GMO crops

The science, impacts, and controversy

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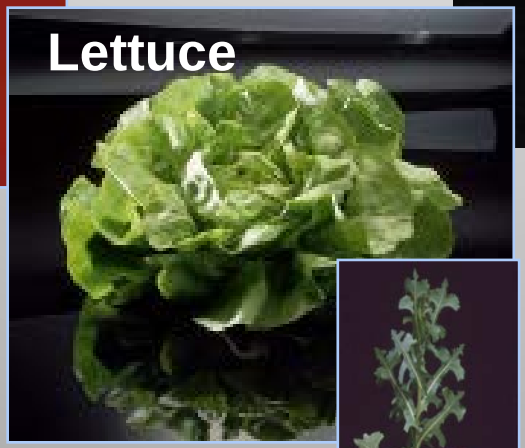
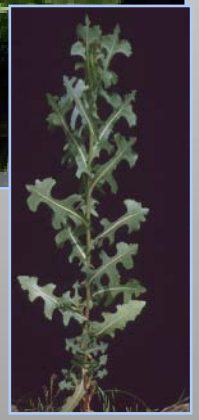
Agenda

- What are they and are not – a brief reminder
- Extent in the world, some impacts, new forms
- Why so controversial, stigmatized?

Most crops moved globally & intensively bred, prior to GMOs = not natural





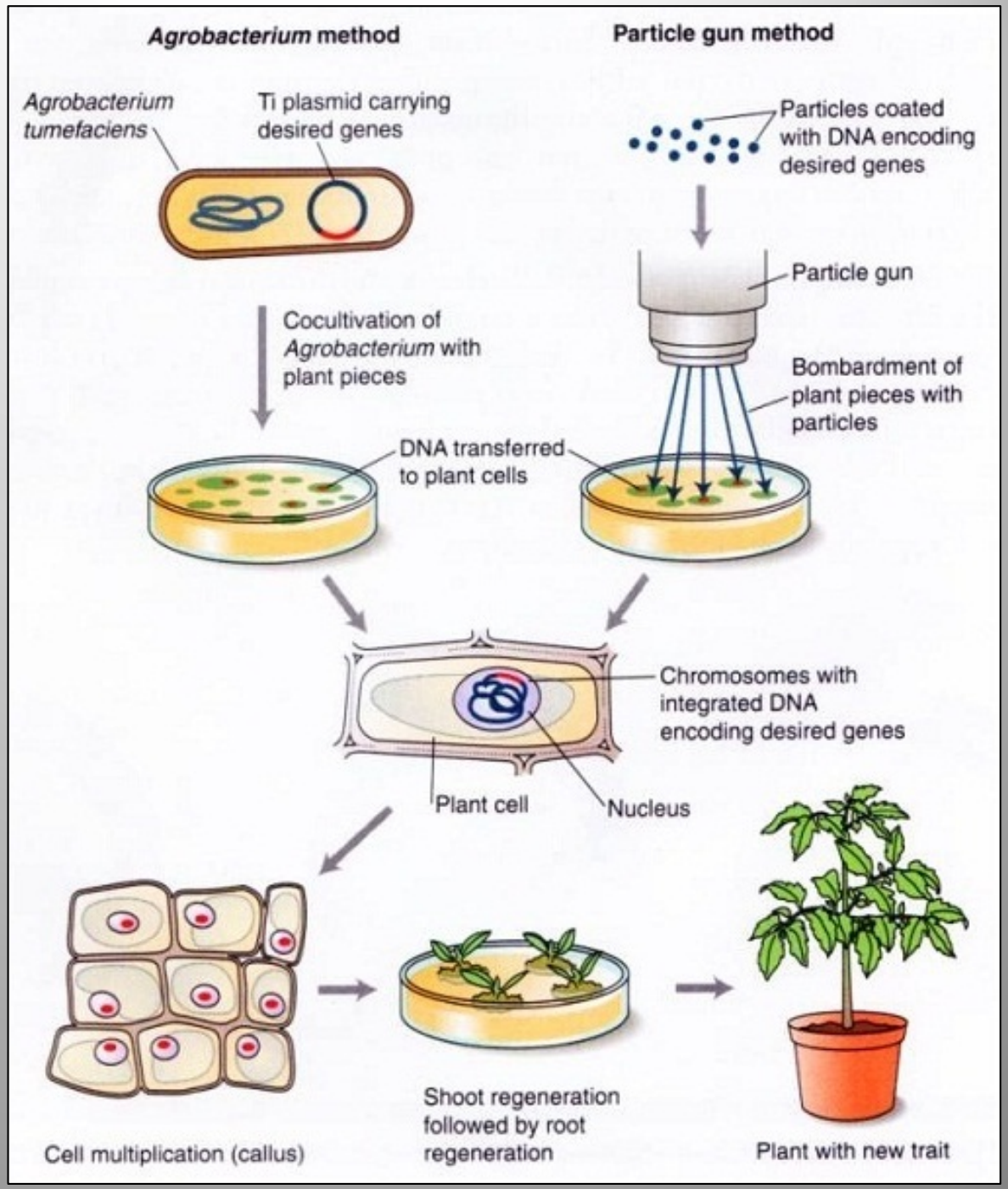
Radical changes in domesticated animals

All dogs derived from the wolf by breeding

What is genetic engineering (GE)

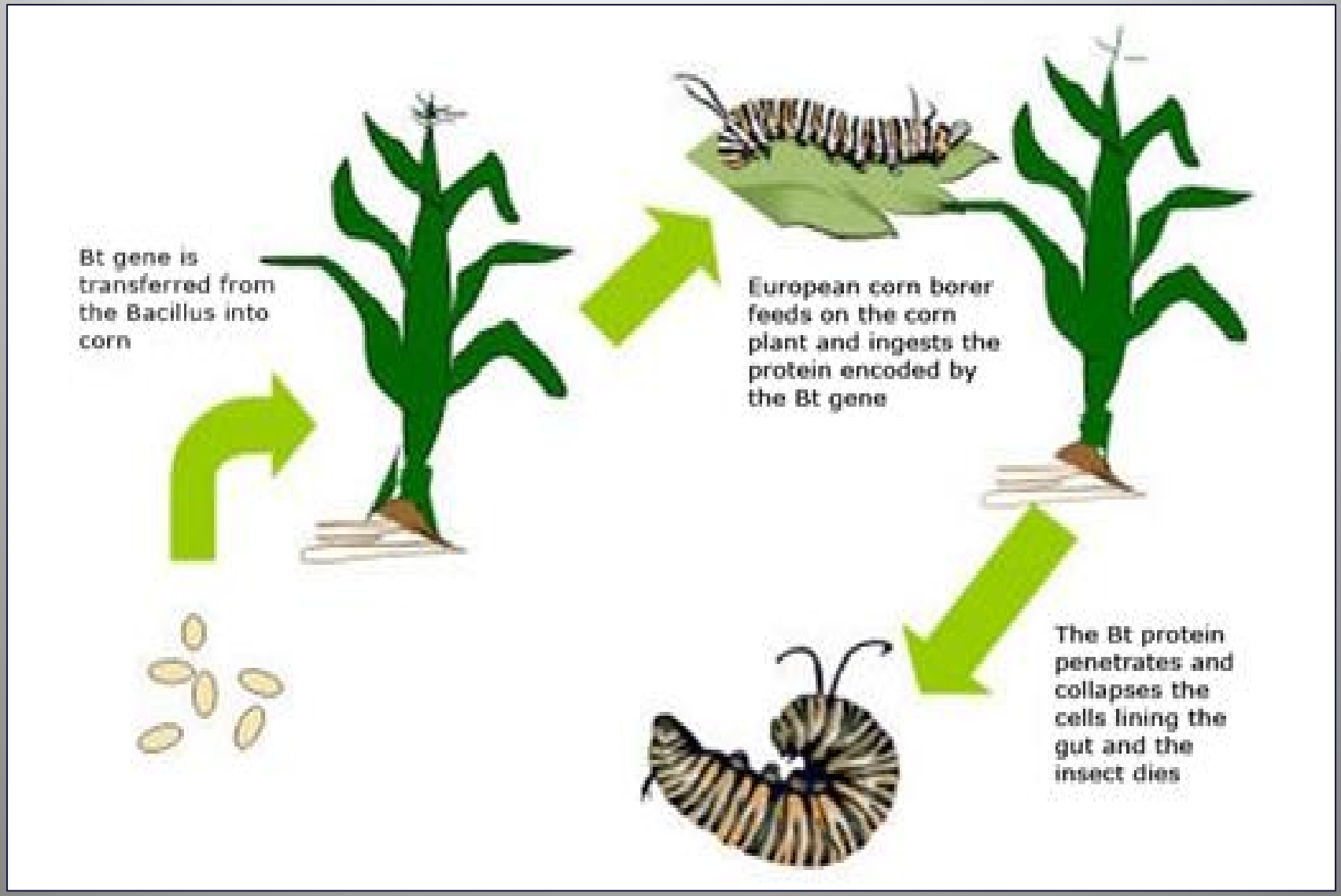
- Direct modification of DNA
  - vs. indirect modification in breeding
- Asexually modified in somatic cells
  - Then regenerated into whole organisms, usually starting in Petri dishes

Steps to create a GE plant



Insect-resistant “Bt crops”

More efficient and less harmful to non-targets than sprays --
Bt sprays widely used in organic agriculture




Breakthrough of the Year, 2015
Science
AAAS


TIME
The Gene Machine
What the CRISPR experiments mean for humanity By Alice Park

Gene editing described

- Technique that allows specific changes to the genome – modification of **native** genes
- Employs methods of genetic engineering but does not leave the editing agent in the genome

Agenda

- What are they and are not – a brief reminder
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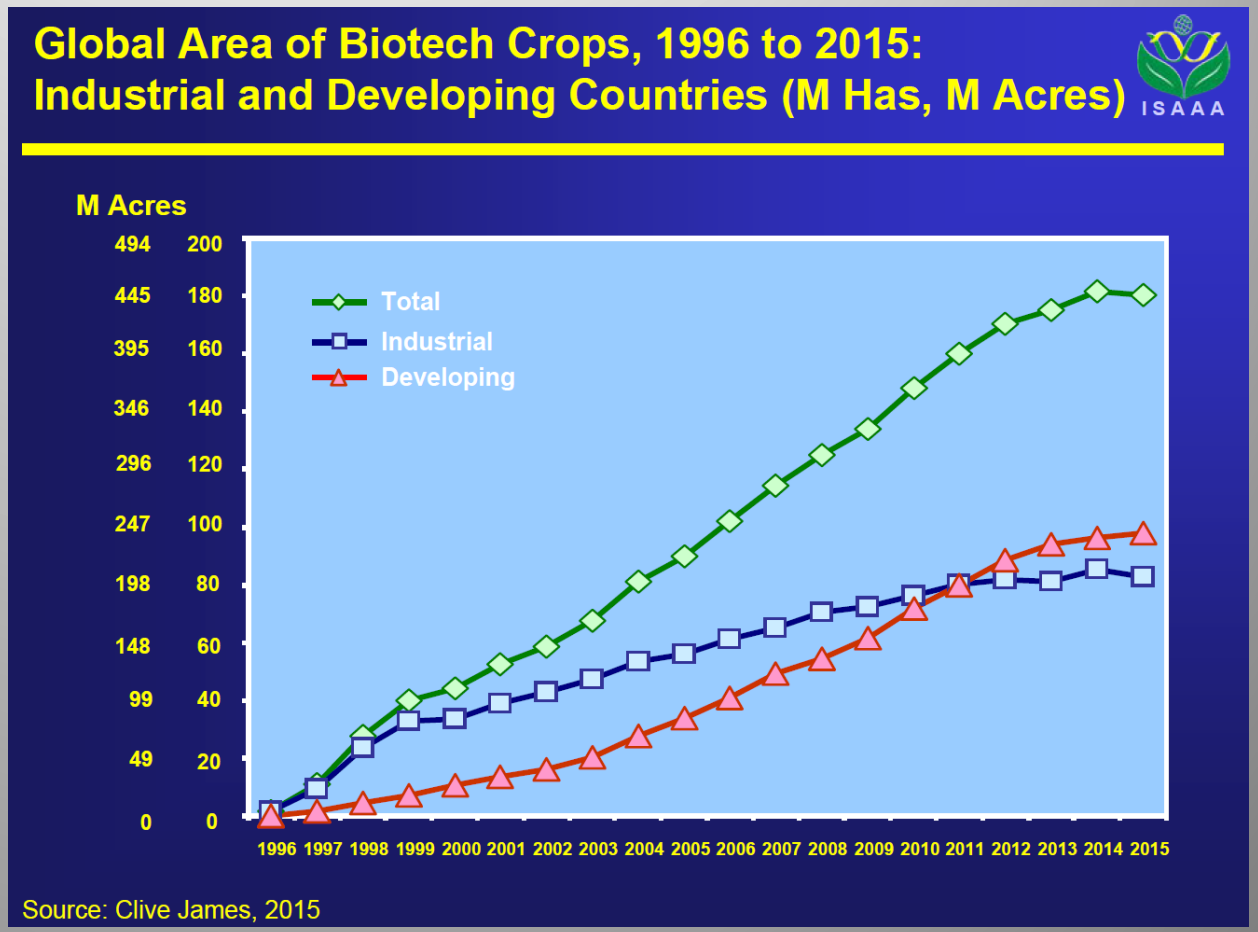
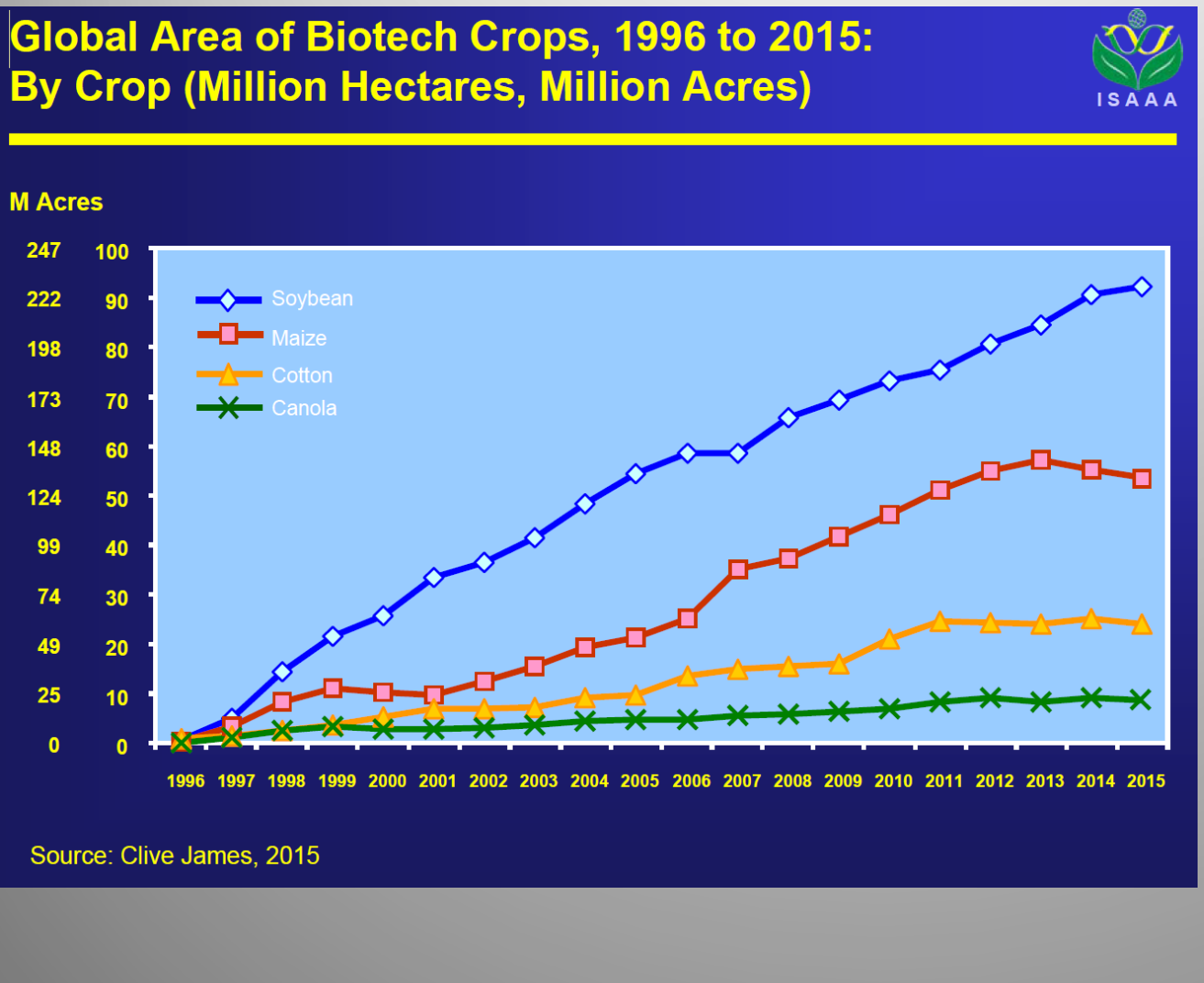
- Why so controversial, stigmatized?

First generation herbicide and insect resistant crops were rapidly adopted by farmers, both in the developed and developing world



Four crops dominate, 8+ crops in USA



Virus-resistant GM papaya

Saved the Hawaiian industry in the mid-1990s, ~80% of crop today

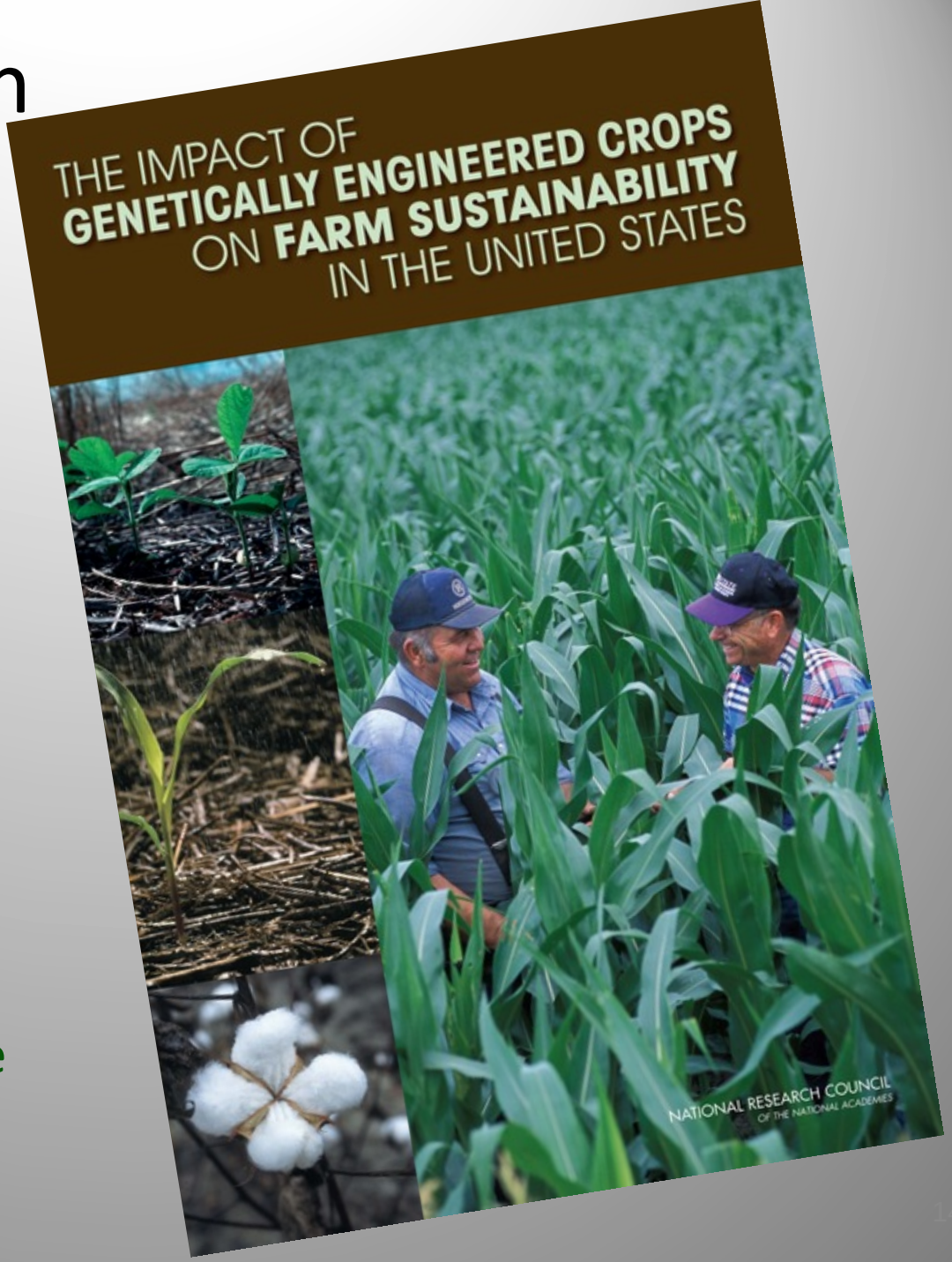
Like a vaccine –
"RNAi immunization" via implanting a viral gene in the papaya genome

GMO, virus-resistant trees

Courtesy of Denis Gonsalves, formerly of Cornell University

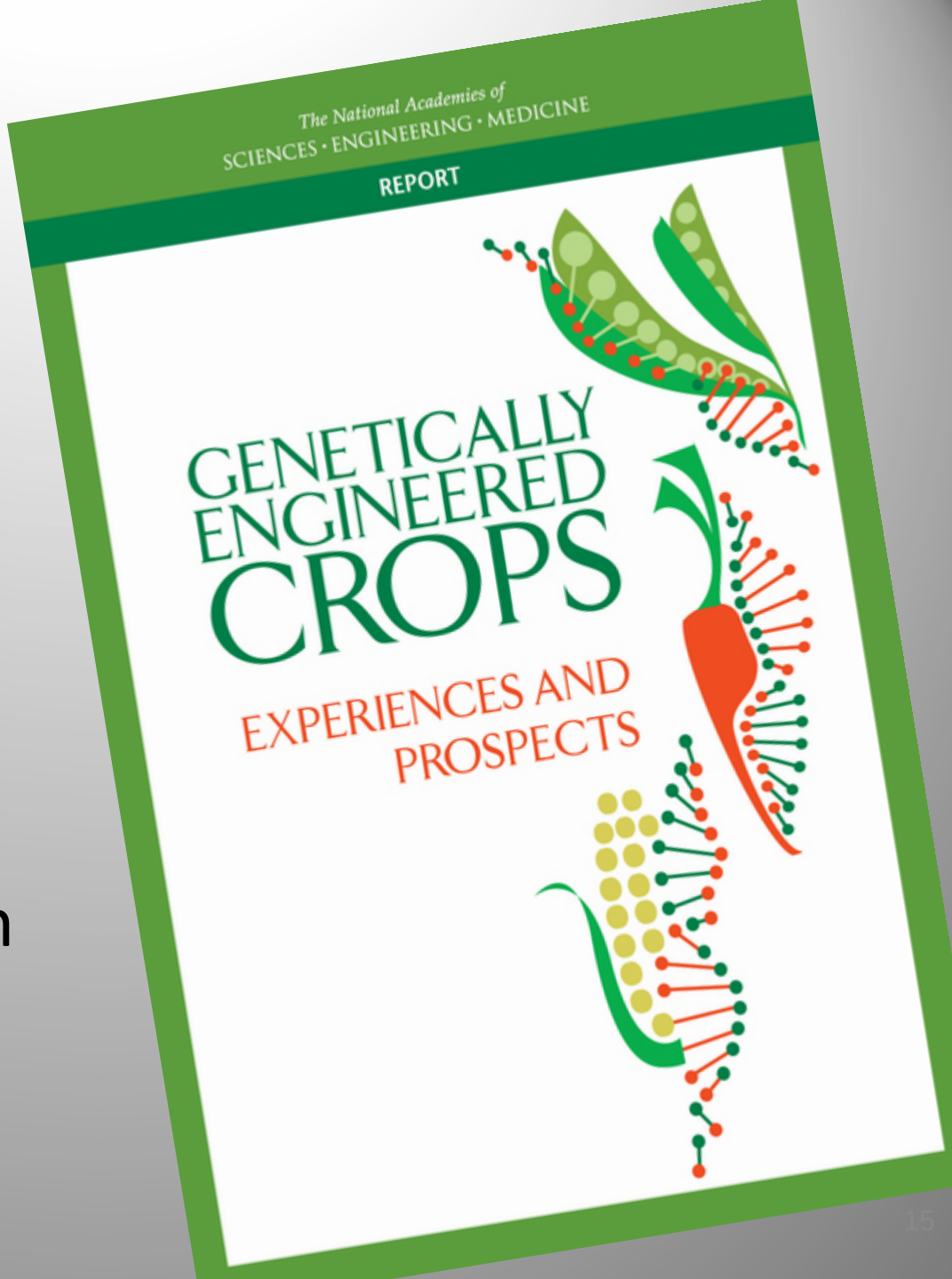
National Research Council Report 2010

- Major pesticide reductions - Bt
- Expanded conservation tillage
- Herbicide tolerant weeds
  - Need more sustainable management



National Research Council Report 2016

- Confirmed food safety
- Confirmed insecticide reduction with Bt crops



Herbicide tolerant plants promote conservation tillage – With many environmental benefits thereof

Conservation Technology Information Center

- Lowers greenhouse gas emissions
- Improves soil organic matter
- Reduces erosion and fertilizer runoff into water

Poor weed management has led to rapid development of herbicide-resistant weeds

And motivated development of new kinds of herbicide tolerant crops

nature biotechnology

nature.com ▸ journal home ▸ archive ▸ issue ▸ news ▸ full text

NATURE BIOTECHNOLOGY | NEWS

Glyphosate resistance threatens Roundup hegemony

Emily Waltz

Nature Biotechnology **28**, 537–538 (2010) | doi:10.1038/nbt0610-537
Corrected online **13 October 2010**
Corrigendum (October, 2010)

PDF | Citation | Reprints | Rights & permissions | Article metrics

Weeds are becoming increasingly resistant to glyphosate, a report from the US National Academy of Sciences (NAS) released in April has found. The driving force, according to the report, is farmers' dependence on the weed killer accompanied by the widespread adoption of genetically modified (GM) herbicide-tolerant crops. Seed makers are hoping to forestall the problem by developing GM crops with 'stacked' traits that tolerate multiple herbicides. But weed scientists warn that if farmers manage these new crops in the same way as they managed their glyphosate-tolerant predecessors, weeds will simply become resistant to the new technologies.

"The number of weed species evolving resistance to glyphosate

BILL BARKSDALE / AGSTOCKUSA /

Roundup tolerant bentgrass escape in Oregon

483

GMO grass
divides gra

8.1k
shares

Feds deregulate controversial GMO grass seed

Linn County bills itself as the grass seed capital of the world. But the thriving grass business has been divided by a controversial genetically modified grass developed by Scotts Miracle-Gro. *(Jeff Manning/The Oregonian)*

By **Jeff Manning | The Oregonian/OregonLive**
Email the author | Follow on Twitter
on January 18, 2017 at 10:00 AM, updated January 18, 2017 at 10:18 AM

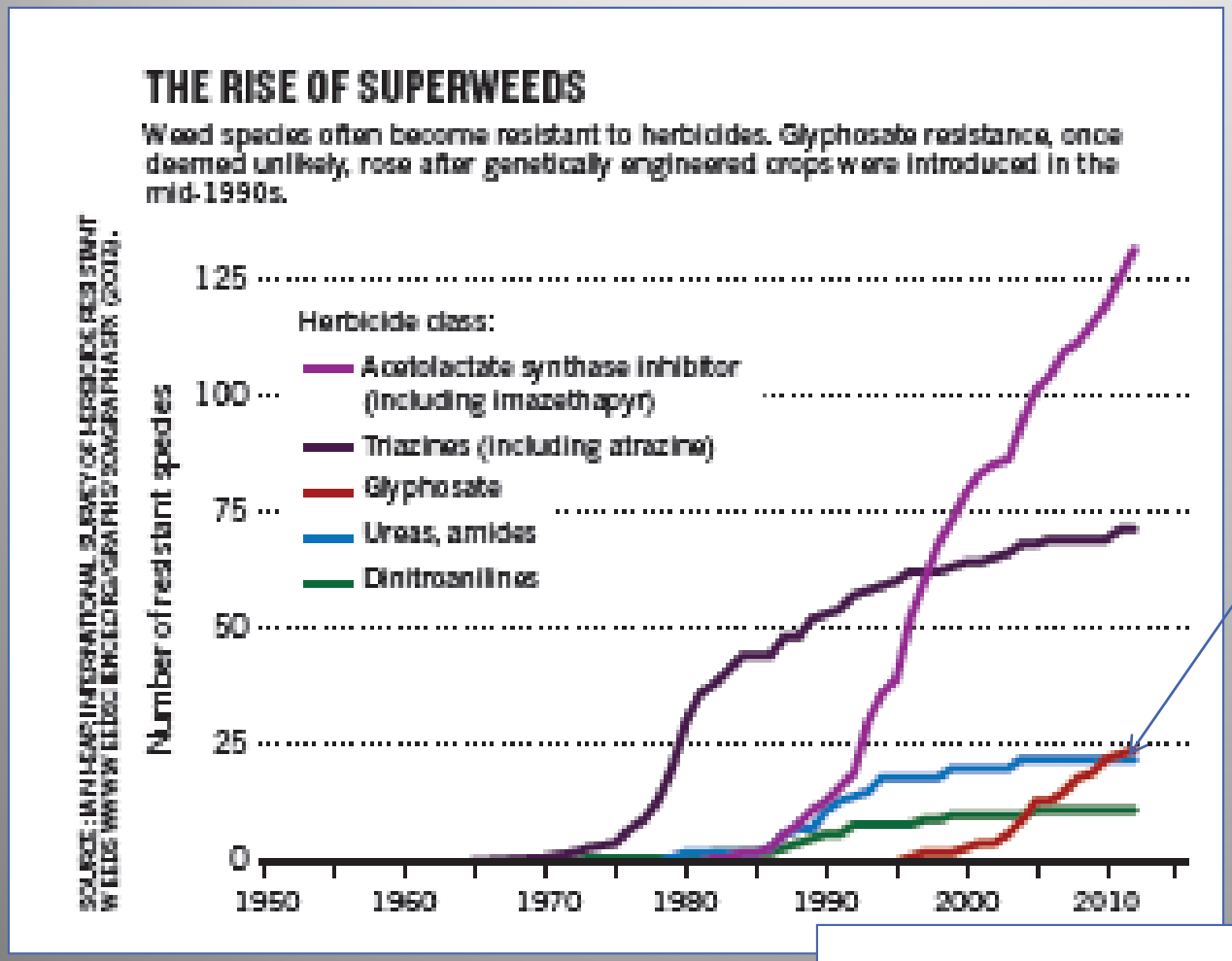
The U.S. Department of Agriculture on Tuesday deregulated a genetically modified grass that some Oregon farmers and dealers say threatens the state's grass seed business.

play 'hangm
is fired, law

http://www.oregonlive.com/business/index.ssf/2017/01/grass_seed_industry_fearful_ab.html

http://www.oregonlive.com/business/index.ssf/2017/01/post_248.html

Herbicide-resistant weeds are an old problem in agriculture, but exacerbated by GE herbicide tolerant crops



Accelerated by GE Roundup-tolerant crops

24 | NATURE | VOL 497 | 2 MAY 2013

ENVIRONMENTAL STUDIES

Genetically engineered crops and pesticide use in U.S. maize and soybeans

10.1126/sciadv.1600850

Edward D. Perry,[1] Federico Ciliberto,[2] David A. Hennessy,[3] GianCarlo Moschini[4]*

The widespread adoption of genetically engineered (GE) crops has clearly led to changes in pesticide use, but the nature and extent of these impacts remain open questions. We study this issue with a unique, large, and representative sample of plot-level choices made by U.S. maize and soybean farmers from 1998 to 2011. On average, adopters of GE glyphosate-tolerant (GT) soybeans used 28% (0.30 kg/ha) more herbicide than nonadopters, adopters of GT maize used 1.2% (0.03 kg/ha) less herbicide than nonadopters, and adopters of GE insect-resistant (IR) maize used 11.2% (0.013 kg/ha) less insecticide than nonadopters. When pesticides are weighted by the environmental impact quotient, however, we find that (relative to nonadopters) GE adopters used about the same amount of soybean herbicides, 9.8% less of maize herbicides, and 10.4% less of maize insecticides. In addition, the results indicate that the difference in pesticide use between GE and non-GE adopters has changed significantly over time. For both soybean and maize, GT adopters used increasingly more herbicides relative to nonadopters, whereas adopters of IR maize used increasingly less insecticides. The estimated pattern of change in herbicide use over time is consistent with the emergence of glyphosate weed resistance.

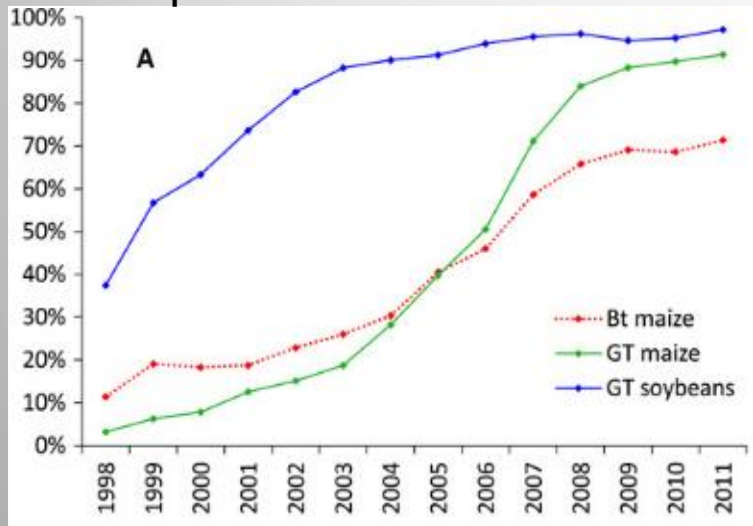
INTRODUCTION

One of the most salient developments in global agriculture in the past 20 years has been the introduction of genetically engineered (GE) crop varieties (*1*–*5*). In the United States in 2015, GE varieties accounted for 94% of planted soybean and 93% of planted maize (*6*). Adoption of this new technology was rapid: First introduced in 1996, GE soybean varieties embedding the glyphosate-tolerant (GT) trait have exceeded 80% of planted hectares since 2003. The share of planted maize using GE varieties—embedding GT and/or insect-resistant (IR) traits—has exceeded 80% since 2008. GT varieties are complementary inputs with glyphosate, and their adoption has inevitably led to substitution away from other herbicides (*7*). Conversely, IR varieties can substitute for over time. In particular, there have been little data to assess whether the recent development of glyphosate-resistant weeds has eroded whatever herbicide use benefits there may have been from GT crops (*11*).

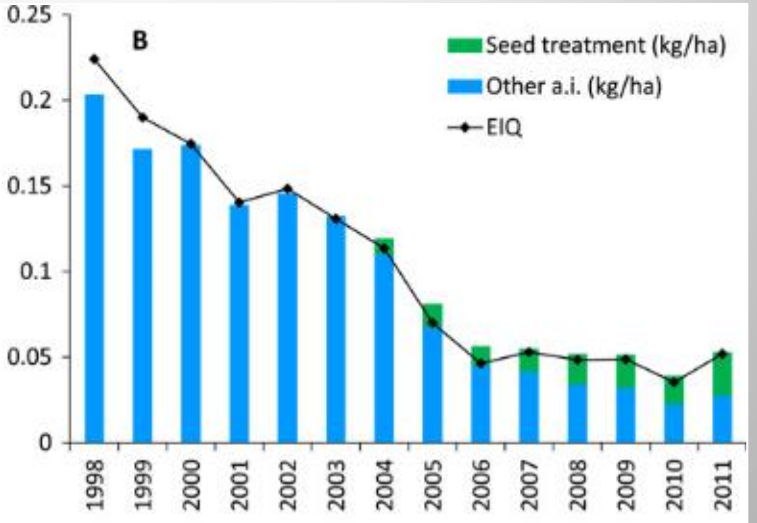
Our analysis relies on a unique, large farm-level data set that spans the period 1998–2011. The data have been assembled annually by GfK Kynetec, a unit of a major market research organization that specializes in the collection of agriculture-related survey data. For each year, the samples are designed to be representative at the crop reporting district (CRD) level and include an annual average of 5424 farmers for maize and 5029 farmers for soybeans (table S1). On the basis of these data, for each farmer, we match the amount of pesticide used with the size of the

GE ADOPTION AND PESTICIDE USE, MAIZE AND SOYBEANS, USA 1998–2011

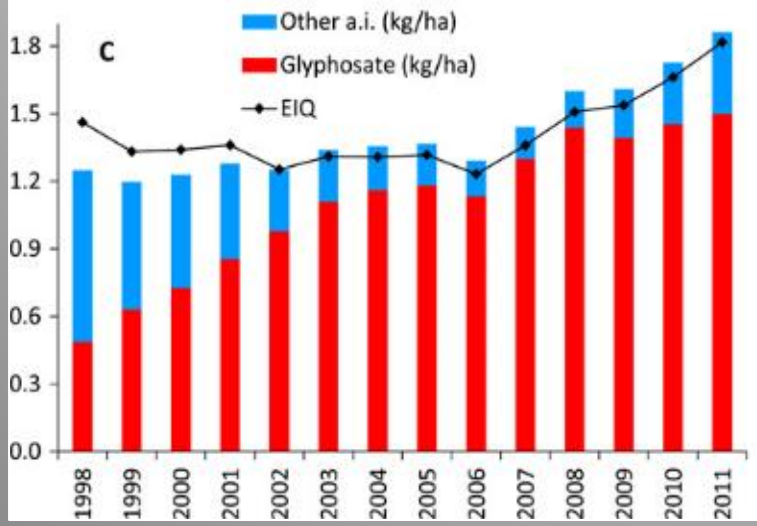
Adoption rates



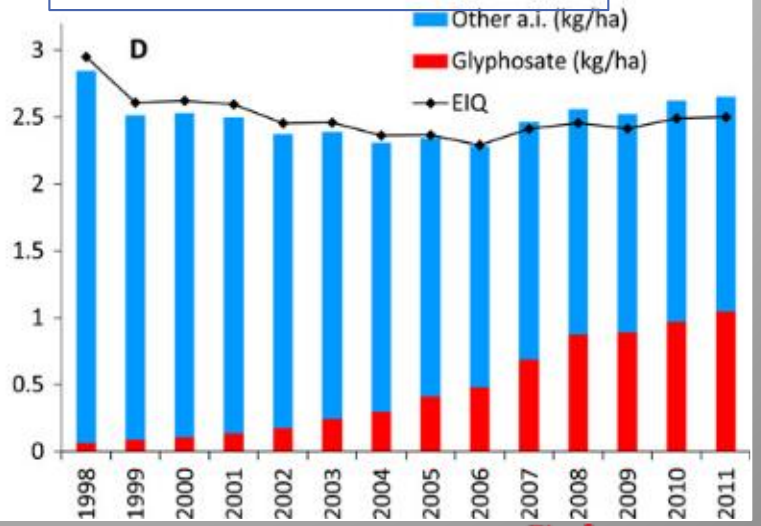
Insecticide use in maize



Herbicide use in soybeans



Herbicide use in maize



Published by AAAS

Edward D. Perry et al. Sci Adv 2016;2:e1600850

ScienceAdvances

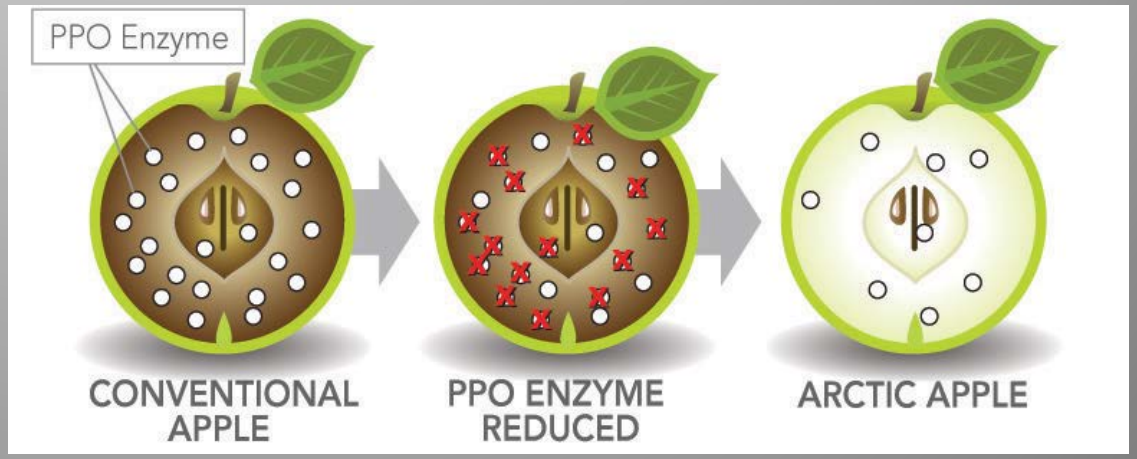
Key results (Perry et al. 2016)

- "…weighted by the environmental impact quotient, …we find that (relative to non-adopters) GE adopters used about….
- the same amount of soybean herbicides
- 9.8% less of maize herbicides
- 10.4% less of maize insecticides
- …the difference in pesticide use has changed significantly over time….
  - GT adopters used increasingly more herbicides relative to non-adopters, (… consistent with the emergence of glyphosate weed resistance)
  - Adopters of IR maize used increasingly less insecticides…"

Non-browning “Arctic Apple”

Reduced spoilage/waste, improved quality – USDA approved

Courtesy of Jennifer Armen, Okanagan Specialty Fruits, Canada



Non-browning “Arctic Apple”

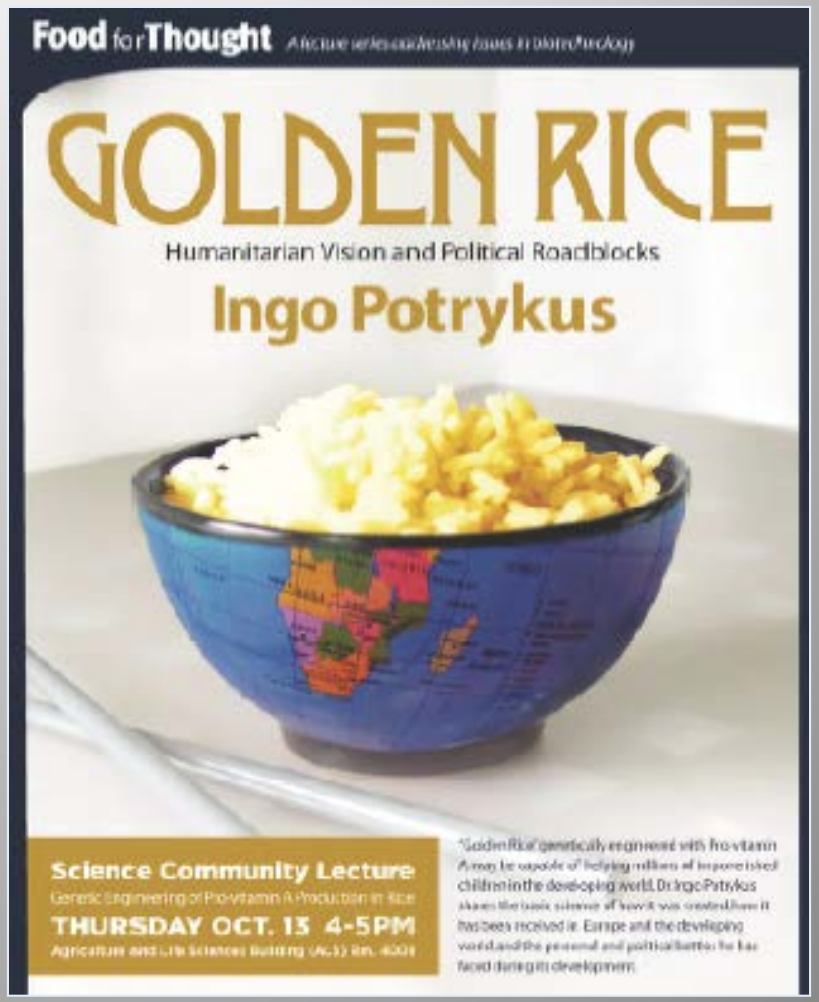
Time lapse video

“Innate” potato – native DNA, non-browning and other traits

One hour after cutting – Control vs. Innate

Two days after cutting – Control vs. Innate

Diverse pipeline of biofortification products = enhancement of critical vitamins or nutrients



Agenda

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- Why so controversial, stigmatized?

The GMO controversy is complex: There are many pieces

- *"It is accurate to say that many of the real ethical issues [of GMOs in agriculture] have little to do with the use of transgenic technologies"* (Burkardt et al. 2005, Agricultural Ethics, CAST)

CAST

COUNCIL FOR AGRICULTURAL SCIENCE AND TECHNOLOGY

ISSUE PAPER

NUMBER 29 FEBRUARY 2005

AGRICULTURAL ETHICS

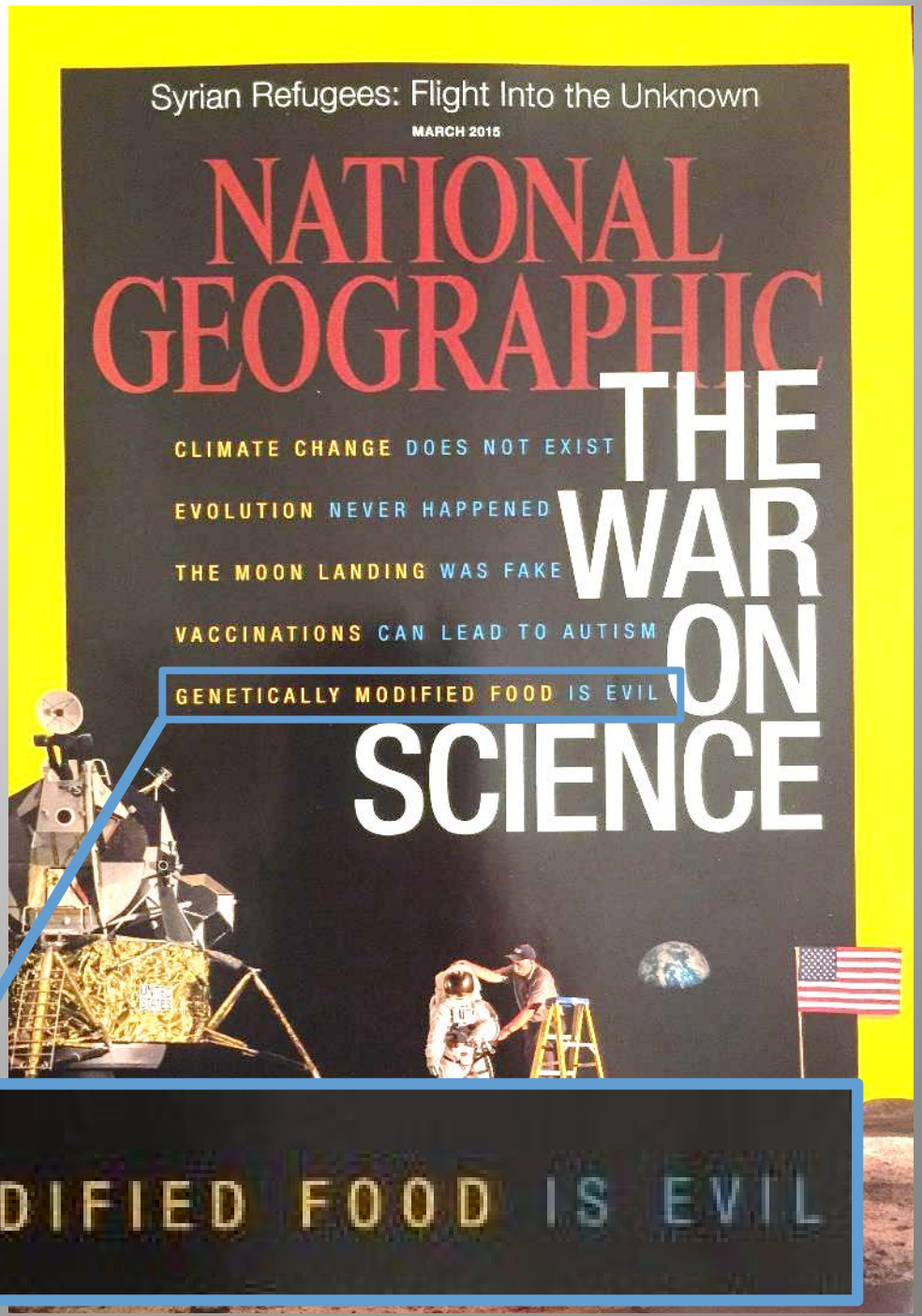
INTRODUCTION

It is widely known that agriculture has a long history. Starting approximately 12,000 years ago, the domestication of plants and animals began independently in several different places, including centers in West Asia, East Asia, Central America, and South America. Domestication also may have occurred in other locations, although convincing archeological evidence has not been found. In the

TASK FORCE MEMBERS: **Jeffrey Burkhardt, Chair**, Department of Food and Resource Economics, University of Florida, Gainesville; **Gary Comstock**, Department of Philosophy and Religion, North Carolina State University, Raleigh; **Peter G. Hartel**, Department of Crop and Soil Sciences, University of Georgia, Athens; **Paul B. Thompson**, Department of Philosophy, Michigan State University, East Lansing; REVIEWERS: **Maarten J. Chrispeels**, Center for Molecular Agriculture, University of California–San Diego; **Charles C. Muscoplat**, College of Agricultural, Food and Environmental Sciences, University of Minnesota, St. Paul; **Robert Streiffer**, Department

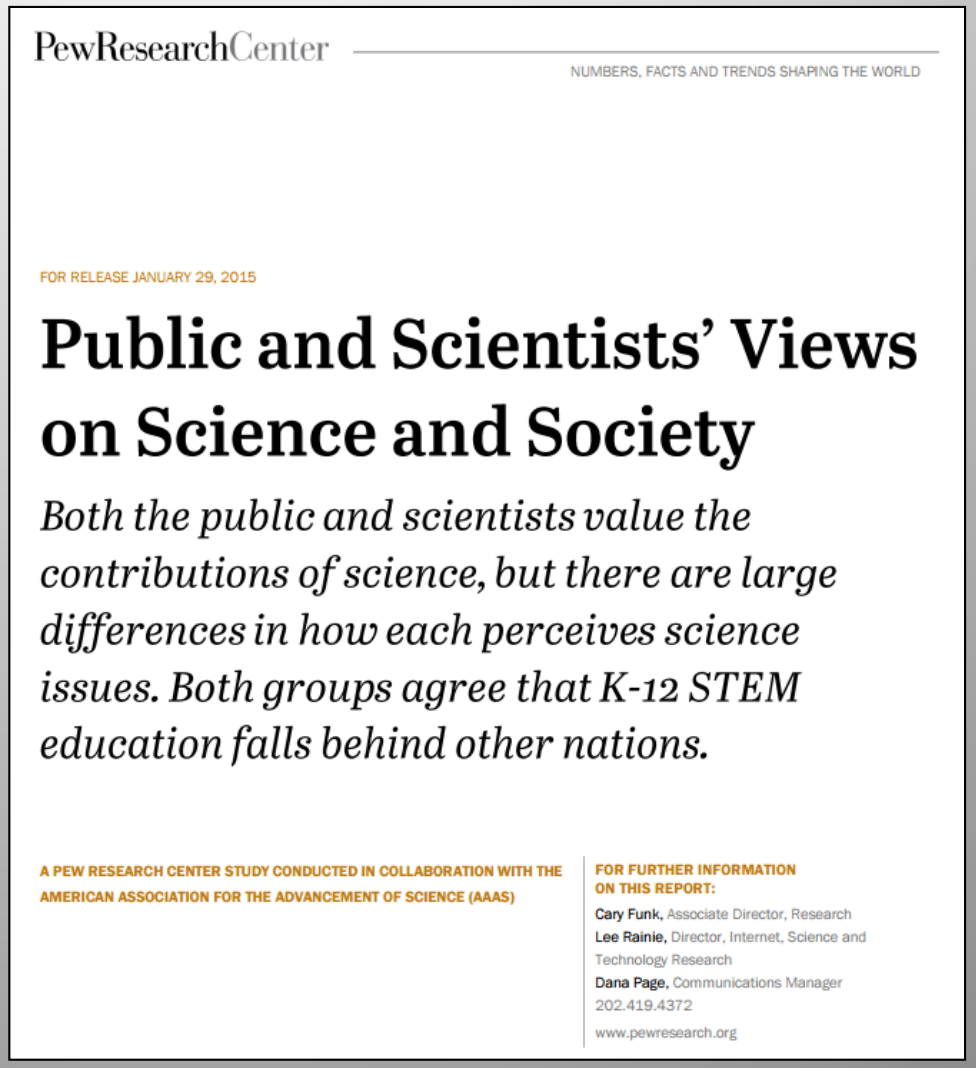
commented on the importance of agricultural knowledge in the quest for the "good life" by the individual and the polity. The fundamental value of agriculture was highlighted by Enlightenment thinkers from John Locke to Thomas Jefferson, who underscored the political, economic, and philosophical importance of "tillers of the soil" (Spiegel 1991). In the United States, problems faced by farmers became the focus of the nine-

It’s hard to tell what science is saying amidst all the noise



GENETICALLY MODIFIED FOOD IS EVIL

Pew Survey on views of controversial science issues - 2015



PewResearchCenter

NUMBERS, FACTS AND TRENDS SHAPING THE WORLD

FOR RELEASE JANUARY 29, 2015

Public and Scientists' Views on Science and Society

Both the public and scientists value the contributions of science, but there are large differences in how each perceives science issues. Both groups agree that K-12 STEM education falls behind other nations.

A PEW RESEARCH CENTER STUDY CONDUCTED IN COLLABORATION WITH THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (AAAS)

FOR FURTHER INFORMATION ON THIS REPORT:
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http://www.pewinternet.org/2015/01/29/public-and-scientists-views-on-science-and-society/

PewResearchCenter *Internet, Science & Tech*

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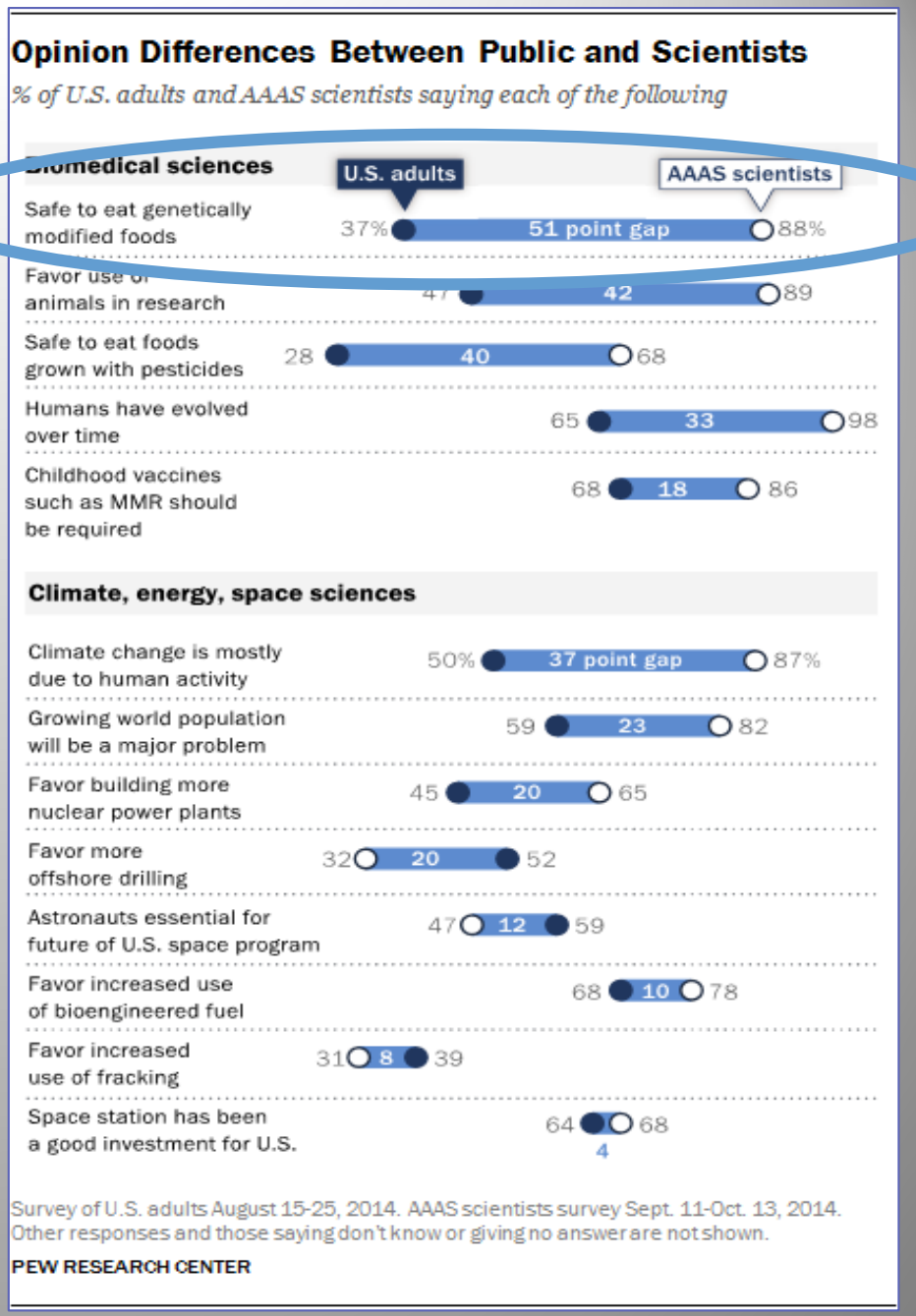
PUBLICATIONS | TOPICS | PRESENTATIONS | INTERACTIVES | KEY INDICATORS

JANUARY 28, 2015

PUBLIC AND SCIENTISTS' VIEWS ON SCIENCE AND SOCIETY

88% of AAAS scientists say genetically modified foods are safe to eat; only 37% of the public agrees

GMOs the largest scientist-public gap, 51%, of any issue surveyed



http://www.pewinternet.org/2015/01/29/public-and-scientists-views-on-science-and-society/

AAAS: Position on GMO labeling

“Legally mandating such a label can only serve to mislead and falsely alarm consumers”

Statement by the AAAS Board of Directors On Labeling of Genetically Modified Foods

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

20 October 2012

There are several current efforts to require labeling of foods containing products derived from genetically modified crop plants, commonly known as GM crops or GMOs. These efforts are not driven by evidence that GM foods are actually dangerous. Indeed, the science is quite clear: crop improvement by the modern molecular techniques of biotechnology is safe. Rather, these initiatives are driven by a variety

conclusion: consuming foods containing ingredients derived from GM crops is no riskier than consuming the same foods containing ingredients from crop plants modified by conventional plant improvement techniques.

Civilization rests on people's ability to modify plants to make them more suitable as food, feed and fiber plants and all of these modifica-

added, the protein must be shown to be neither toxic nor allergenic. As a result and contrary to popular misconceptions, GM crops are the most extensively tested crops ever added to our fo
occasional clain
foods to animals
ranging from dig
to sterility, tumo
death. Although such claims are often sensationalized and receive a

Approved by the AAAS Board of Directors on 20 October 2012

AAAS
ADVANCING SCIENCE, SERVING SOCIETY

GE/GMO a technology with diverse outcomes, including many…..

- Genes/traits - Types of crops - Places
- Values - Approaches

- **A general technology**: More like a wheel or computer than a medicine or saxophone

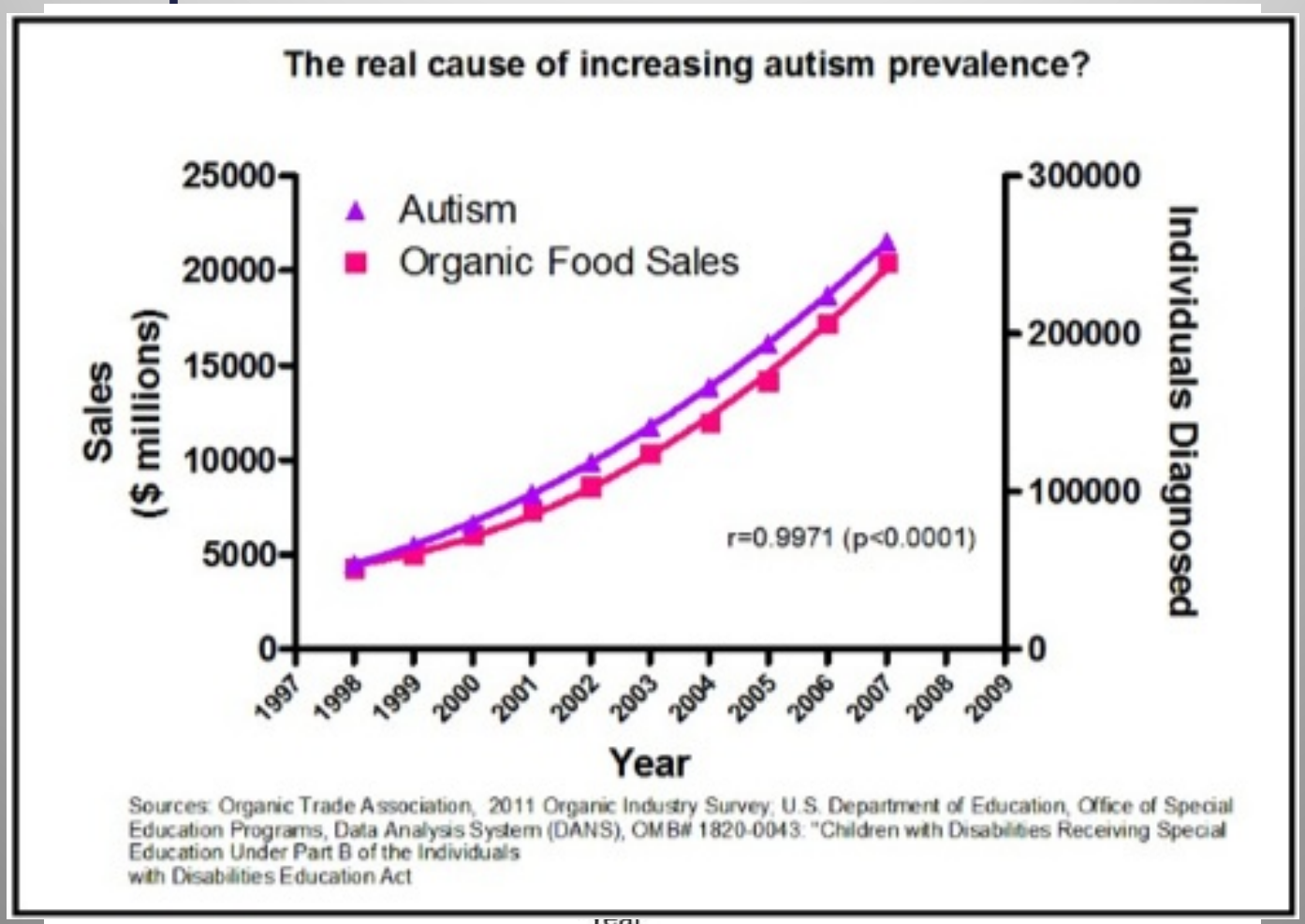
- **“Product not process,” “case by case,”** is global consensus for science assessments

Are GE/GMO foods safe? Are they good for the environment?

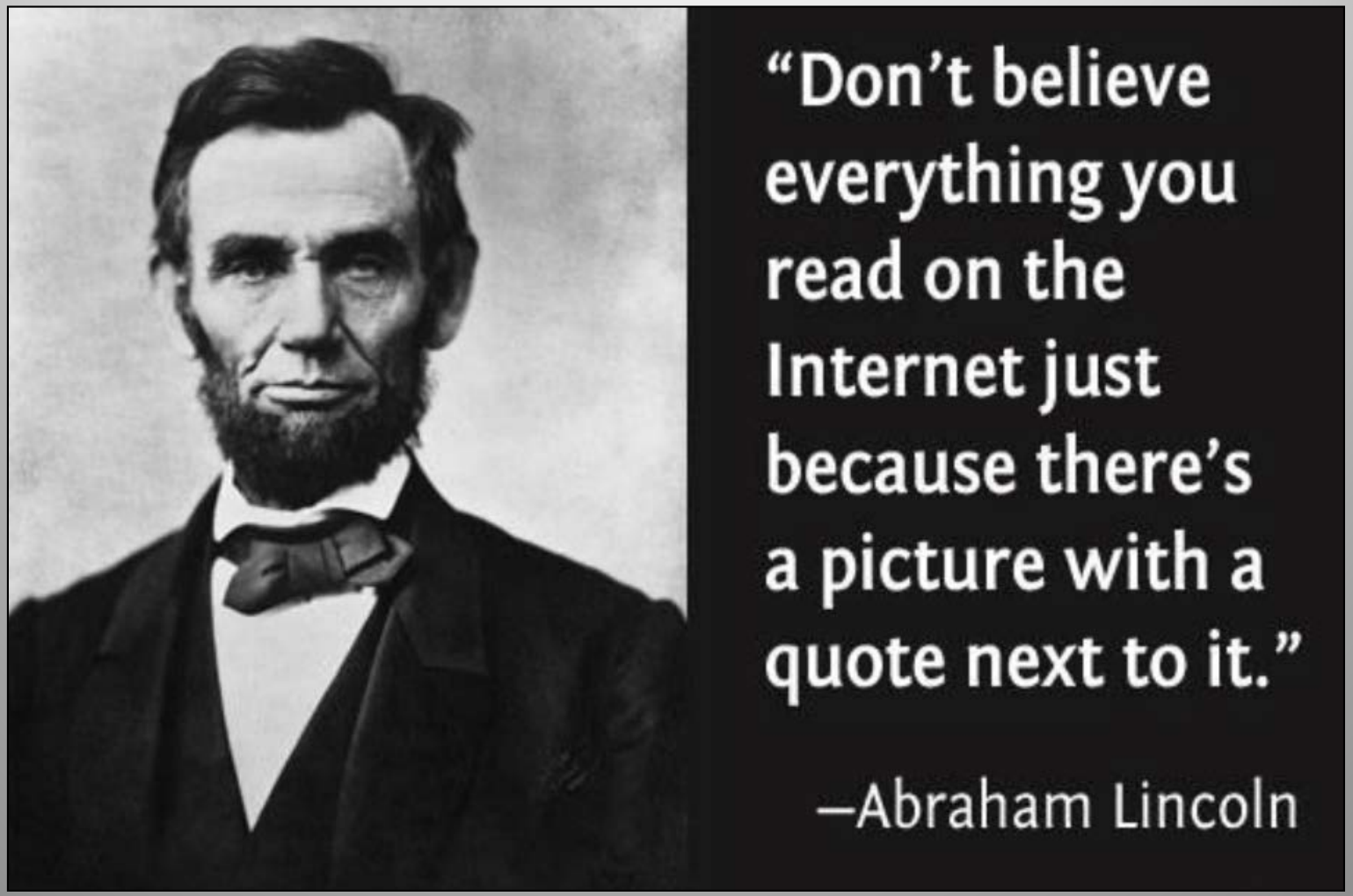
The more relevant questions

- Is agriculture becoming more pro… sustainable, resilient?
- If food becoming healthie…
- Are we using genetic metho… …ane… sustainability, healthfulness, p…oductivity?
- There are no silver bullets: Are we making intelligent choices, management tactics, and tradeoffs to move in the right direction ?

Much pseudo-science: “Half of all children will be Autistic by 2025 due to Roundup warns MIT scientist”



Abe Lincoln warned us, but….



http://weknowmemes.com/2012/07/dont-believe-everything-you-read-on-the-internet

FOOD BUSINESS NEWS
Trend of the Year

FOOD SERVICE | BEVERAGES | FROZEN FOODS | DAIRY | TREND OF THE YEAR | VISIT FOODBUSINESSNEWS.NET

Trend of the Year: Clean Label

Industry answers the call for simple ingredients

http://features.foodbusinessnews.net/corporateprofiles/2015/trend-index.html

Kraft has announced that the orange glow of its iconic Macaroni & Cheese will no longer come from synthetic coloring agents.
(Kevork Djansezian / Getty Images)

http://www.chicagotribune.com/business/sc-clean-labels-food-0210-20160218-story.html

ment for


PEACE
ALL NATURAL
BONUS 35% MORE!
NO
NO
NO
SWEET & CRUNCHY CORN PUFFS
Reese's Puffs
NEW!
SELECTS
NEW YORK STYLE
RESPECT
Breakfast Sandwich
NO ARTIFICIAL PRESERVATIVES OR FLAVORS
Kraft
Singles
AMERICAN
16g Protein
NET WT. 4.80 OZ. (136 g)
COLA
zevia
ZERO CALORIE
OVEN ROASTED
DELI TURKEY
NO PRESERVATIVES
100% NATURAL
Hormel
NATURAL
CHOICE
DOUBLEMINT
perfectly
sweet
NO ARTIFICIAL
SWEETENERS

FDA laxity one reason for demand, but not clear “clean” products are “cleaner”

WEBMD SPECIAL REPORT: FOOD ADDITIVES

The Dirty Secrets of 'Clean' Labels

By Brenda Goodman, MA, Reviewed by Michael W. Smith, MD on July 20, 2015

WebMD News Archive

July 23, 2015 -- Consumers have become deeply distrustful of their food.

There's Samantha Adams, who had her “aha moment” when she happened to read the label of the barbecue sauce she was feeding her 1-year-old.

http://www.webmd.com/news/breaking-news/food-additives/20150723/foods-clean-labels?page=1

GMO-free labels a significant feature of clean label movement

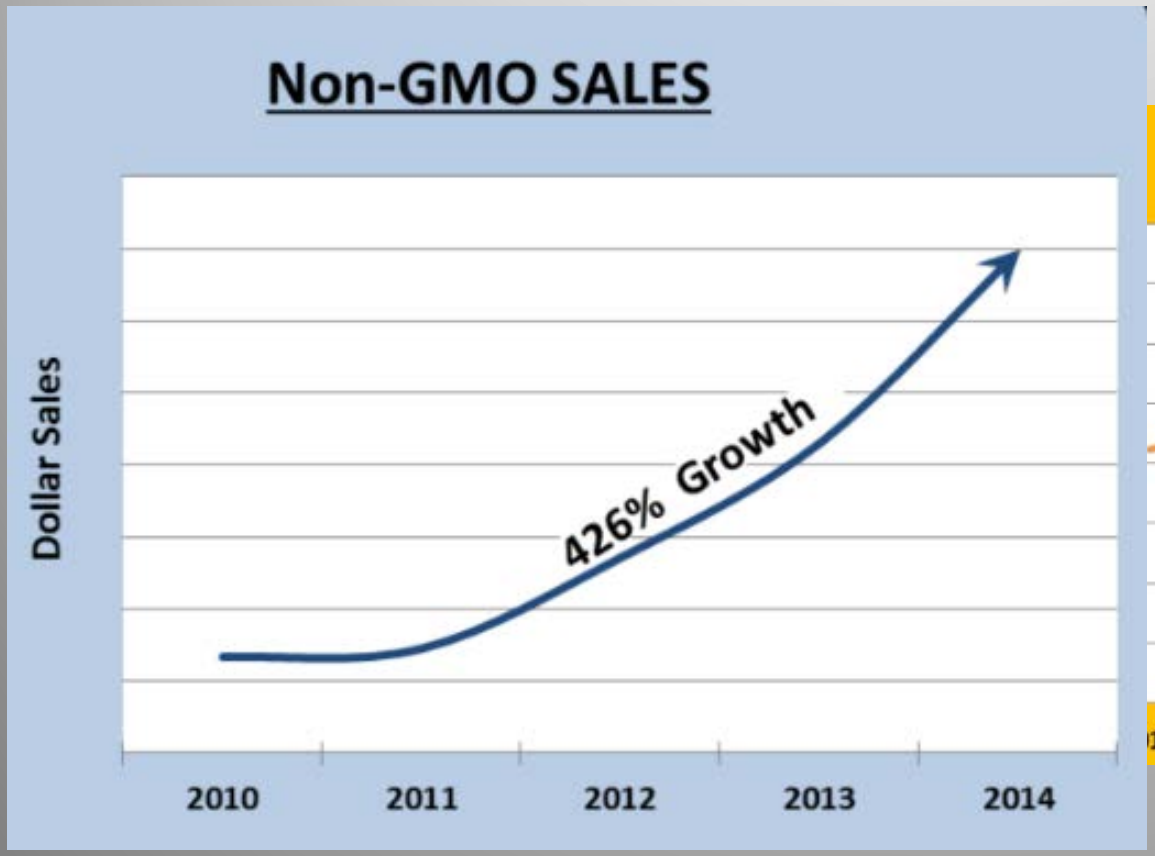
NON GMO Project
VERIFIED
nongmoproject.org

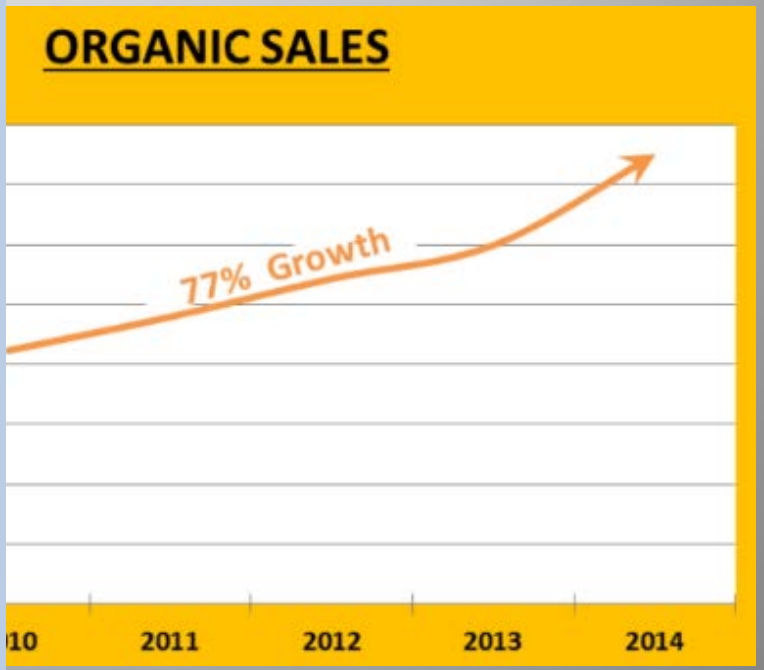
Meteoric rise of no-GMO labels

- GMO-free claims jumped 237% in new products 2012 to 2013

Organic and Non GMO Market Growth 2015

Errol Schweizer
Executive Global Grocery Coordinator
Whole Foods Market





https://www.aphis.usda.gov/stakeholders/downloads/2015/coexistence/Errol-Schweizer.pdf

My list of key factors

1. Complexity in an internet powered world looking for slogans and simple answers
   - Clean label movement
2. Vested interest in stigma for economic and ideological reasons
   - Internet, media celebrity experts
   - Fake and “half-truthed” news and science
3. Phobia for pesticides, chemicals in any dose
   - The “Food Babe” effect
4. Scientific novelty and complexity vs. inertia of regulations and marketing systems

My list of key factors

5. Roles and perceptions of large seed/chemical and food corporations – the “Monsanto effect”
6. Tool in global battles / trade wars
7. Scientific complexity of environmental impacts – biodiversity vs. climate vs. pesticide impacts
8. Poor management, fear of herbicide tolerant GE crops
9. Legal complications and perceptions around gene flow and patents
10. Decreasing confidence in experts, scientists – who to trust?

Summary

- GMO is a breeding method not a particular kind of product
- Large benefits for economics, soil tillage, humanitarian applications
- Also very significant management, global acceptance, trade problems
- Diverse pipeline of new products
  - Gene editing a major new tool, but acceptance unclear
- “Clean label” movement limiting GMOs, helping to teach public they are unsafe as a group?
- Fake and half-truth information, decreasing trust in scientists, government, media, and most other institutions – inflames and confuses