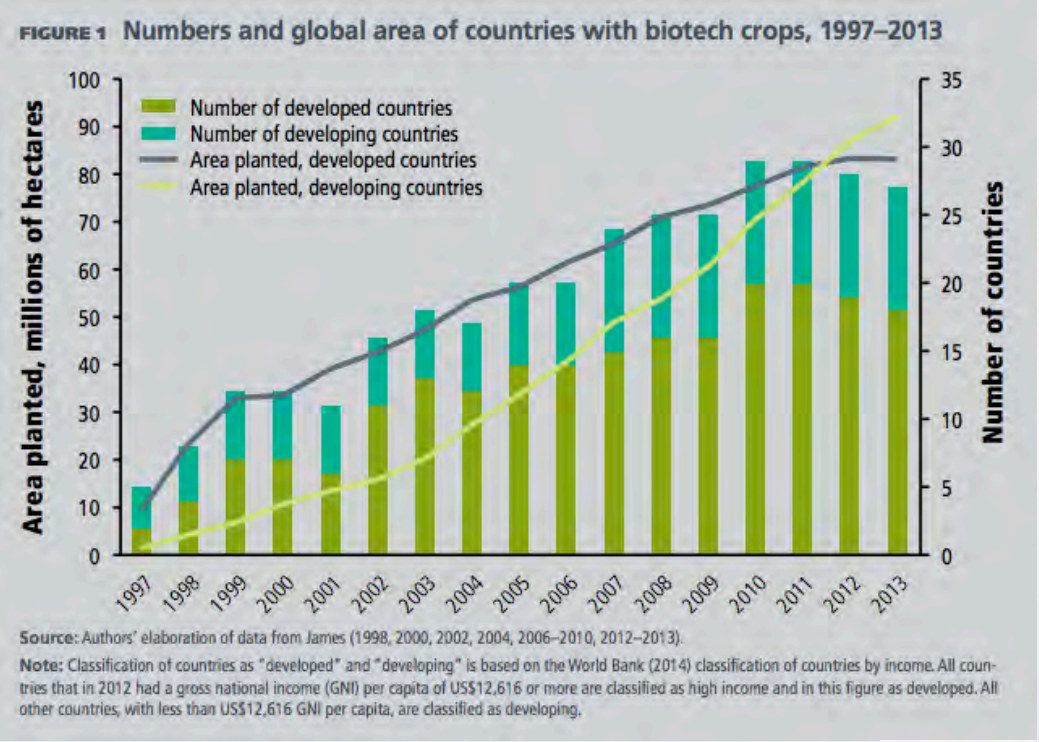
Mutation Breeding – Irradiation

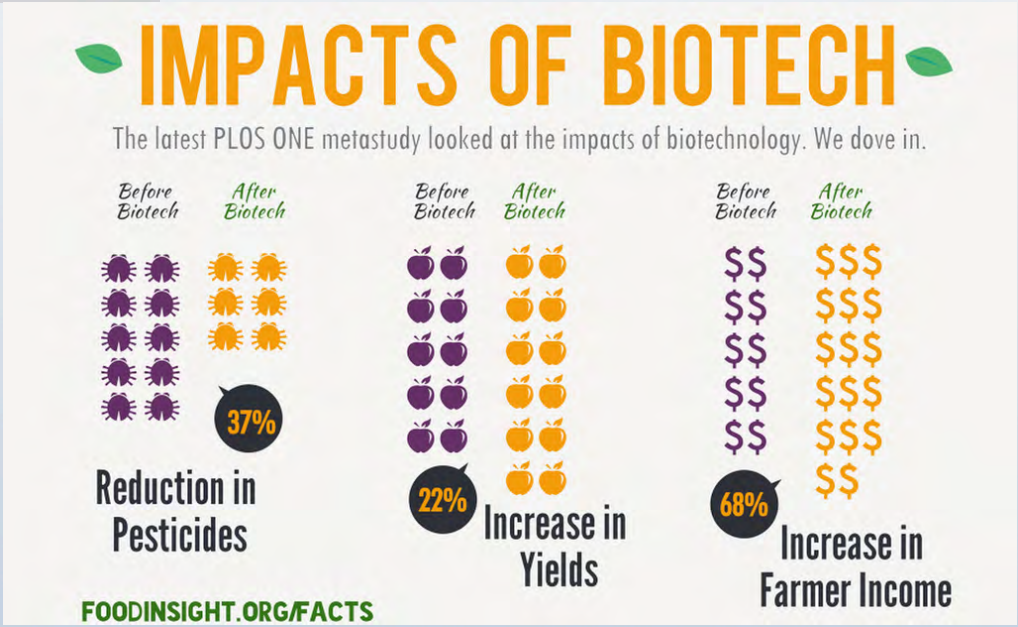
Then and Now

How modern breeding changed water melon? Renaissance paintings will tell! L paint, R now!

vox.com/2015/7/28/9050…

Advent of GM Crops

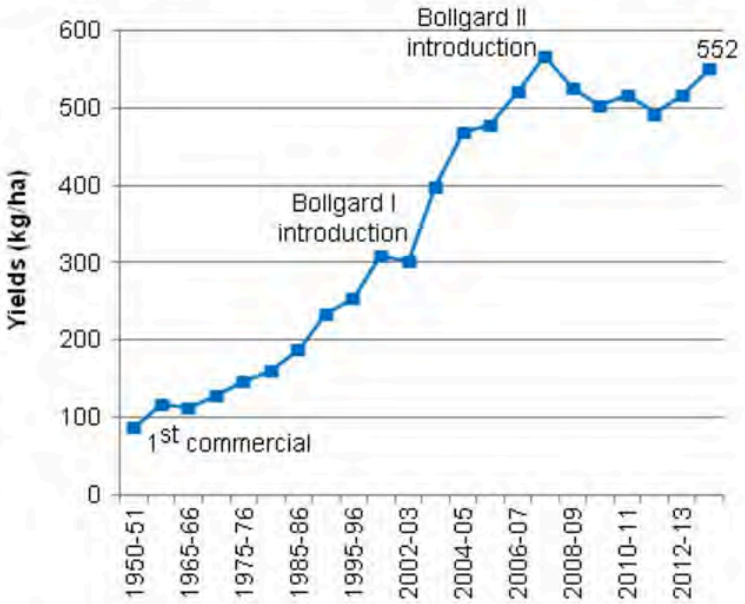




Source ISAAA.org; : http://www.ifpri.org/sites/default/files/publications/pbs_afdb_report.pdf

GMO or Non-GMO?

Figure 2. Cotton yields in India (kg/ha) 1950-51 to 2013-14.



Source: The Cotton Corporation of India Ltd. (2014)

Bt Cotton - India
Yields have gone up
Pesticide Use is Down

Soybean

pest resistance

he soybean at left expresses a Bt gene for resistance to caterpillar

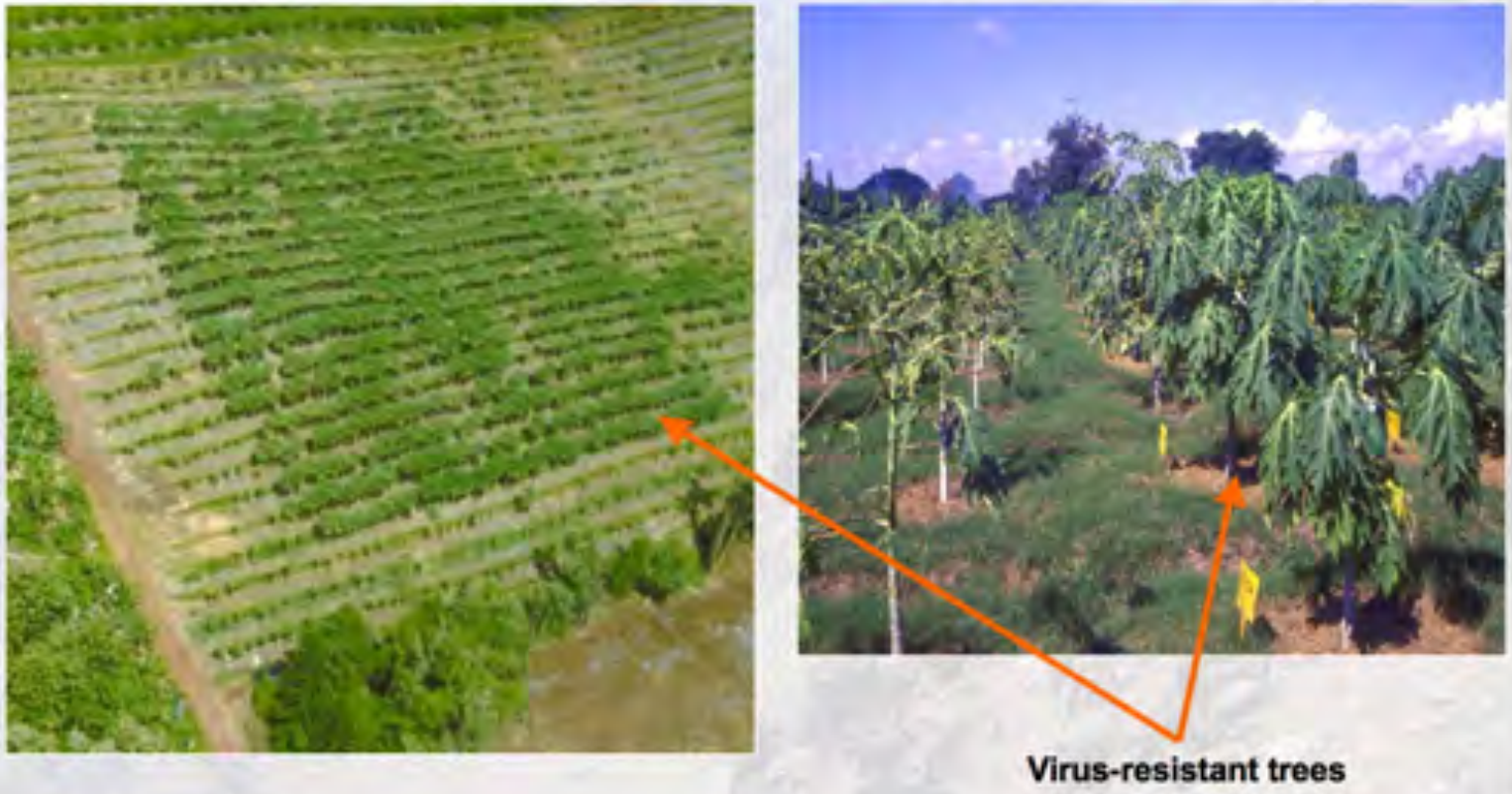
Potato resistance

Colorado potato beetle

Late Blight Disease (Irish Famine Disease!)

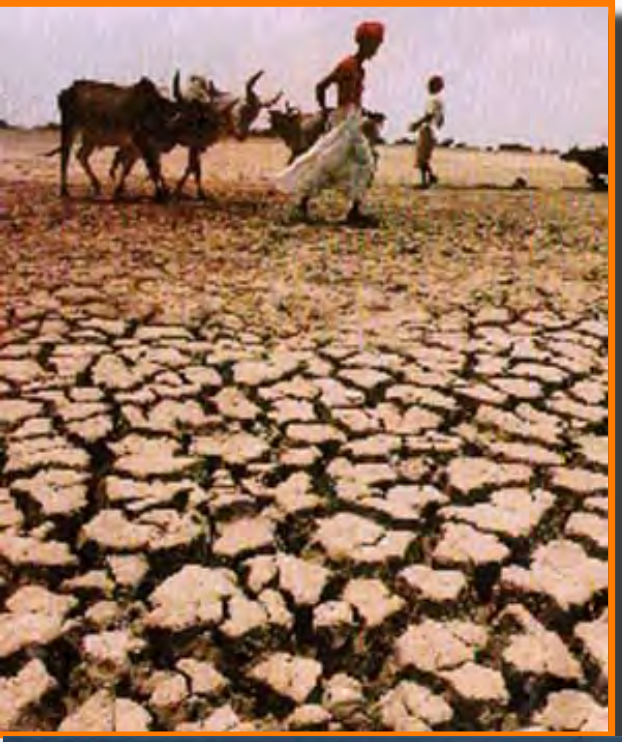
Virus-resistant papaya

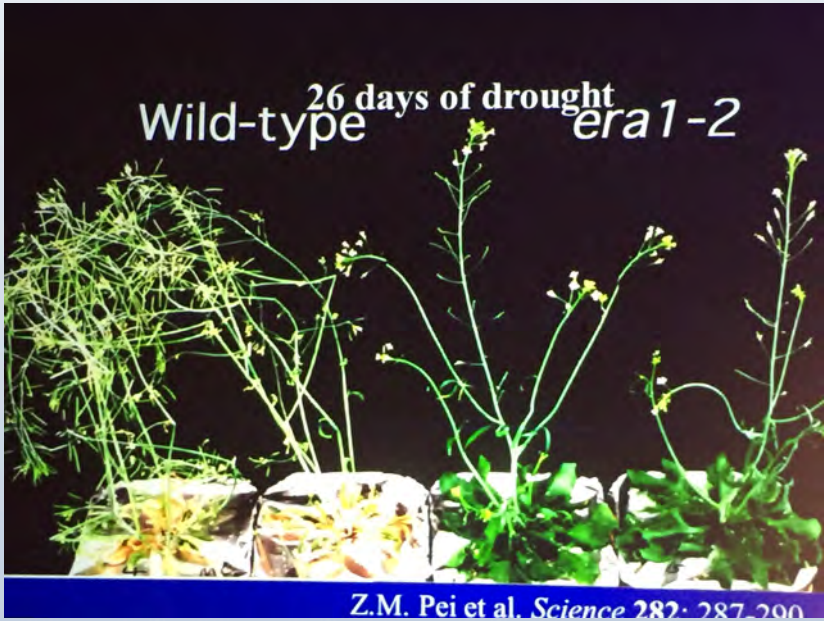
Saved the Hawaiian industry in the mid-1990s
90% of crop today



Provided by Denis Gonsalves, formerly of Cornell University

Climate Smart Crops: Drought





Flood-tolerant Rice

International Rice Research Institute, Philippines

Freeze Tolerant Biotech *Eucalyptus*

Results from first winter in South Carolina

Results from second winter in Alabama

Field results indicate freezing tolerance to ~16°F (- 8° to - 9°C)

Source: www.arborgen.us

Bringing back the Great American Chestnut

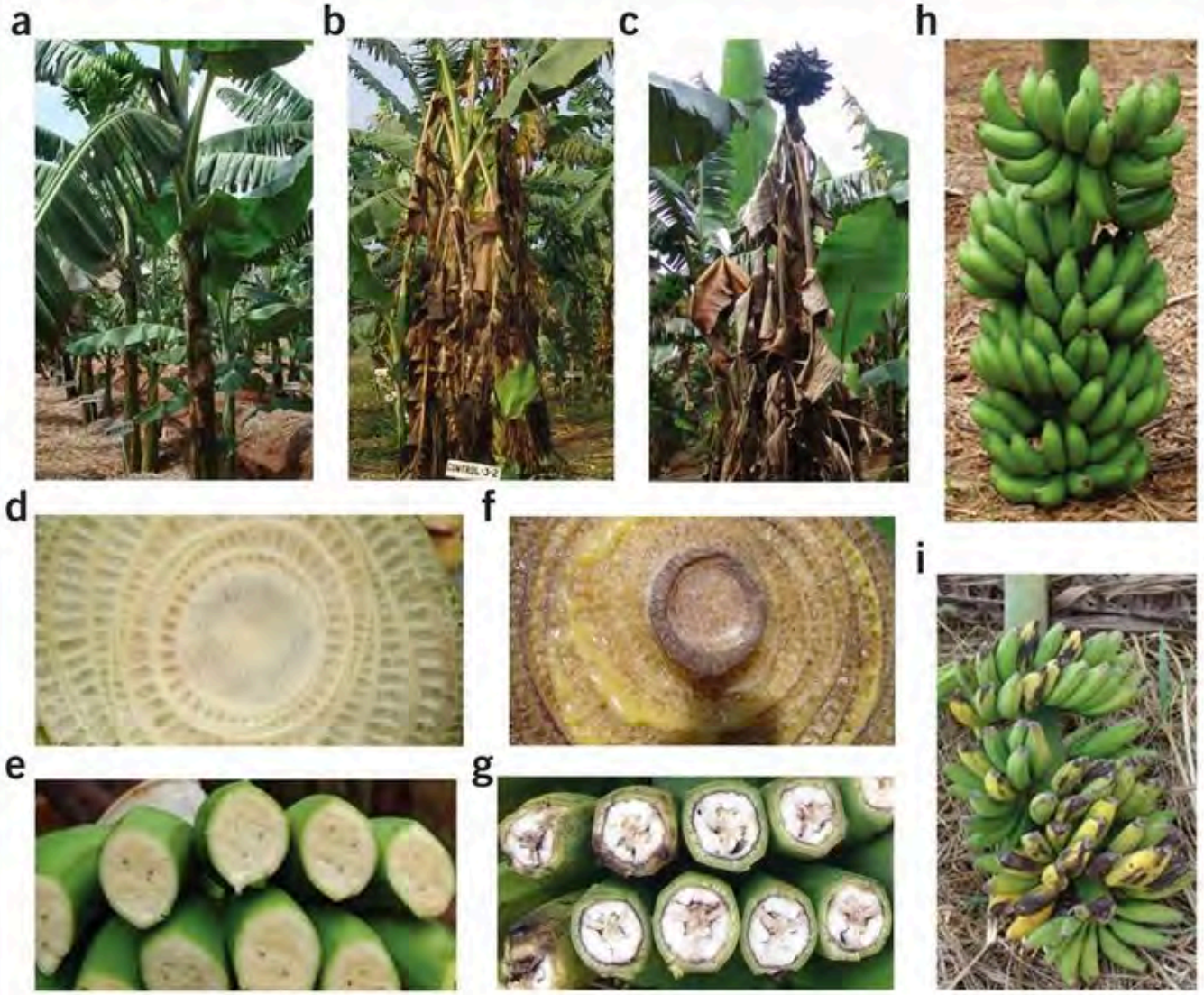
http://www.syracuse.com/

Field trial of *Xanthomonas* wilt disease-resistant bananas in East Africa

Leena Tripathi, Jaindra Nath Tripathi, Andrew Kiggundu, Sam Korie, Frank Shotkoski & Wilberforce Kateera Tushemereirwe

Nature Biotechnology **32**, 868–870 (2014) | doi:10.1038/nbt.3007

Published online 09 September 2014



(**a**) Asymptomatic transgenic plant showing no symptom after artificial inoculation. (**b**) Nontransgenic plant showing wilting of leaves post inoculation. (**c**) Symptomatic plants showing rotten fruit bunch. (**d**,**e**) Transverse section of pseudostem and fruits of transgenic plants showing no internal symptoms. (**f**,**g**) Transverse section of pseudostem and fruits of nontransgenic plants showing internal symptoms (yellow ooze, brown scars and ooze on the margin). (**h**) Fruit bunch of transgenic plant showing no external symptoms. (**i**) Fruit bunch of nontransgenic plant showing premature ripening.

Bt Eggplant in Bangladesh

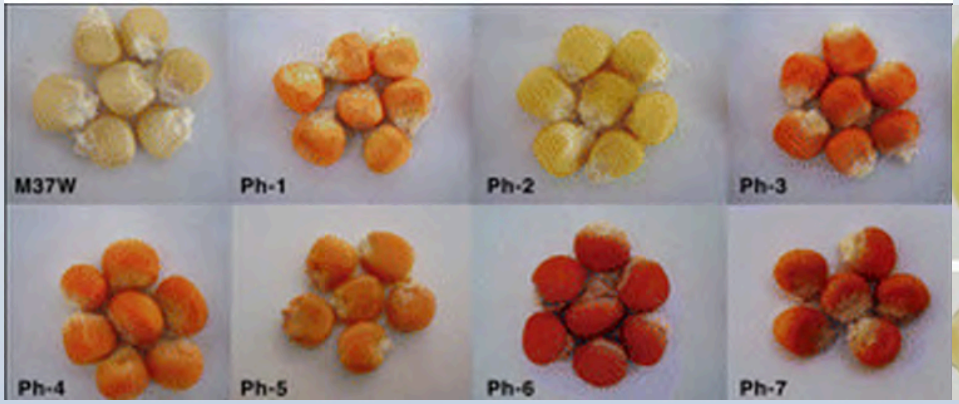
"Bt brinjal has been very effective against the key pest – the fruit and shoot borer,"
Mohammad Rafiqul Islam Mondal, Director-General, BARI.

Figure 3. Non-Bt eggplant Figure 4. Bt Eggplant
Photo: UPLB IPB Bt Eggplant Project, 2014

http://www.isaaa.org/resources/publications/pocketk/48/default.asp

Vitamin A Fortification

carotenoids, extraordinary levels!
pnas.org/content/105/47…

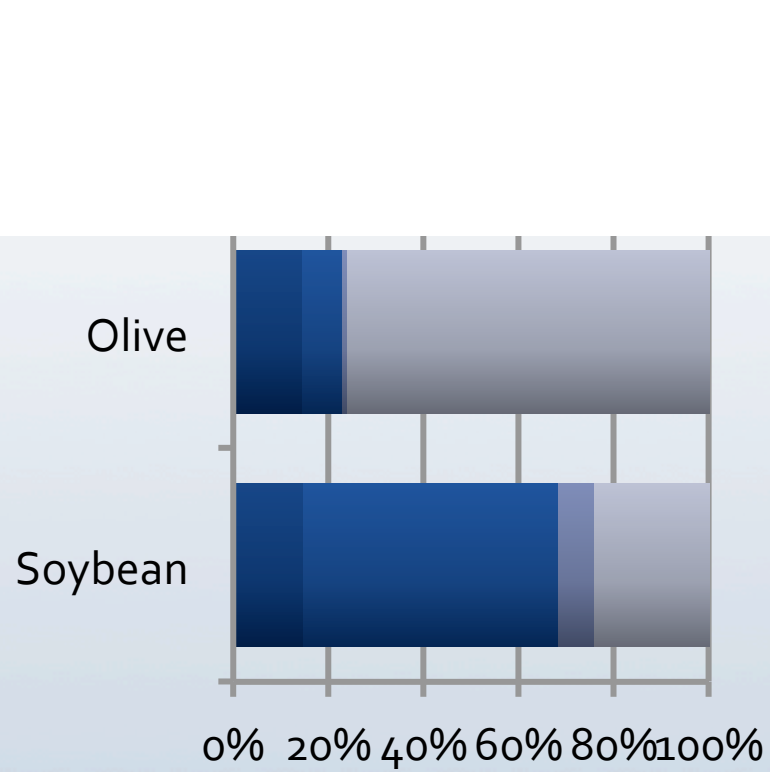


Better Nutrition

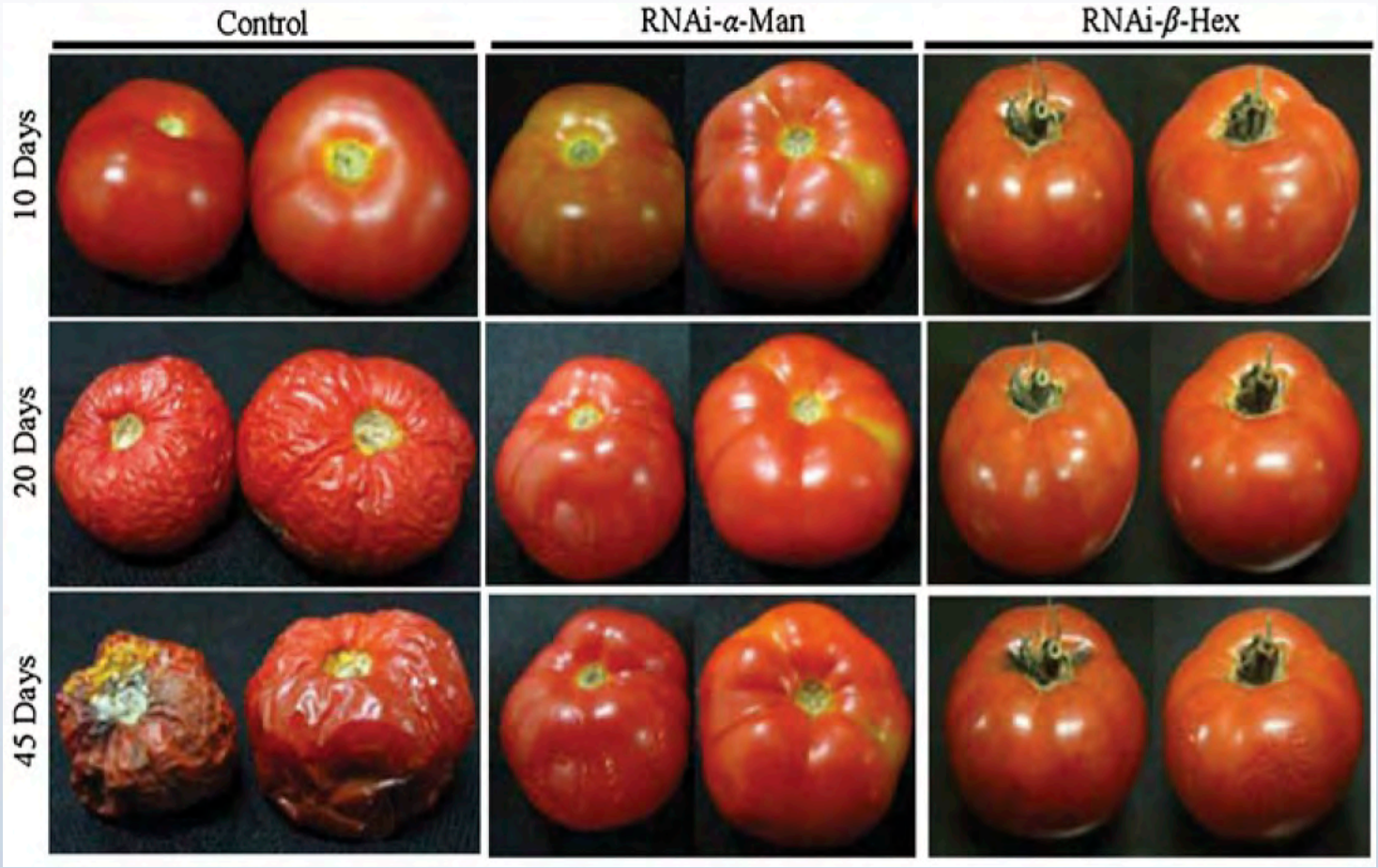
Univ of Florida; John Innes Centre - UK

High oleic oil

Eliminates transfats



Engineered tomatoes have ~30 day extension of shelf life



SOURCE: Meli, V.S., Ghosh, S., Prabha, T.N., Chakraborty, N., Chakraborty, S., and Datta, A. 2010. Enhancement of fruit shelf life by suppressing N-glycan processing enzymes. Proceedings of the National Academy of Sciences USA, doi/10.1073/pnas.0909329107.

Prevent food spoilage

Non-browning potato & apple

JR Simplot &
Okanagan Specialty Fruits

Safer Food; Less Mycotoxin

Zmapp – Ebola serum produced in GMO tobacco in Kentucky

Tobacco plants grown in greenhouses at Kentucky BioProcessing in Owensboro were "infected" with a protein, which the plants then reproduced, that is turned into a serum to fight the Ebola virus

Blue Rose!

Gene editing – CRISPR to the Rescue?

- **No Foreign genes**
- **Minimal genome disruption**
- **High frequency**
- **Circumvent or minimize regulation?**
- **Greater public acceptance?**

Making plants shorter

http://www.sciencedaily.com/releases/2015/11/151130084628.htm

I hope that there is nothing genetically modified in this

How Safe is GM Food?

- As Safe as Conventional Food
- Subject to Sound Regulation - FDA, EPA, USDA
- Every Product Tested on Case-by-Case
- Over 4 Billion Acres Grown Since 1996
- More than 30,000 Food Products Contain GM
- Not One Single Instance of Hazard
- Dozens of Scientific Societies Have Endorsed it
- >5,000 Scientists plus 24 Nobel Laureates
- EU Scientific Commission - 'Safer than Conventional Food'
- 2000+ scientific peer-reviewed papers confirm safety
- Recent review – 30 years, 100 billion livestock. Trillion meals - safe

16 years + $135 M to develop biotech crop

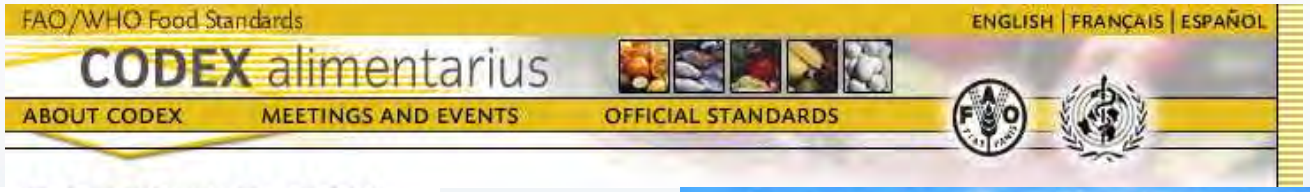
	Discovery Gene/trait identification	Phase 1 Proof of concept	Phase 2 Early development	Phase 3 Advanced development	Phase 4 Prelaunch
Average duration	54 months	27 months	30 months	37 months	49 months
Average cost	USD 31 million	USD 28.3 million	USD 13.6 million	USD 45.9 million	USD 17.2 million
Key activity	• High-throughput screening • Model crop testing	• Gene optimization • Crop transformation	• Trait development • Preregulatory data • Large-scale transformation	• Trait integration • Field testing • Regulatory data generation • Product development	• Regulatory submission • Seed bulk-up • Premarketing • Product development

Figure 1

Overview of the development process of a genetically engineered crop, including activities, durations of those activities, and costs. Durations and costs are industry averages (60). Because various activities overlap, the cumulative total of each phase does not reflect the actual duration of the overall research and development process.

http://www.annualreviews.org/doi/abs/10.1146/annurev-arplant-050213-040039 ...

Global Gate Keepers



Societal Cost of Regulation

- Increased regulatory process stifles innovation. Today's approval takes 2 more years than 2002.

- Discovery, development and authorization of a new biotech crop trait is $136 million.

- Regulatory costs and the lengthy approval process are barriers to entry for small biotech firms with new ideas for innovation.

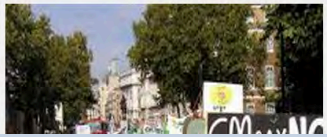
http://www.geneticliteracyproject.org/2014/12/economic-consequences-of-regulations-of-gm-crops/

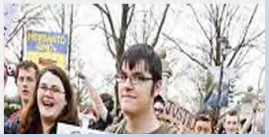
GMOs in Mother Nature

Sea slug has chloroplast genes and makes its own food

http://news.discovery.com/animals/sea-slug-uses-gene-from-algae-to-live-like-a-plant-150204.htm

Opposition to GMO





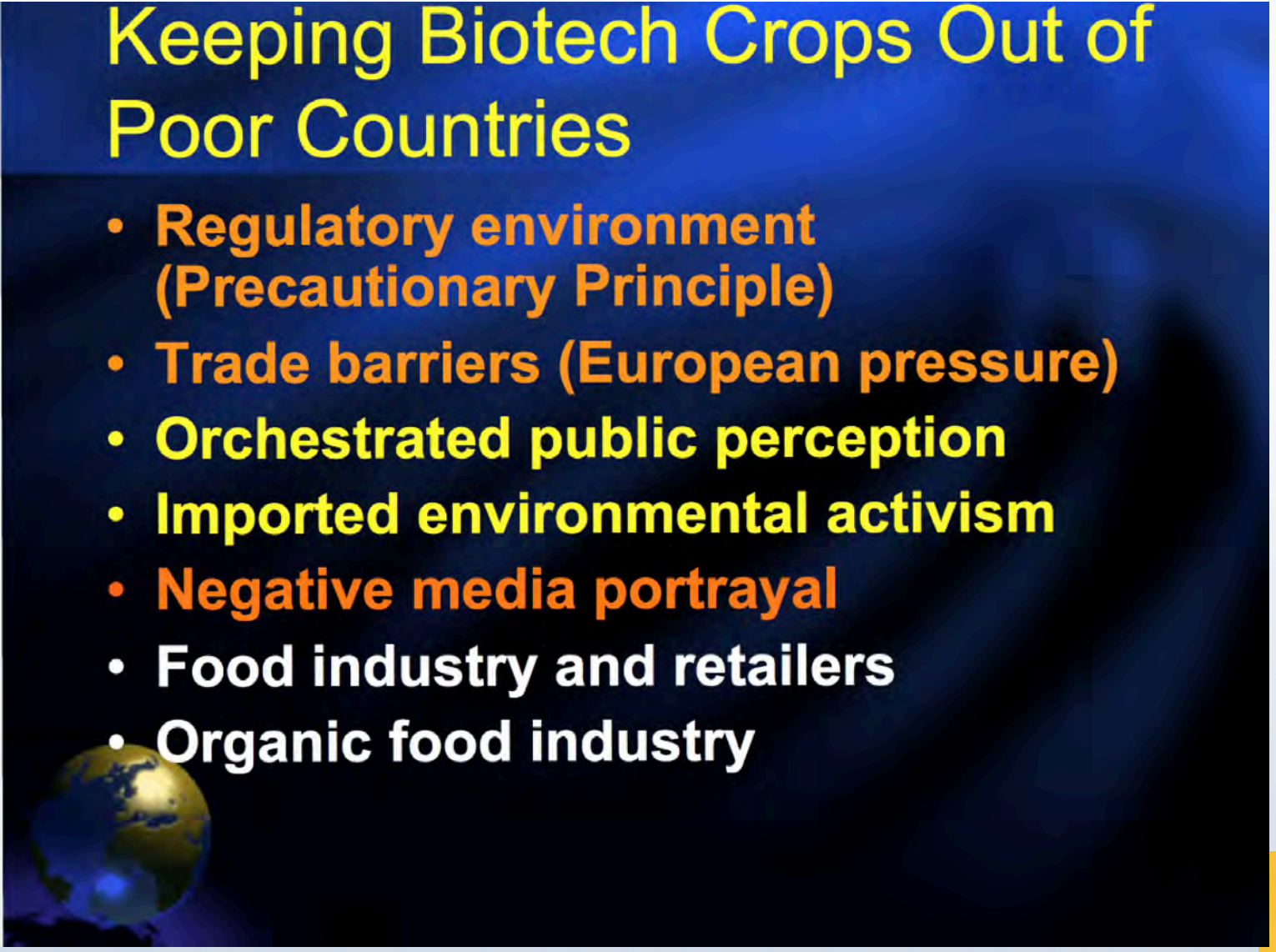
Destruction of GMO test sites; food aid

We wouldn't think of going to our doctor and saying 'Treat me the way doctors treated people in the 19th Century,' and yet that's what we're demanding in food production.

Nina Fedoroff

Keeping Biotech Crops Out of Poor Countries

- Regulatory environment (Precautionary Principle)
- Trade barriers (European pressure)
- Orchestrated public perception
- Imported environmental activism
- Negative media portrayal
- Food industry and retailers
- Organic food industry



The saddest aspect of life right now is that science gathers knowledge faster than society gathers wisdom.

Isaac Asimov
American Scientist

QUOTEHD.COM

C. S. Prakash @AgBioWorld · Aug 7

Response of an young girl in Liberia to the news of Ebola vaccine development

blog.wellcome.ac.uk/2015/08/07/ima…

RETWEETS 84

FAVORITES 61

Thank you!

Slides Sources

Dr. Peggy Lemaux - ucbiotech.org
Dr. Wayne Parrott - University of Georgia
Dr. Mary Williams – ASPB plantcell.org
Dr.Kevin Folta – Univ of Florida
ISAAA.org
Acsh.org
Sivb.org

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