5 big takeaways from the most thorough review of GMOs yet

This week, the National Academies of Sciences released **the most thorough review yet** of genetically modified crops — a hulking 420-page report. It's an independent look at all the research on GMOs to date, vetted for conflicts of interest. I'll start with a quick, crude summary and then dive into the nuances of what the expert committee found.

The crude summary goes like so: Despite all the controversy, the GM crops available to date — mostly a few crops engineered to be resistant to herbicides or to pests — are considered just as safe to eat as conventional crops. These crops have proved an economic boon to many farmers, although they haven't led to a huge surge in yields. Current GM crops seem mostly fine for the environment, with insect-resistant varieties allowing farmers to use fewer chemical pesticides. That said, there's a danger that over-spraying of herbicide-resistant crops has given rise to herbicide-resistant weeds.

If you just want a bite-size assessment of present-day GM crops, that will likely do. But if you plunge deeper into the report, you'll find a whole bunch of asterisks and caveats to all the sentences above.

For one, it's hard to make many sweeping, definitive statements about GM crops because there *isn't* any one single "GM crop." Different crops can be modified for different purposes and uses around the world. A big farm planting herbicide-tolerant

GM corn in Iowa doesn't have much in common with a smallholder growing pest-resistant GM cotton in India:

*(**National Academies of Sciences, "Genetically Engineered Crops: Experiences and Prospects"**)*

Type and location of commercially grown genetically engineered crops in 2015. In 2015, almost 180 million hectares of GE crops were planted globally. More than 70 million hectares were planted in the United States.

Second, genetic engineering tools themselves are changing rapidly — and so is the definition of what actually counts as a "GMO." That will make it even tougher to generalize going forward.

For decades, when people talked about "genetic modification," they typically meant the practice of transplanting genes from other plants or organisms into a target crop in order to give it a desired trait. For example, scientists have taken DNA from Bt soil bacteria, which produces an organic pesticide, and put it into corn or cotton, enabling the crop to ward off pests like rootworm. That's a "GMO," and it's long been deemed categorically distinct from crops whose genes are altered via "conventional" breeding.

But, as the report makes clear, transferring genes is just the tip of the ~~iceberg~~ corncob. Advanced gene-editing tools like **CRISPR/Cas-9** will soon allow even more precise tweaking of plant genomes, giving scientists power to make creative modifications — wheat better able to withstand drought, say, or more nutritious vegetables. What's more, many new techniques will blur the line between "conventional" and "genetically engineered" food. And our regulations have yet to catch up.

There's a ton to unpack in the report, so let's go through the big points one by one:

1) The best evidence suggests current GM crops are just as safe to eat as regular crops

(Shutterstock)

There be GMOs in this aisle! (No, really, basically anything with high-fructose corn syrup probably has GMO corn.)

It's tough to definitively establish the safety of *any* food product — whether it's GM or not. There always might be lurking unknowns or long-term health effects that have yet to be detected. But scientists have been studying GM foods for decades now, and so far they haven't seen any evidence of adverse health effects in people or animals.

Ever since the first GM crops hit the market in the 1990s, billions of people worldwide have been consuming GM ingredients — largely corn, soy, and canola — without any noticeable problems. Scientists haven't found any upticks in obesity or cancer or gastrointestinal illnesses or allergies that could plausibly be correlated with the introduction of GM foods anywhere in the world.

This has been corroborated by animal studies, which, while imperfect, have found no particular dangers from eating GM foods. (There are signs that animals on GM diets show "small perturbations" in their gut microbes, but nothing that's expected to cause health problems in humans.) Nor is there reason to think GM crops could pose a health risk by "transferring" their modified genes to animals or humans.

The committee does caution that modifying the DNA of plants could conceivably introduce new allergens into our foods that are difficult to test for — though, again, we haven't seen any broad upticks in allergies among people eating GM crops. (In any case, allergens are **also a risk for traditional foods**, particularly imported foods that receive less screening.)

That's why the report ultimately concludes that "no differences have been found that implicate a higher risk to human health and safety from [current] GE foods than from their non-GE counterparts."

2) Current GM crops have proven valuable to many farmers — but context matters

(Scott Olson/Getty Images)

A cotton field waits to be harvested on BTC farm near Clarksdale, Mississippi. Of 1,000 acres, 80 percent is genetically modified (GM) Bt, Roundup Ready cotton. Regulators mandate that at least 20 percent of acreage is planted with conventional cotton to help prevent insects from developing an immunity.

Asking whether GM crops are "good for farmers" is a broad question. Often we have to specify: Which crops? Which farmers?

The vast, vast majority of GM crops on the market today are corn, soy, canola, and cotton crops that have been modified to be resistant to either certain insects or certain herbicides (or both). These varieties are typically owned and sold by major seed companies — usually the only ones that can afford to jump through the strict regulatory hoops governments have set up for GMOs. (More on that later.)

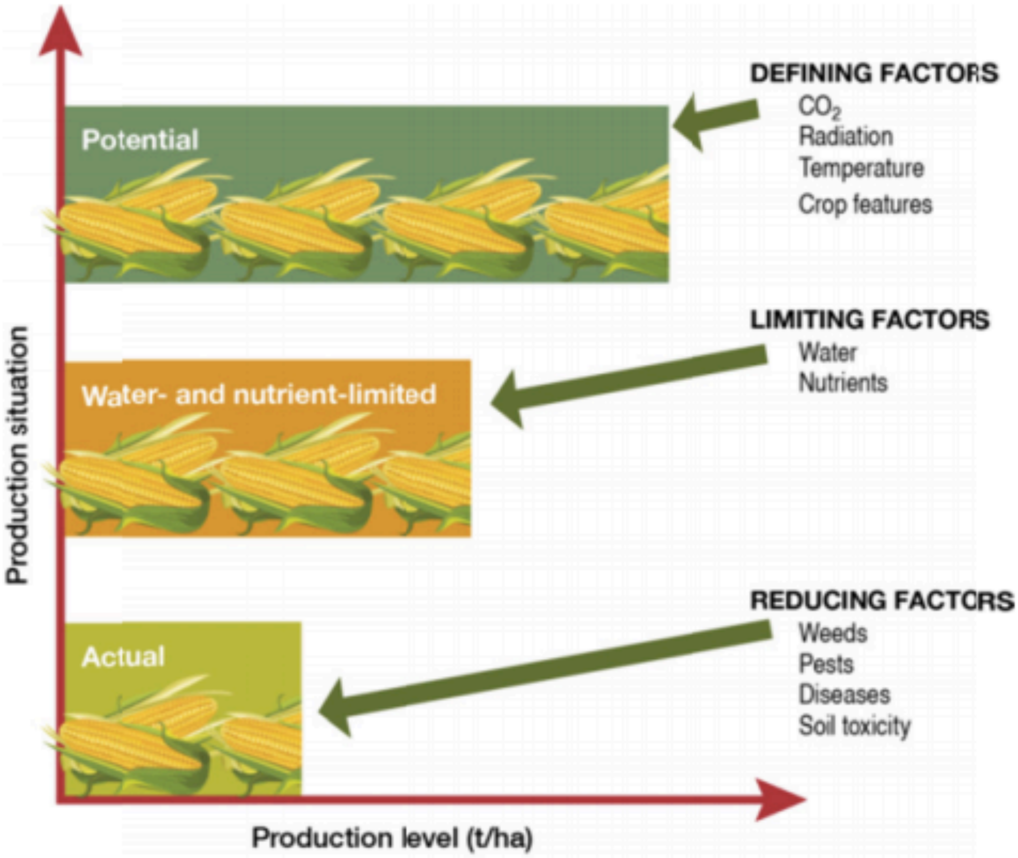
There's evidence that these particular GM crops have been quite valuable to farmers in many places, from the United States to Europe to India. Crops modified to be resistant to insects, like Bt corn, have demonstrably reduced losses from pests. Crops engineered to be herbicide-tolerant make it easier to spray for weeds, giving farmers more time to secure off-farm income.

But situations can vary across regions. Small-scale farmers in lower-income countries can't always afford the high price of GM seeds (or face financial risk when buying them). Variations in GM crop regulations among different countries may lead to hard-to-predict trade disruptions. And there's endless debate over how different systems for patenting GM seeds benefits and hurts different types of farmers. As with any technology you can name, there are winners and losers.

3) Beware of simplistic arguments over whether GM crops can "feed the world"

Advocates of GM crops **have sometimes claimed** there is no way we'll be able to feed the world without the technology, especially with the Earth's population set to soar past 9 billion. So the committee delved into the question of whether GM crops actually provide higher yields — that is, the amount of food produced per acre.

The report starts by making a distinction between *potential* yield (how much food a crop can theoretically produce under ideal conditions) and *actual* yield (what's left after weeds, pests, diseases, and so forth):



(*[National Academies of Sciences, Genetically Engineered Crops: Experiences and Prospects]*)

Factors that determine crop yield.

There's little evidence that current GM crops have greatly boosted *potential* yields. In fact, conventional plant-breeding techniques appear to be more successful on this score to date. On the other hand, some insect-resistant GM traits appear to have helped increase *actual* yield for certain crops by minimizing pest losses in places like India or the United States. So it's a mixed bag.

In the future, new genetic modifications might conceivably do more to boost potential yields for certain crops by, for instance, improving photosynthesis or increasing the nutrient uptake of plants. But the report cautions that it's way too early to predict success, so we should be wary any overconfident claims.

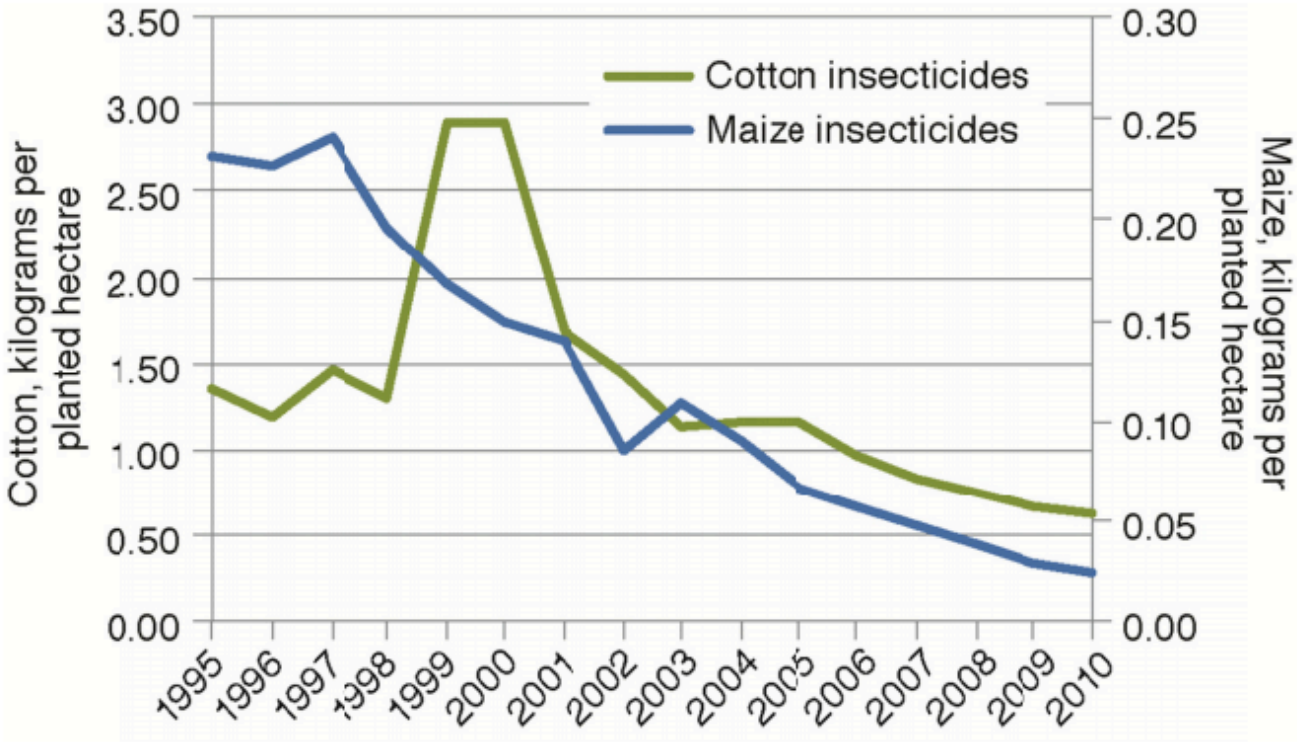
The committee also warns that even if future GM technology *can* help increase crop yields, it will still only be one tool among many for feeding the world: "Such issues as soil fertility, integrated pest management, market development, storage, and extension services will all need to be addressed to improve crop productivity, decrease post-harvest losses, and increase food security."

4) Some GM crops have had positive environmental effects — but watch out for "superweeds"

(Ian Waldie/Getty Images)

One of the more complicated questions around GM crops is how they affect the environment. (If you guessed "it depends," you've been following along.)

Some GM crops do offer clear ecological benefits. Cotton that's engineered to be pest-resistant has allowed farmers to use fewer chemical pesticides. Likewise, the use of Bt corn — which is modified to produce a naturally occurring pesticide — has allowed US farmers to use fewer chemicals in their fields. Wild insect biodiversity has increased as a result:



(*National Academies of Sciences, "Genetically Engineered Crops: Experience and Prospects"*)

Rates of insecticide application on cotton and maize from 1995 to 2010.

It's a murkier story when we consider herbicide tolerance. Many crops like soy, corn, cotton, and canola are now genetically modified to be resistant to the chemical glyphosate (also known as Roundup), letting farmers spray their fields more easily to kill the weeds while protecting the crops. That has led to an increase in herbicide use in the United States. But it's unclear how bad that actually is: Glyphosate is less toxic than some of its predecessors, and this increased spraying hasn't led to a decrease in wild plant diversity around many farms.

The report does warn, however, that GM technology can have serious adverse effects when used improperly. Farmers who plant herbicide-resistant crops sometimes use a limited range of herbicides on their fields, which can give rise to **herbicide-resistant "superweeds."** Those are becoming a serious (and costly) problem in places. Similarly, overplanting of Bt corn or cotton can help create resistant insects. In both cases, proper management (planting a mix of GM and non-GM crops) is essential.

Then there are the unknowns: There's still disagreement about whether glyphosate spraying **has negatively affected monarch butterfly populations** in North America. Likewise, the rise of GM crops in the US has been accompanied by a decline in crop diversity and crop rotations (not good!) but also **a rise in no-till farming**, which reduces soil erosion (quite good!). In both cases, the committee couldn't find a clear causal link to GM crops.

Finally, there have been cases in which GM crops like canola have escaped into the wild; and sometimes GM crops like herbicide-resistant alfalfa have transferred modified traits to wild relatives. But, the report notes, so far there is no evidence that this "gene flow" has had harmful ecological impacts.*

In the end, there's little to suggest that current GM crops pose inherently greater environmental risks than conventional crops. But analyzing the effects of new products and farming practices on complex ecosystems is notoriously difficult, and future GM crops could well have unexpected impacts. New drought-tolerant crops, for instance, might radically improve sustainability — or they could lead to expanded farming into fragile new ecosystems. We'll have to watch closely.

5) Genetic engineering is changing radically — and regulations need to adjust

(Shutterstock)

Things are getting wild.

The report does argue that regulations will continue to be necessary for GM crops. Just because most current GM varieties are benign doesn't mean every single future GM crop will be, too. Remember, you can't generalize!

The real question, then, is *how* we should regulate. And there's reason to think our current regulations are becoming badly outdated.

Ever since the 1980s, "genetic engineering" has usually entailed a handful of specific laboratory techniques (such as using agrobacterium to transfer genes from other plants or organisms into a crop). Regulations in the United States and elsewhere **evolved to focus explicitly** on these particular methods.

But molecular biology has advanced substantially in the past few decades, and new gene-editing techniques, such as **CRISPR/Cas9**, will soon expand the boundaries of what we consider "genetic engineering." (CRISPR **allows** researchers to edit, cut out, and replace genes in any animal more quickly and efficiently than anything that's come before.)

These new tools might one day allow us to develop crops that better tolerate heat and drought, or are more nutritious, or are more efficient at photosynthesis. But our currently regulatory regime doesn't really cover these techniques. They weren't around in the '80s.

Making things more complicated: Many new tools will increasingly make nonsense of our current regulatory distinctions between "genetically engineered" crops and "conventionally bred" crops. Some methods considered "conventional" under current rules can involve complex gene sequencing, or things like using radiation to induce mutations. It's not clear that this is inherently "safer" than genetic engineering.

So, as an alternative, the committee argues that regulations probably shouldn't focus on specific plant-modification *techniques*. Instead, we should regulate crops based on the size and novelty of the changes being made — regardless of how it's actually done. Here's the key passage:

> Emerging genetic technologies have blurred the distinction between genetic engineering and conventional plant breeding to the point where regulatory systems based on process are technically difficult to defend.
>
> The committee recommends that new varieties—whether genetically engineered or conventionally bred—be subjected to safety testing if they have novel intended or unintended characteristics with potential hazards. It proposes a tiered approach to regulation that is based in part on new -omics technologies that will be able to compare the molecular profiles of a new variety and a counterpart already in widespread use

This is typically known as regulating plant *products* rather than *processes*, and the details get awfully complex. But that's the basic framework. (And it's how Canada does things.) Some crops we'd consider GM today might get regulated more lightly under this new system if they simply involve traits we already know to be safe. By contrast, some "conventionally" bred plants may get closer scrutiny if they have really novel traits that could pose hazards.

The committee also has plenty to say about policy issues like GMO labeling and seed patents. There are no firm recommendations except to say that any rules should balance the potentially large benefits of GM crops with the potential risks. And increasing public trust in the broader regulatory process is utterly crucial. (Some GMO advocates **have even favored labeling** for this exact reason — to alleviate consumer unease.)

Finally, the committee points out that a lot of key issues around GM crops aren't purely scientific questions. Scientists should certainly lend their expertise to these discussions, but they aren't the only ones who can weigh in. "Policy regarding GE crops has scientific, legal, and social dimensions," the report concludes, "and not all issues can be answered by science alone."

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* *Correction:* I originally noted that there have been instances of GM sunflowers transferring their BT traits to non-GM relatives. I should have clarified that this was shown in a controlled lab study — not in the wild.

Further reading:

- Seriously, anyone interested in GM crops should read the full National Academies of Sciences **report**. It's long, but quite accessible. Plus, I've almost certainly oversimplified parts. (It's inevitable, sorry!)
- Here's some **expert commentary** on the NAS report.
- Nathanael Johnson **once wrote a terrific piece** on how it's practically impossible to define "GMOs." That really speaks to some of the perils of making sweeping statements about the technology.
- Two old articles on the (complex and technical) debate over how to better regulate GM crops from **Henry Miller and Drew Kershen** and **Jennifer Kuzma**.