Ten big things about GE/GMO crops and foods

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1. GE crop and food issues are messy and **extremely** controversial
There are numerous myths that are rampant and recycled in media.
And many more...

I'm no ordinary apple
I'm a genetically modified one that never rots

facebook.com/theorganicindian

TAKE A BITE
Much pseudo-science: “Half of all children will be Autistic by 2025 due to Roundup warns MIT scientist”
Food Evolution movie debunks the “data” of the extreme anti-GMO left.
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.

Scientist views contrast with public on GMOs

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

GMOs one of the “fake news - fake science” issues

It’s hard to tell what science is saying amidst all the noise
2. GE is a **diverse set of methods**, not a specific product or mode of use
Steps to create a GE plant

1. Agrobacterium method
   - Agrobacterium tumefaciens
   - Ti plasmid carrying desired genes
   - Cocultivation of Agrobacterium with plant pieces
   - DNA transferred to plant cells
   - Cell multiplication (callus)
   - Shoot regeneration followed by root regeneration
   - Plant with new trait

2. Particle gun method
   - Particles coated with DNA encoding desired genes
   - Particle gun
   - Bombardment of plant pieces with particles
   - Chromosomes with integrated DNA encoding desired genes
   - Plant cell
   - Nucleus
   - Plant with new trait
What is genetic engineering (GE)

• Direct modification of DNA
  – Vs. indirect modification in breeding
• Asexually modified, usually in somatic cells
  – Then regenerated into whole organisms, usually starting in Petri dishes
Gene editing technology for diverse traits

Science magazine names CRISPR ‘Breakthrough of the Year’

By Robert Sanders | DECEMBER 18, 2015

In its year-end issue, the journal *Science* chose the CRISPR genome-editing technology invented at UC Berkeley 2015’s Breakthrough of the Year.

A runner-up in 2012 and 2013, the technology now revolutionizing genetic research and gene therapy “broke away from the pack, revealing its true power in a series of spectacular achievements,” wrote *Science* correspondent John Travis in the Dec. 18 issue. These included “the creation of a long-sought ‘gene drive’ that could be used to eliminate diseases and unwanted species.”

Growing two-dimensional crystals | Managing biological risk | Algal train alters spatial memory | 2015 BREAKTHROUGH YEAR
Dawn of the gene-editing age

EVERYWHERE
Recombinetics creates hornless cattle – mimics a natural mutation

*Open Season Is Seen in Gene Editing of Animals*

By AMY HARMON  NOV. 26, 2015

A calf, left, approximately the same age as the first two genetically modified calves to have their DNA edited so that they do not grow horns, right. Jenn Ackerman for The New York Times
3. The most radically modified crops and foods are not GE
Where did our crops come from?

Answer: All over the world
Most crops intensively bred, prior to GMOs

Maize

Rice

Lettuce

Tomato

Banana
Mutants are some of our best friends: Domestication of wild cabbage

Wild cabbage

Kale, 500 BC

Kohlraibi
Germany, 100 AD

Ornamental kale
Late 1900's

Cabbage, 100 AD

Cauliflower
1400's

Broccoli
Italy, 1500's

Brussel sprouts
Belgium, 1700's
Breeding is continually changing varieties in response to markets, climate change, pests...

University of Kentucky wheat variety trials

OSU wheat variety trials
Oregon wheat traits of interest

- **Grain yield**
  - Yield stability
  - Broad adaptation

- **Grain quality**
  - Test weight
  - Kernel size, weight
  - Hardness

- **Stress tolerance**
  - Optimal maturity
  - Winter-hardiness
  - Straw strength
  - Drought tolerance
  - Heat tolerance

- **Disease resistance**
  - Stripe rust
  - Leaf and stem rust
  - Strawbreaker footrot
  - Cephalosporium stripe
  - Fusarium crown rot
  - Dryland footrots
  - Septoria tritici
  - Septoria nodorum
  - Mildew

- **Insect resistance**
  - Hessian fly
Sources of genes include mutation breeding

- 3,217 registered varieties developed from mutation breeding
  - FAO/IAEA database (http://www-infocris.iaea.org/MVD/)

- DNA changes include deletions, insertions, inversions

Institute of Radiation Breeding
Ibaraki-ken, JAPAN
www.irb.affrc.go.jp/
Radical changes in domesticated animals
All dogs derived from the wolf by breeding
4. GE crops have provided great value to farmers and environment, and have been taken up at an extraordinary rate (where allowed)
First generation herbicide and insect resistant crops were rapidly adopted by farmers, both in the developed and developing world.
Four crops dominate, 8+ in USA

Global Area of Biotech Crops, 1996 to 2017: By Crop (Million Hectares, Million Acres)

- Corn: 247 million acres, 94.1 million hectares
- Soybeans: 222 million acres, 90 million hectares
- Cotton: 198 million acres, 80 million hectares
- Canola: 173 million acres, 70 million hectares
- Maize: 148 million acres, 60 million hectares
- Alfalfa: 124 million acres, 50 million hectares
- Sugar Beets: 99 million acres, 40 million hectares
- Potatoes: 74 million acres, 30 million hectares
- Cabbage, Broccoli: 49 million acres, 20 million hectares
- Papaya, Blackeye Beans: 25 million acres, 10 million hectares

ISAAA, 2017
Global “meta-analysis” of early impacts

“147 original studies were included.”
“On average, GM technology adoption has reduced chemical pesticide use by 37%, increased crop yields by 22%, and increased farmer profits by 68.”
Adoption rates highly variable

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

24 countries which have adopted biotech crops

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.


<table>
<thead>
<tr>
<th>Country</th>
<th>Hectares</th>
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<td>USA</td>
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<tr>
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<td>Argentina*</td>
<td>23.6 million</td>
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<td>Costa Rica*</td>
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* Developing countries

3% Increase from 2016

ISAAA
5. Some GE crops and management practices are **not** a good idea, and very tough to manage
It is possible to transfer allergens with GE methods. Thus caution warranted. This product never developed for commercial use or marketed.
Roundup tolerant bentgrass escape in Oregon

GMO grass that 'escaped' defies eradication, divides grass seed industry

Roundup tolerant bentgrass permitted

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.

http://www.oregonlive.com/business/index.ssf/2017/01/grass_seed_industry_fearful_ab.html
Poor weed management has led to rapid development of herbicide-resistant weeds and motivated development of new kinds of herbicide tolerant crops.
Damage from growing use of dicamba resistant crops – due to chemical’s volatility
Insect resistance development

Surge in insect resistance to transgenic crops and prospects for sustainability

Bruce E Tabashnik & Yves Carrière

Transgenic crops have revolutionized insect pest control, but their effectiveness has been reduced by evolution of resistance in pests. We analyzed global monitoring data reported during the first two decades of transgenic crops, with each case representing the responses of one pest species in one country to one insecticidal protein from Bacillus thuringiensis (Bt). The cases of pest resistance to Bt crystalline (Cry) proteins produced by transgenic crops increased from 3 in 2005 to 16 in 2016. By contrast, in 17 other cases there was no decrease in pest susceptibility to Bt crops, including the recently introduced transgenic corn that produces a Bt vegetative insecticidal protein (Vip). Recessive inheritance of pest resistance has favored sustained susceptibility, but even when inheritance is not recessive, abundant refuges of non-Bt host plants have substantially delayed resistance. These insights may inform resistance management strategies to increase the durability of current and future transgenic crops.
Insect resistance has risen in parallel with crop use.
6. **Simple** answers to ag and food problems should set off alarm bells
Non-GMO labels have proliferated
GMO-free labels a major feature of “clean label” movement
Non-GMO claims on orange juice

Some Tropicana and Other PepsiCo Products to Carry Non-GMO Project Seal

By STEPHANIE STROM  DEC. 10, 2015  The New York Times
In spite of GE solutions to devastating ‘citrus greening’ threatening the industry
CRISPR-modified grapefruit resistant to citrus canker

Genome editing of the disease susceptibility gene *CsLOB1* in citrus confers resistance to citrus canker

Hongge Jia¹, Yunzeng Zhang¹, Vladimir Orbović², Jin Xu¹, Frank F. White³, Jeffrey B. Jones³ and Nian Wang¹,*
American chestnut was an iconic, widespread keystone forest tree in the USA.

It was extirpated as a forest tree by Chestnut Blight.
Complete destruction of chestnut trees in mixed stands. Note healthy condition of trees of other species. Views along Long Island Railroad, near Richmond Hill, New York.—Photograph by Prof. Collins.
Breeding has not worked despite nearly 100 years of effort – give genetic engineering a chance?
“Green” certification of forests create severe barriers to field research, markets

Genetically modified trees are prohibited...

Forest Stewardship Council

...genetically modified trees are prohibited...
The Deeply Offensive Marketing Ploy of “Clean Food”

When the commercial says that I should select clean food it makes my blood boil.
7. There is a vast variety of GE products shown in research, but only two kinds have dominated due to economic and regulatory/market obstacles.

And with rare exceptions, as a result only big ag can play.
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
“Innate” potato – native DNA, non-browning and other traits

One hour after cutting – Control vs. Innate

Two days after cutting – Control vs. Innate
“Innate 2.0” potato – late blight resistant, and reduced sprouting and browning (↓ waste, ↑ safety, ↓ pesticide, ↑ yield)
Diverse pipeline of biofortification products = enhancement of critical vitamins or nutrients

Golden Rice creator Ingo Potrykus
8. There is no credible scientific evidence GE foods have had any harms to humans or animals
• No evidence to support food/feed safety concerns
• Confirmed large insecticide reduction with Bt crops
Is GM food safe?

if an overwhelming majority of experts say something is true, then any sensible non-expert should assume that they are probably right

The American Association for the Advancement of Science is an international non-profit organization. AAAS serves some 231 affiliated societies and academies of science. “The science is quite clear: crop improvement by the modern molecular techniques of biotechnology is safe.”

The premier body of physicians in the United States. “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.”

The National Academy of Sciences is a non-profit organization in the United States. It is the premier scientific body in the United States. “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.”

England’s top medical society, the Royal Society of Medicine is an independent educational organisation for doctors, dentists, scientists and others involved in medicine and health care. “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

The World Health Organization (WHO) is the directing and coordinating authority for health within the United Nations system. “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.

The European Commission (EC) is the executive body of the European Union. “The main conclusion to be drawn from the efforts of more than 120 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 e.g. conventional plant breeding

http://www.axismundionline.com/blog/the-new-is-gm-food-safe-meme/
9. If you ask **bad questions** you will get bad answers
Are GE/GMO foods safe? Are they good for the environment?

Are we asking the \textbf{RIGHT} questions?
GE/GMO a technology with diverse outcomes, including many.....

- Genes/traits - Types of crops - Places
- Societies - Crop/Eco-systems
- Means of regulation & management

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

- “Product not process,” “case by case,” is global consensus for science assessments
10. Vilification of GE is a tool for unscrupulous or uncompetitive companies, countries, and NGOs
Non-GMO labels have proliferated
Very well funded activism against GMOs and related issues

More than 500 activist organizations in North America are spending in excess of $2 billion annually engaging in food-related campaigns targeting biotech and many other elements.

Jay Byrne, 2012, V-fluence
Leading scientists attack Greenpeace over anti-GMO activism

107 Nobel laureates sign letter blasting Greenpeace over GMOs

By Joel Achenbach  June 30, 2016
Some lessons

• GE a general technology – many uses
• Newer methods more precise, very powerful (RNAi, CRISPR)
• No credible evidence for human safety harms
• Extensive uptake, large benefits, also significant problems in management
• Regulatory and market restrictions greatly limit GE crop use and benefit for society, both in USA and around the globe – despite stresses from climate change, pest proliferation, and growing human need