GMOs 101

What are they, impacts & fuss

16 June 2024 / Summer Agriculture Institute

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Agenda

- Take home messages
- Making a GMO or gene edit
- Some impacts
- Public controversy / skepticism
- Take home messages

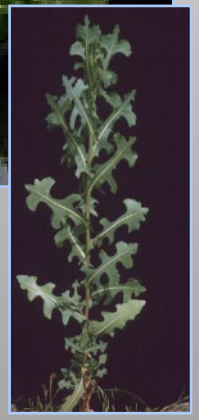
Take-home messages - 1

- Nearly all our food is highly genetically modified, the old way
- GMO or gene editing is a method with many possible uses and impacts
- The method has been so intensely regulated and excluded from markets that the tech is greatly limited in most of the world
- It has many rich opponents who benefit from the limitation/stigma, due to ideology and $$
  - Organic, environmental, alternative health, geopolitical, federal regulatory bureaucracies

Take-home messages - 2

- Regulations and patents make it very costly to use, causing consolidation to a few multinationals and thus added social resistance
- Conventional breeding is growing ever more powerful due to the genomic, computation, AI revolutions
  - Providing work arounds to GMOs
- A few pest/weed control traits are in wide use in several parts of the world and the USA, with large beneficial impacts but also the usual large-scale management problems

These are highly genetically modified but not GMO



Many plant varieties derived from induced mutations – not GMO

Calrose 76 semi-dwarf rice

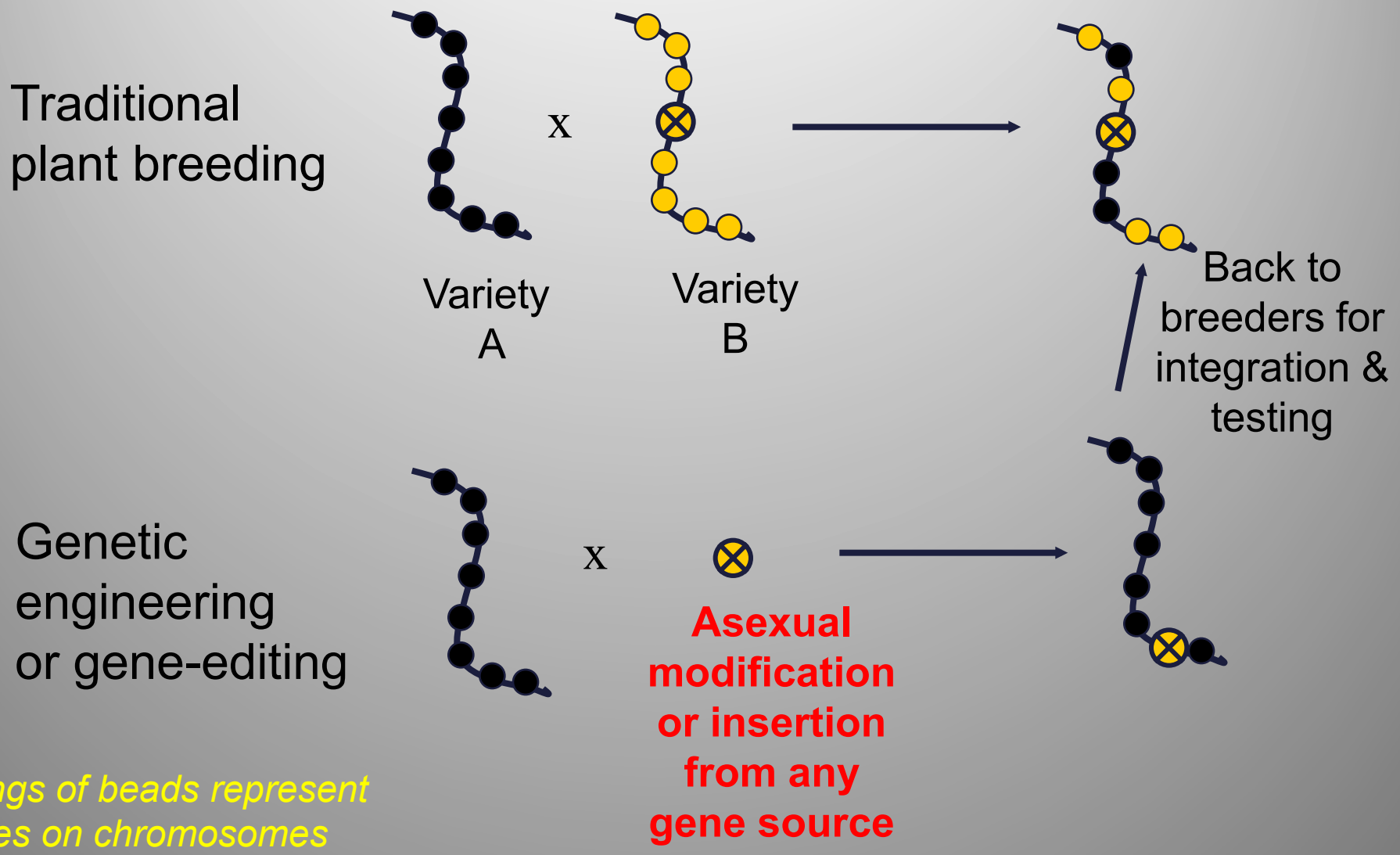
Over 3,000 crop varieties derived from mutagenesis have been commercialized

High oleic sunflower

Rio Red grapefruit

Domesticated animals are radically modified – not GMO

GE/GMO refers to a method of breeding, not particular kinds of products



What it looks like

Young GE cottonwoods starting out their new life and “trying on new genes”

Gene editing

- A gene you insert to change other genes in the genome
- Gives highly specific, efficient modification of native genes
- CRISPR the main method out there
- Works well everywhere!

Teacher kits easy to find

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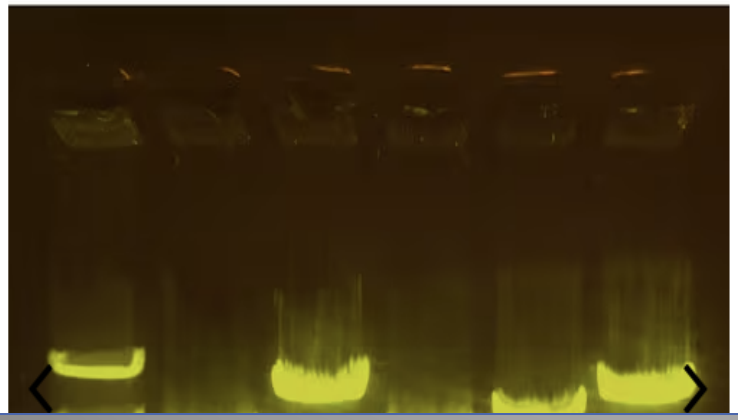
A-maize-ing Editing: Using CRISPR to Improve Crops

SKU: 210 | NEW



$159.00

Quantity

1

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ABOUT THIS PRODUCT:

A gene-edited crop on the market:

Soybean with increased oleic acid

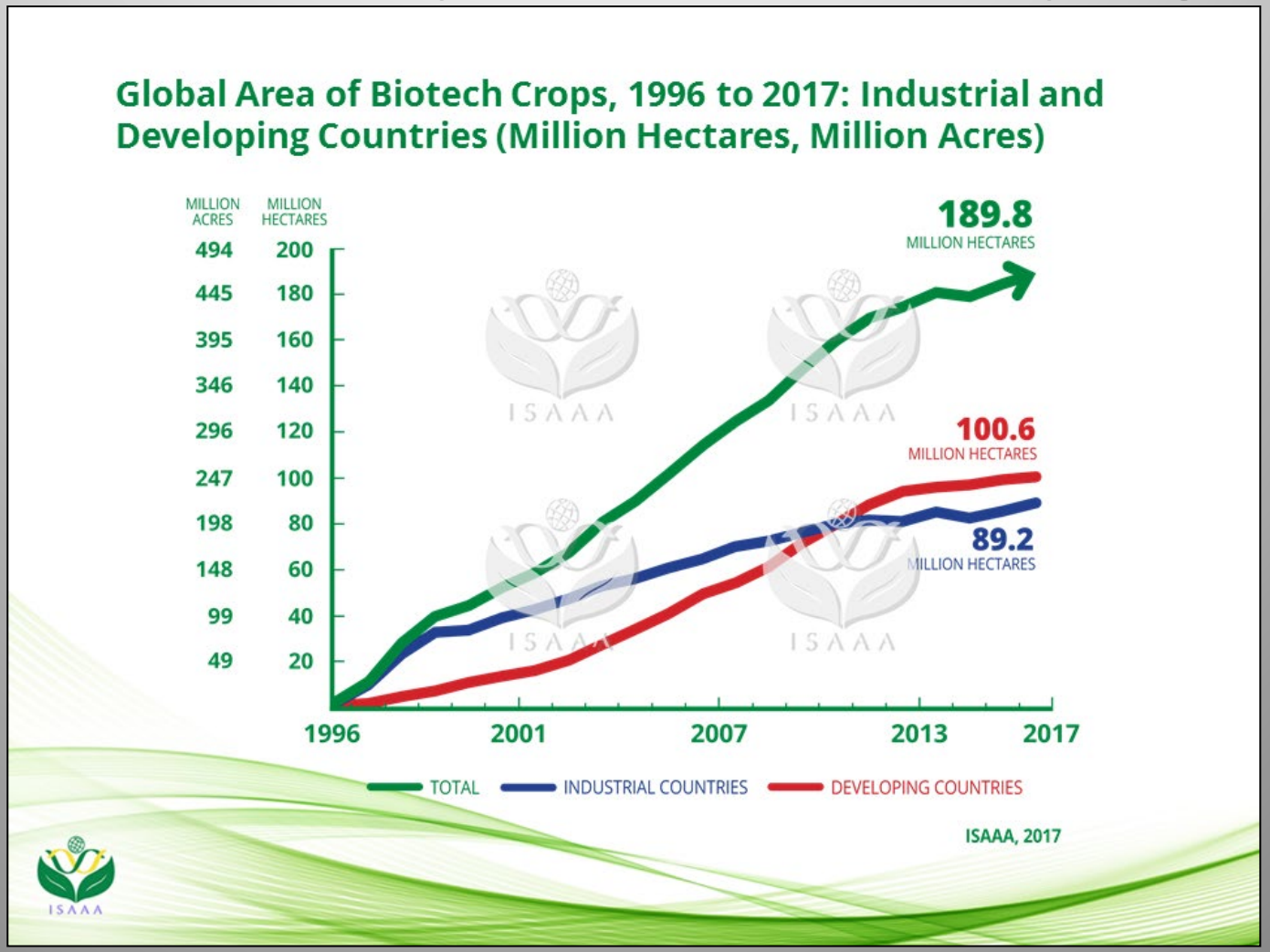
- Its soy oil with properties of olive oil!
- Benefits to consumer and producer
  - Consumer-centric trait: Reduced saturated fats, no trans fats – same basic properties as olive oil!
  - Producer-centric trait: Improved shelf-life without need for hydrogenation
- Not labeled as GMO ("bioengineered") in the USA as there is no DNA above the 5% threshold
  - But due to FDA rules is labeled as being nutritionally distinct from normal soy oil

Global Status of Commercialized Biotech/GM Crops in 2017:

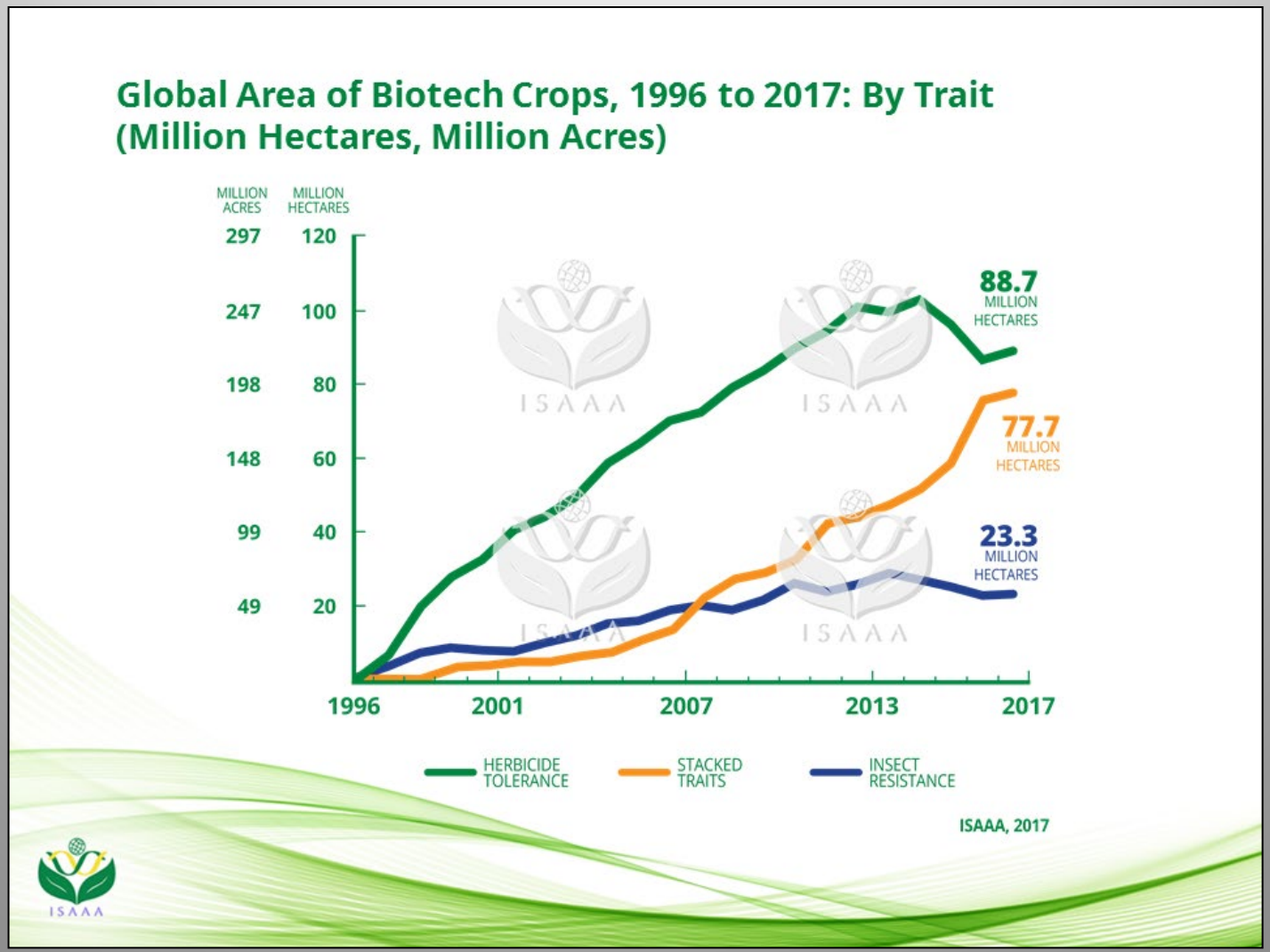
Biotech Crop Adoption Surges as Economic Benefits Accumulate in 22 Years

International Service for the Acquisition of Agri-biotech Applications (ISAAA)

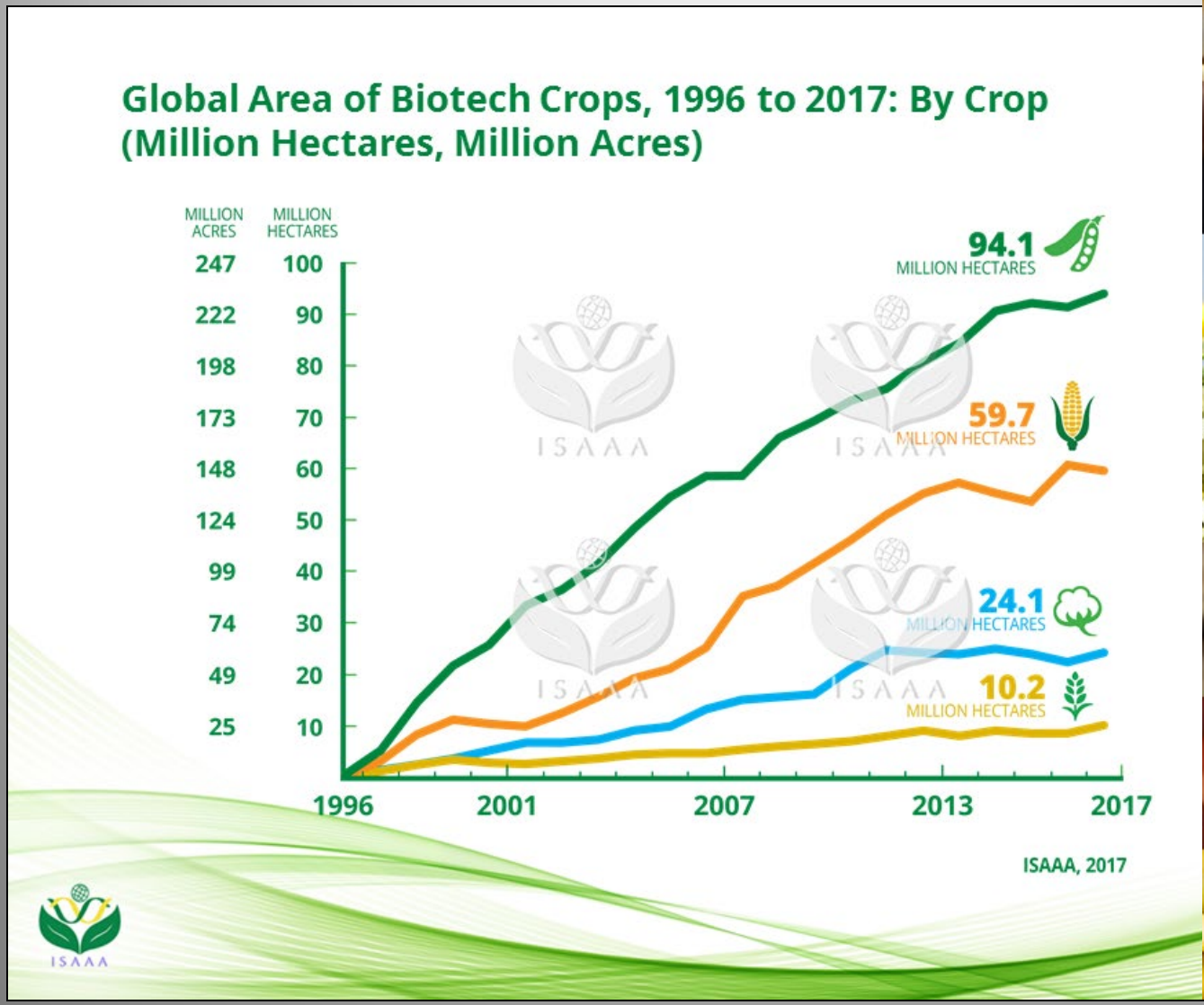
First generation herbicide and insect resistant crops rapidly adopted by farmers, in developed and developing world



Herbicide and pest resistance traits dominate worldwide, increasingly “stacked” in trait-combinations

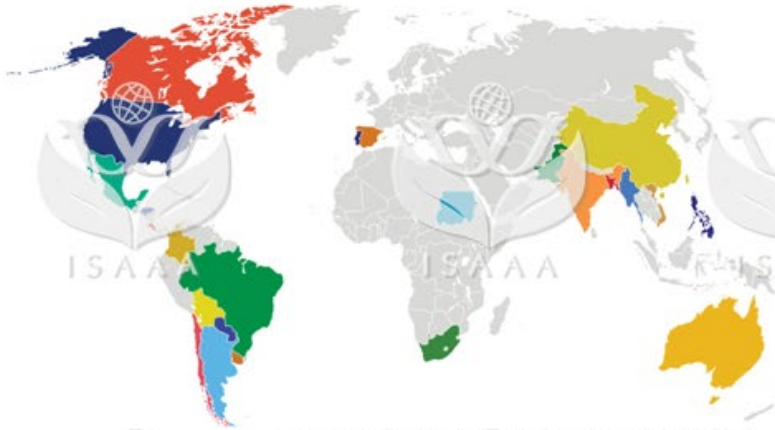


Four crops dominate, 8+ GMO crops in USA



Adoption rates around the world mostly low, highly variable

Global Area of Biotech Crops, 2017: By Country (Million Hectares)



24 countries which have adopted biotech crops

3% Increase from 2016

In 2017, global area of biotech crops was 189.8 million hectares, representing an increase of 3% from 2016, equivalent to 4.7 million hectares.

Source: ISAAA, 2017.

50,000 hectares, or more

1.	USA	75.0 million
2.	*Brazil**	50.2 million
3.	*Argentina**	23.6 million
4.	Canada	13.1 million
5.	*India**	11.4 million
6.	*Paraguay**	3.0 million
7.	*Pakistan**	3.0 million
8.	*China**	2.8 million
9.	*South Africa**	2.7 million
10.	*Bolivia**	1.3 million
11.	*Uruguay**	1.1 million
12.	Australia	0.9 million
13.	*Philippines**	0.6 million
14.	*Myanmar**	0.3 million
15.	*Sudan**	0.2 million
16.	Spain	0.1 million
17.	*Mexico**	0.1 million
18.	*Colombia**	0.1 million

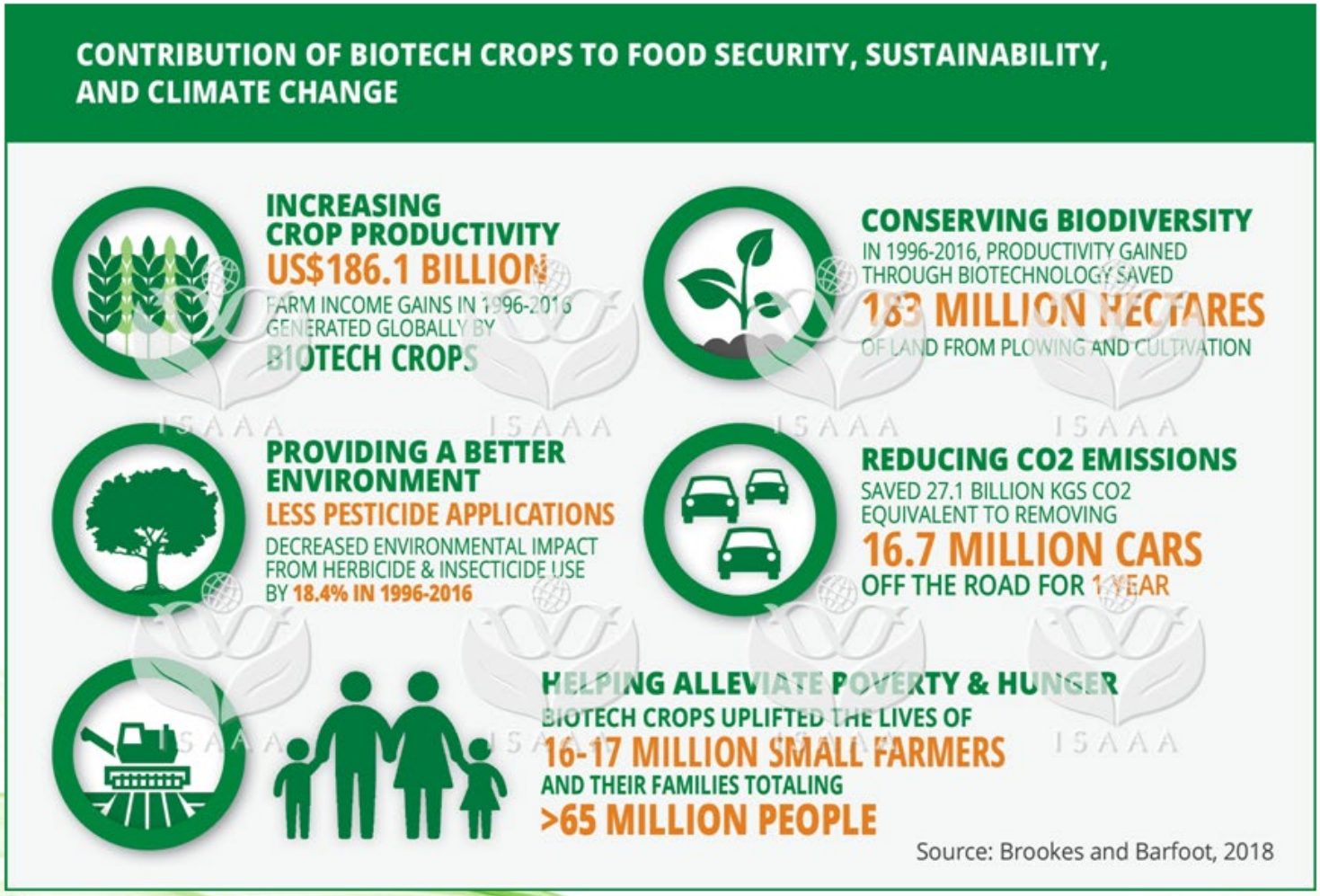
Less than 50,000 hectares

*Vietnam**	Portugal
*Honduras**	*Bangladesh**
*Chile**	*Costa Rica**

** Developing countries*

ISAAA

Claims of large environmental benefits



https://www.tandfonline.com/doi/full/10.1080/21645698.2017.1309490 for details/updates

Insect-resistant crops with huge impact on economics and sustainability

Pray et al., 2002. Plant J. 31:423-430
Photo: entomologytoday.org Dominic Reisig

Non-GMO vs. insect resistant Bt cotton without pesticide use

Insect resistant eggplant a great success in Bangladesh, illegal plantings in India

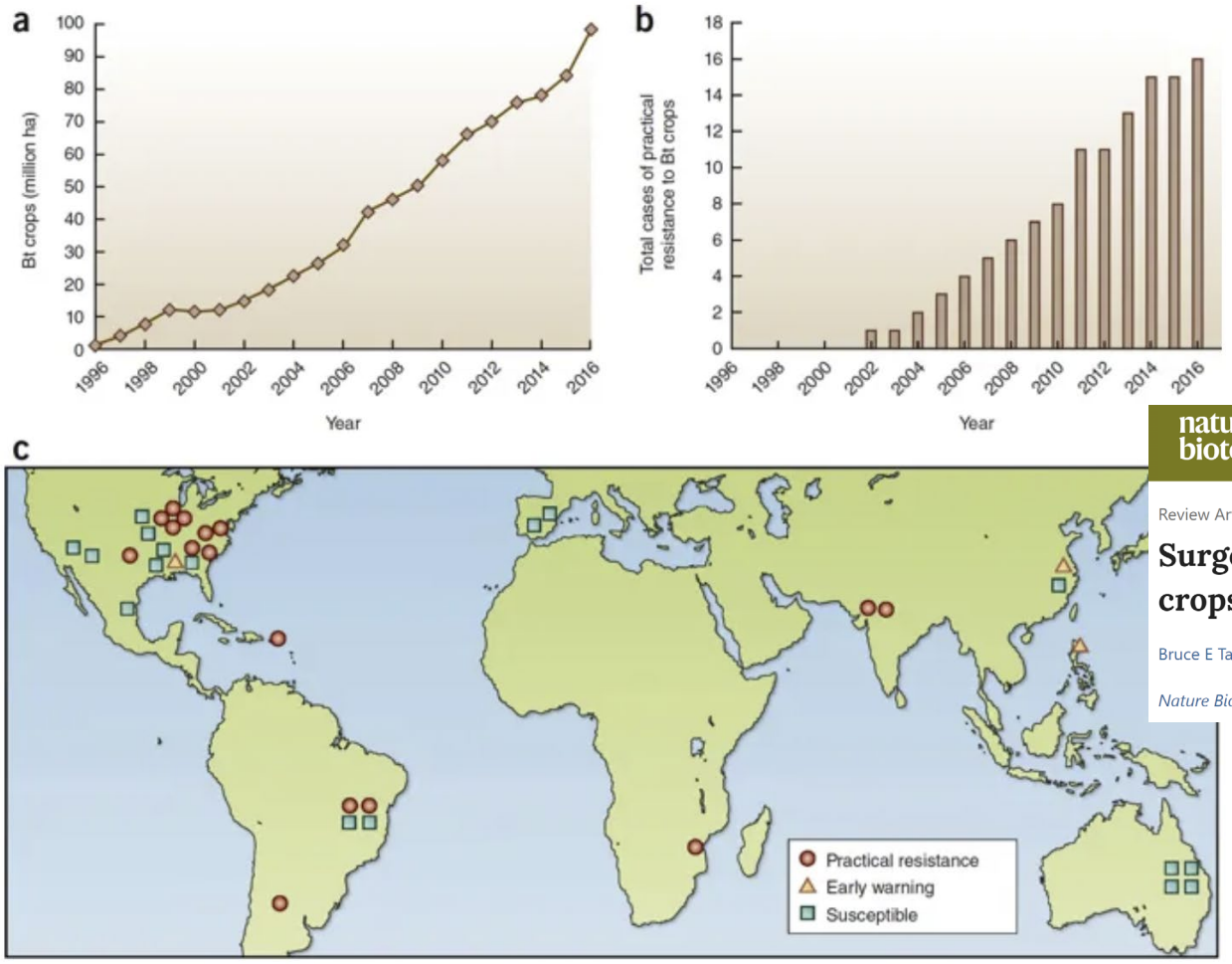
Non-Biotech

Biotech

http://www.isaaa.org/resources/publications/briefs/47/download/isaaa-brief-47-2014.pdf

But, insect resistance to BT also growing

Figure 1: Global status of pest resistance to Bt crops.



nature biotechnology

Review Article | Published: 11 October 2017

Surge in insect resistance to transgenic crops and prospects for sustainability

Bruce E Tabashnik & Yves Carrière

Nature Biotechnology **35**, 926–935(2017) | Cite this article

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

GMO crops have accelerated development of herbicide-resistant weeds

And motivated development of new kinds of herbicide tolerant crops

nature biotechnology

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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)

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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

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

Breeding is based on diversity

Many genes, species, hybrids, clones, traits, uses, environments, markets – stark contrast to GMOs with few genes of major effect

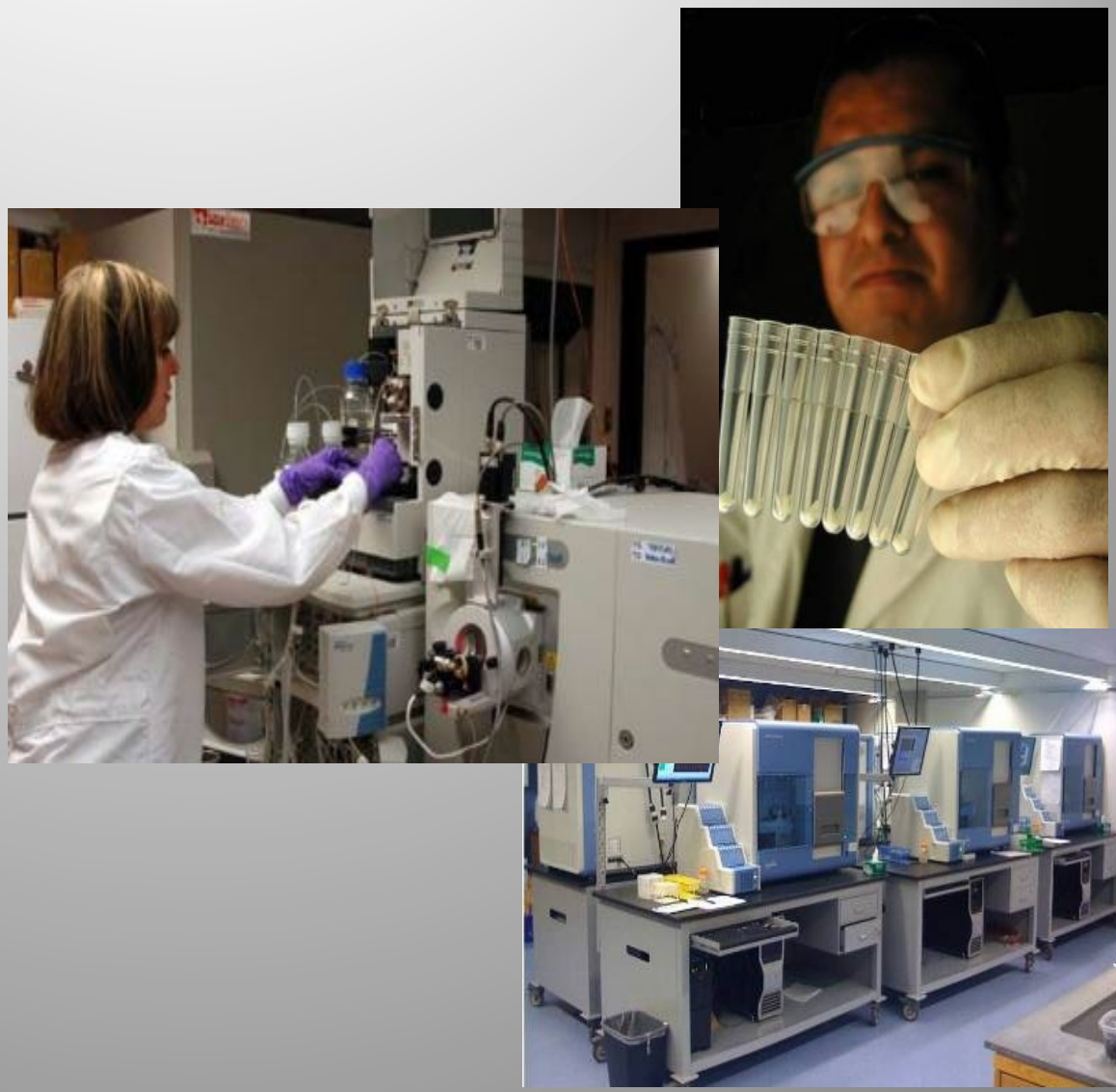
OSU wheat variety trials

University of Kentucky wheat variety trials

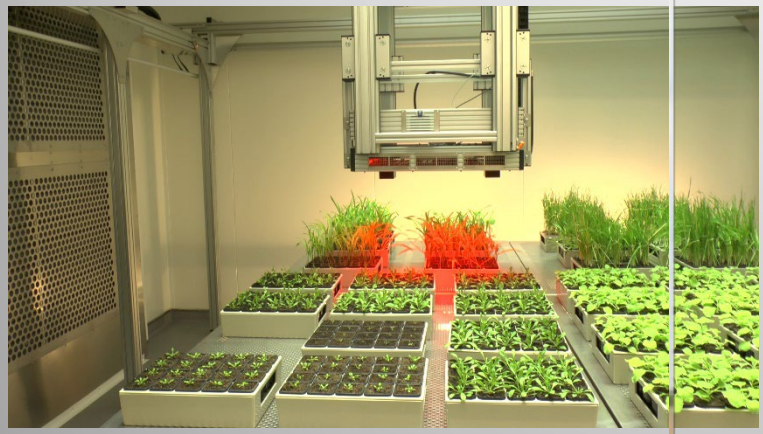
Modern plant breeders use advanced genome and imaging technology

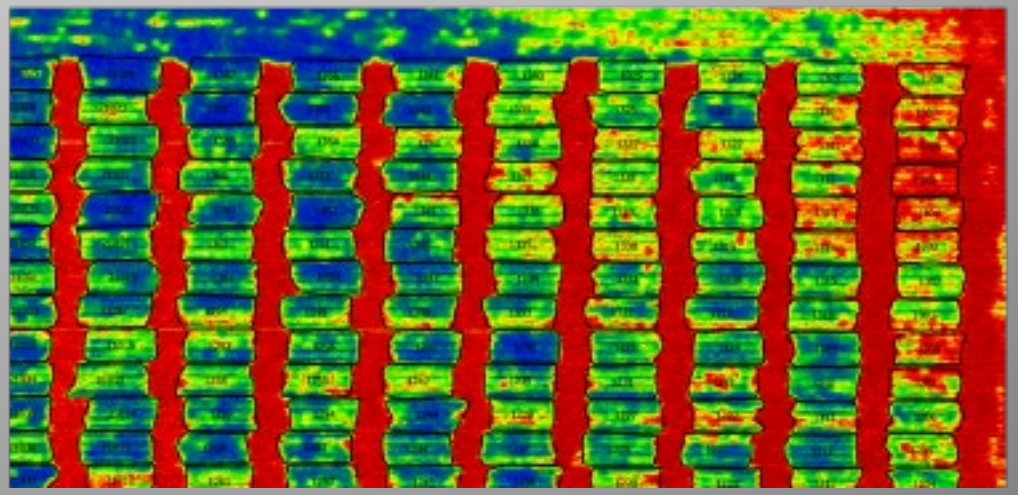
Omics = **large-scale**

DNA genotyping for indirect breeding



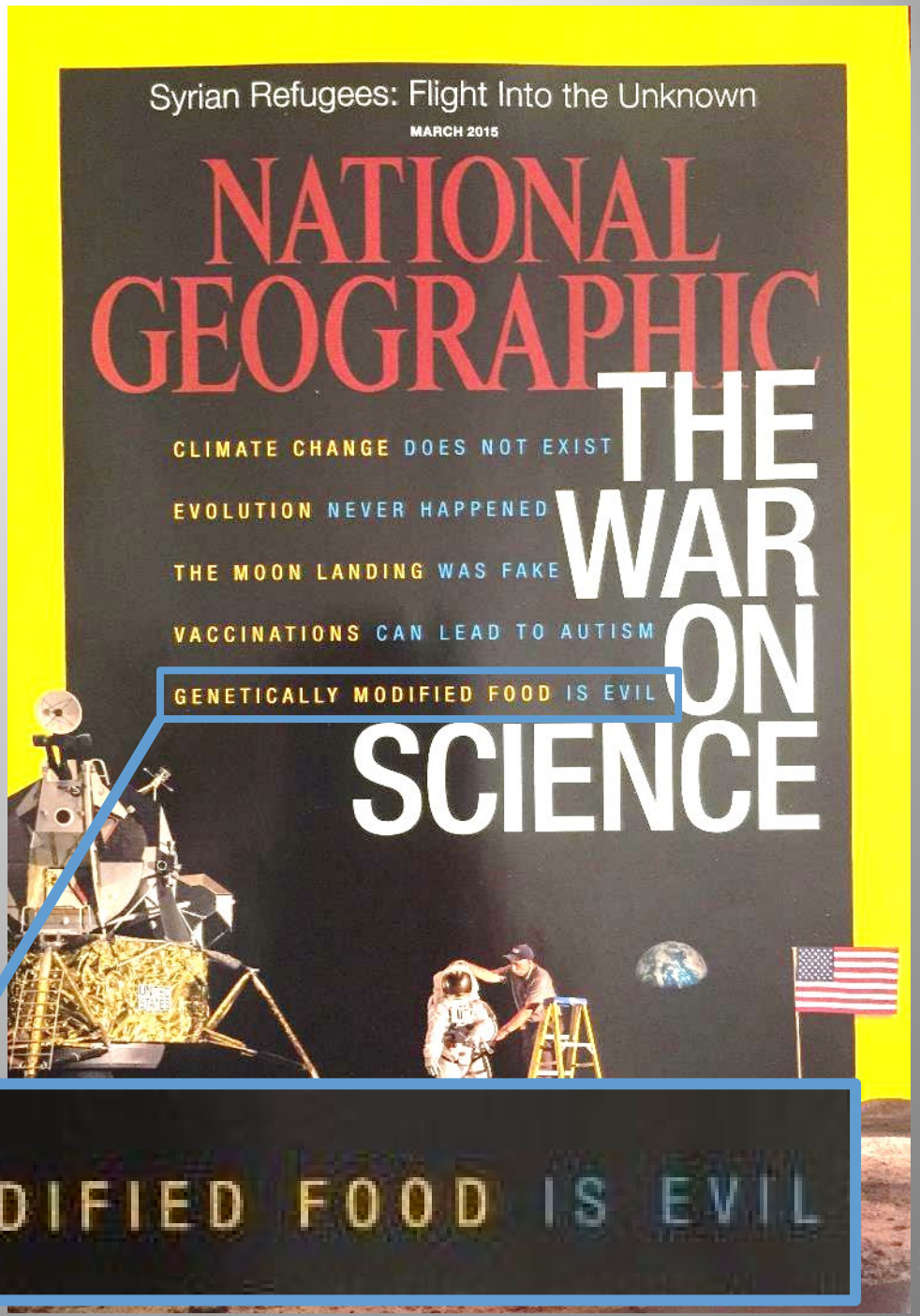
Phenomics: Lab and field scale imaging and analysis





GMOs one of the "fake news - fake science" issues

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



GENETICALLY MODIFIED FOOD IS EVIL

"GMO" has taken on a social stigma that has nothing to do with science, environment, or food safety

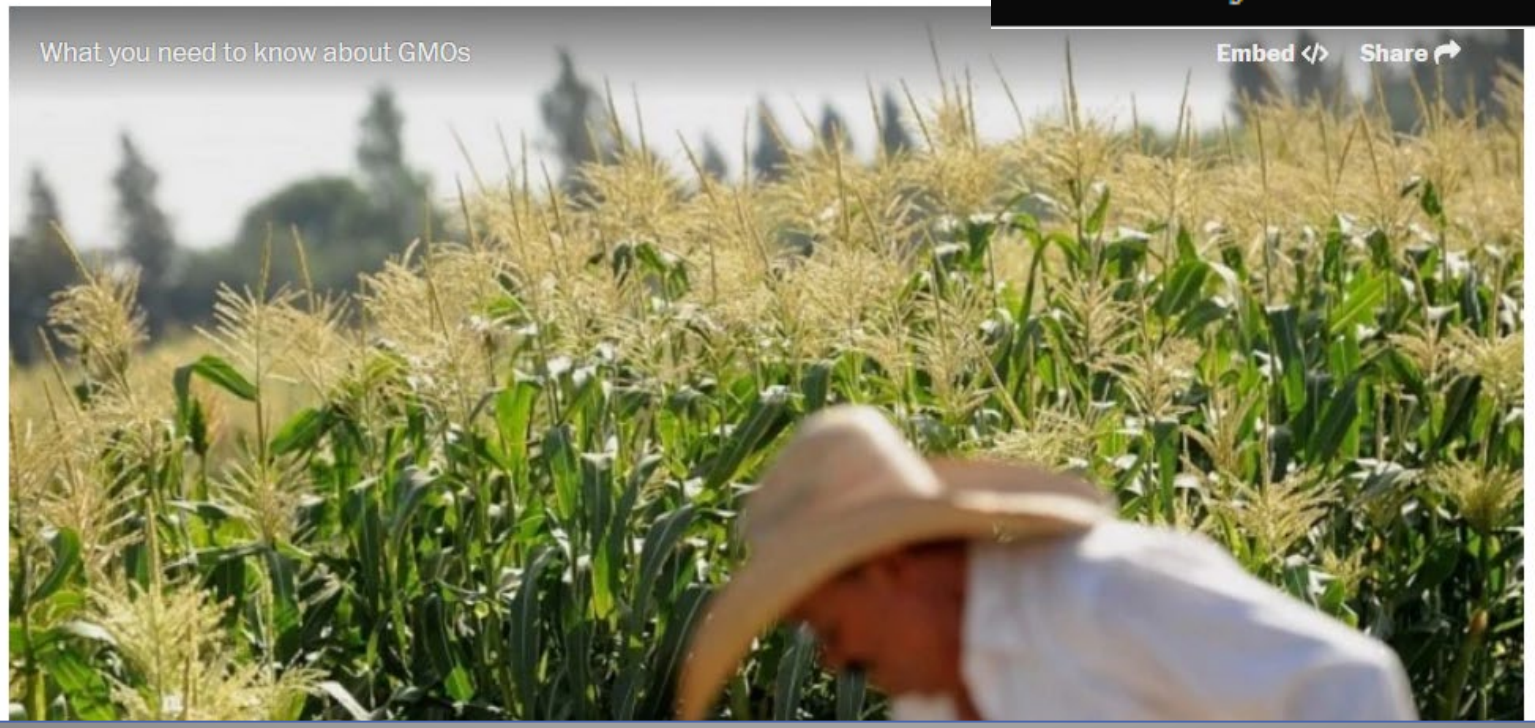
Greenpeace the environmental anti-GMO leader: Top scientists try to counter

Speaking of Science

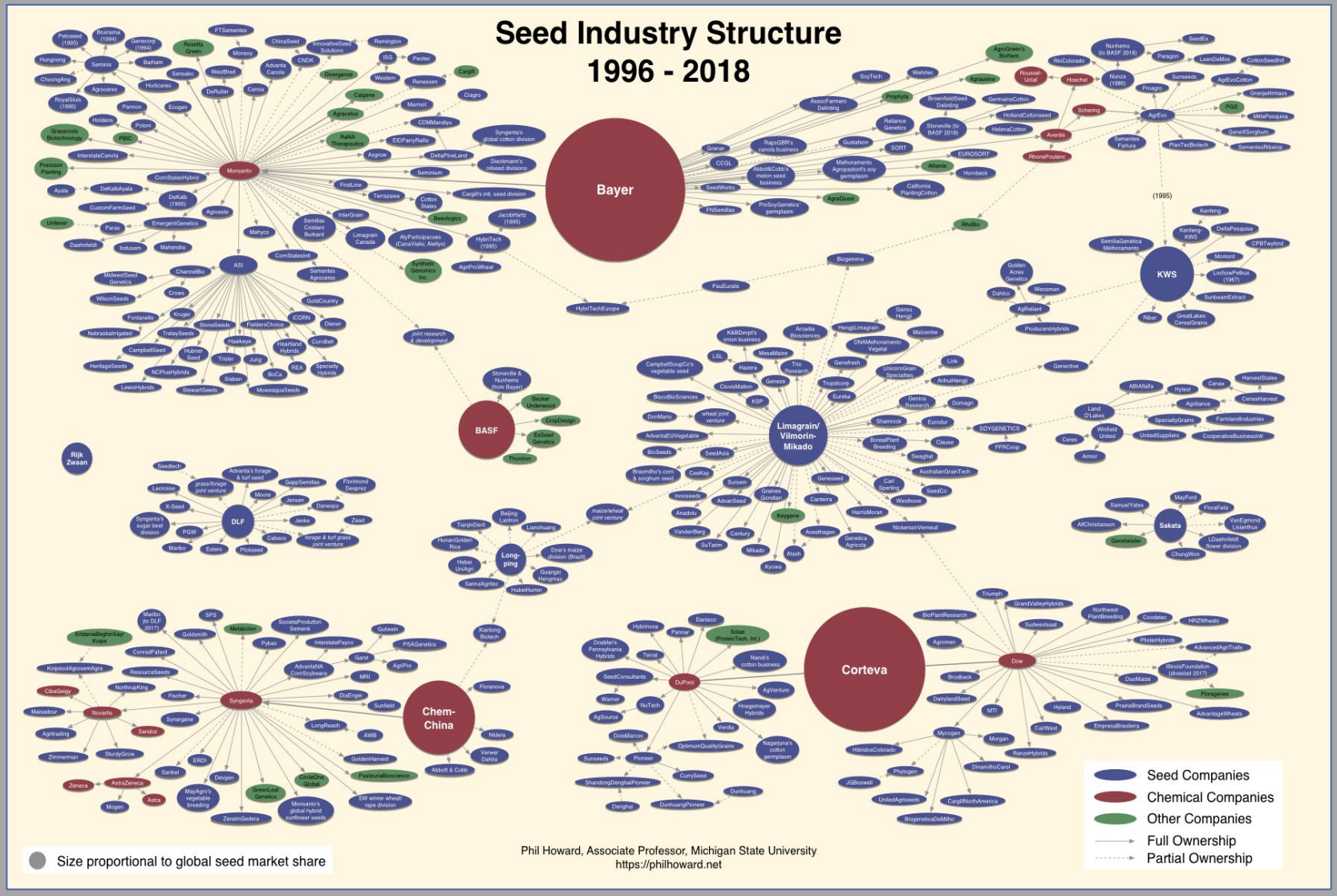
107 Nobel laureates sign letter blasting Greenpeace over GMOs

The Washington Post
Democracy Dies in Darkness

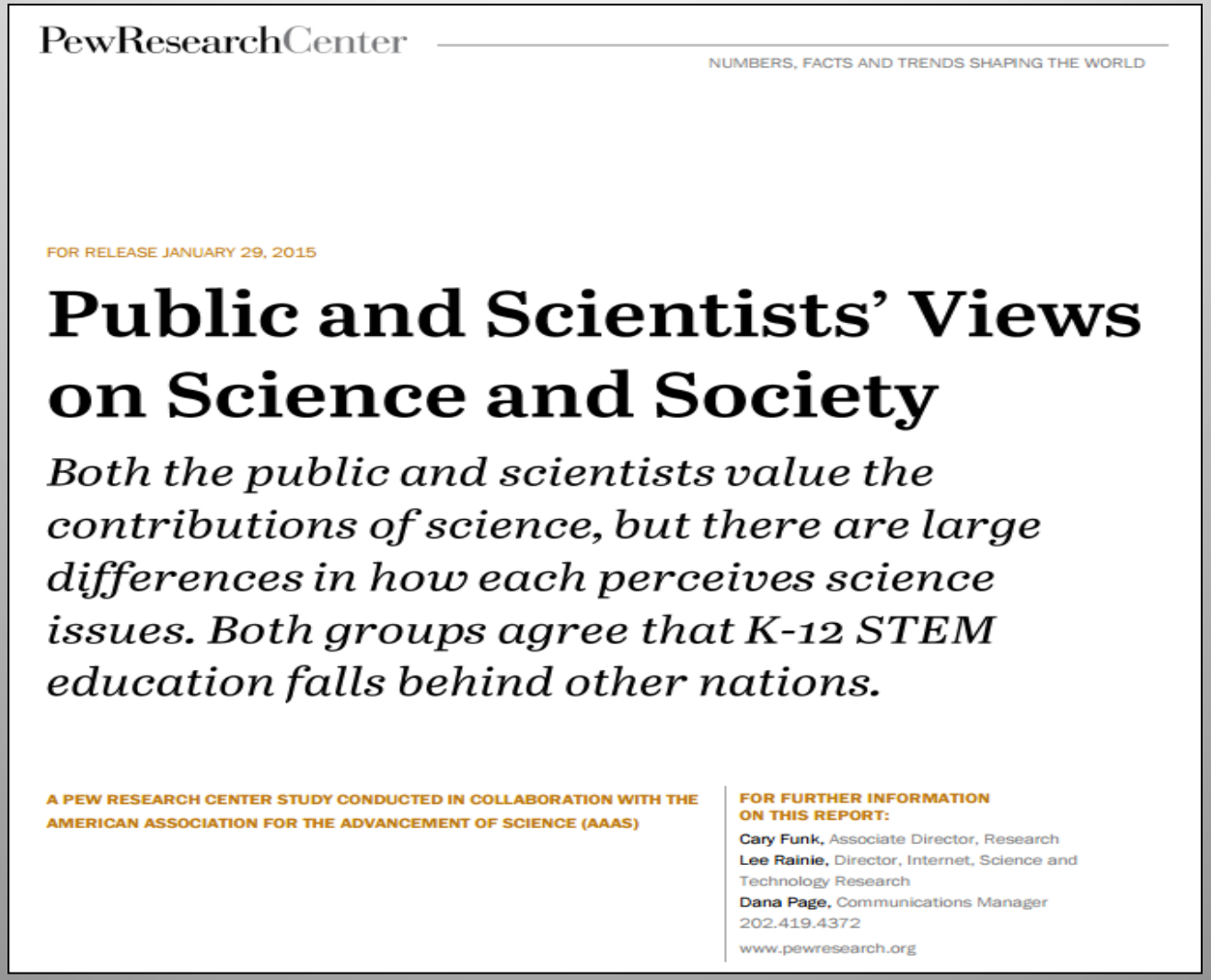
By Joel Achenbach June 30, 2016



Extensive consolidation, chemical industry control of seeds not popular



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)

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Dana Page, Communications Manager
202.419.4372
www.pewresearch.org

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

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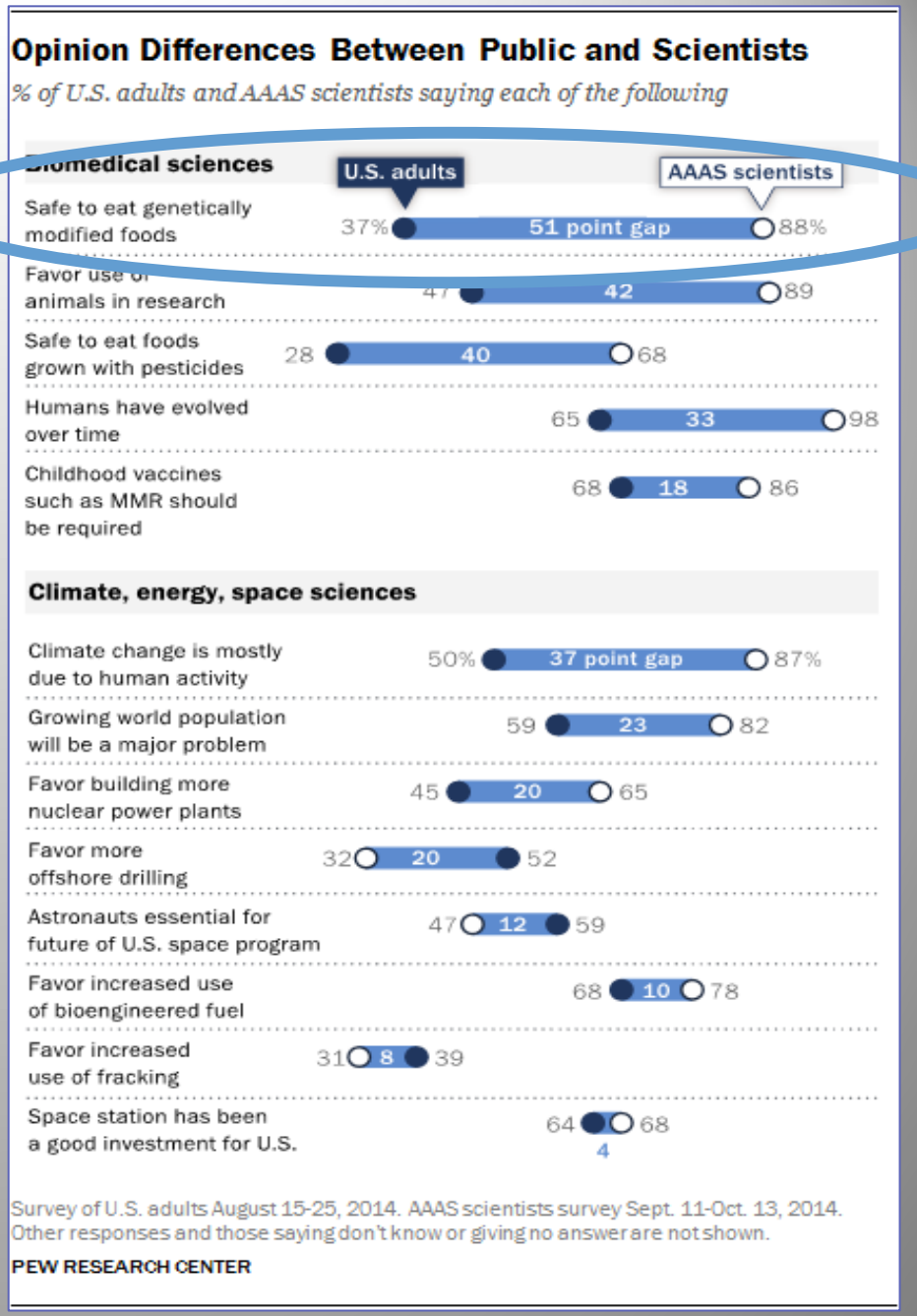
JANUARY 28, 2015

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/

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