

What's Eating America

Corn is one of the plant kingdom's biggest successes. That's not necessarily good for the United States.

BY MICHAEL POLLAN

DESCENDANTS of the Maya living in Mexico still sometimes refer to themselves as “the corn people.” The phrase is not intended as metaphor. Rather, it's meant to acknowledge their abiding dependence on this miraculous grass, the staple of their diet for almost 9,000 years.

For an American like me, growing up linked to a very different food chain, yet one that is also rooted in corn, *not* to think of himself as a corn person suggests either a failure of imagination or a triumph of capitalism.

Or perhaps a little of both. For the great edifice of variety and choice that is an American supermarket rests on a remarkably narrow biological foundation: corn. It's not merely the feed that the steers and the chickens and the pigs and the turkeys ate; it's not just the source of the flour and the oil and the leavenings, the glycerides and coloring in the processed foods; it's not just sweetening the soft drinks or lending a shine to the magazine cover over by the checkout. The supermarket itself – the wallboard and joint compound, the linoleum and fiberglass and adhesives out of which the building itself has been built – is in no small measure a manifestation of corn.

There are some 45,000 items in the average American supermarket, and more than a quarter of them contain corn. At the same time, the food industry has done a good job of persuading us that the 45,000 different items or SKU5 (stock keeping units) represent genuine variety rather than the clever rearrangements of molecules extracted from the same plant.

How this peculiar grass, native to Central America and unknown to the Old World before 1492, came to colonize so much of our land and bodies is one of the plant world's greatest success stories. I say the *plant* world's success story because it is no longer clear that corn's triumph is such a boon to the rest of the world.

AT ITS MOST BASIC, the story of life on earth is the competition among species to capture and store as much energy as possible – either directly from the sun, in the case of plants, or, in the case of animals, by eating plants and plant eaters. The energy is stored in the form of carbon molecules and measured in calories: the calories we eat, whether in an ear of corn or a steak, represent packets of energy once captured by a plant. Few plants can manufacture quite as much organic matter (and calories) from the same quantities of sunlight and water and basic elements as corn.

The great turning point in the modern history of corn, which in turn marks a key turning point in the industrialization of our food, can be dated with some precision to the day in 1947 when the huge munitions plant at Muscle Shoals, Alabama, switched over from making explosives to making chemical fertilizer. After World War II, the government had found itself with a tremendous surplus of ammonium nitrate, the principal ingredient in the making of explosives. Ammonium nitrate also happens to be an excellent source of nitrogen for plants. Serious thought was given to spraying America's forests with the surplus chemical, to help the timber industry. But agronomists in the Department of

Agriculture had a better idea: spread the ammonium nitrate on farmland as fertilizer. The chemical fertilizer industry (along with that of pesticides, which are based on the poison gases developed for war) is the product of the government's effort to convert its war machine to peacetime purposes. As the Indian farmer activist Vandana Shiva says in her speeches, "We're still eating the leftovers of World War II."

F₁ hybrid corn is the greediest of plants, consuming more fertilizer than any other crop. Though F₁ hybrids were introduced in the 1930s, it wasn't until they made the acquaintance of chemical fertilizers in the 1950s that corn yields exploded. The discovery of synthetic nitrogen changed everything – not just for the corn plant and the farm, not just for the food system, but also for the way life on earth is conducted.

All life depends on nitrogen; it is the building block from which nature assembles amino acids, proteins and nucleic acid; the genetic information that orders and perpetuates life is written in nitrogen ink. But the supply of usable nitrogen on earth is limited. Although earth's atmosphere is about 80 percent nitrogen, all those atoms are tightly paired, nonreactive and therefore useless; the 19th-century chemist Justus von Liebig spoke of atmospheric nitrogen's "indifference to all other substances." To be of any value to plants and animals, these self-involved nitrogen atoms must be split and then joined to atoms of hydrogen.

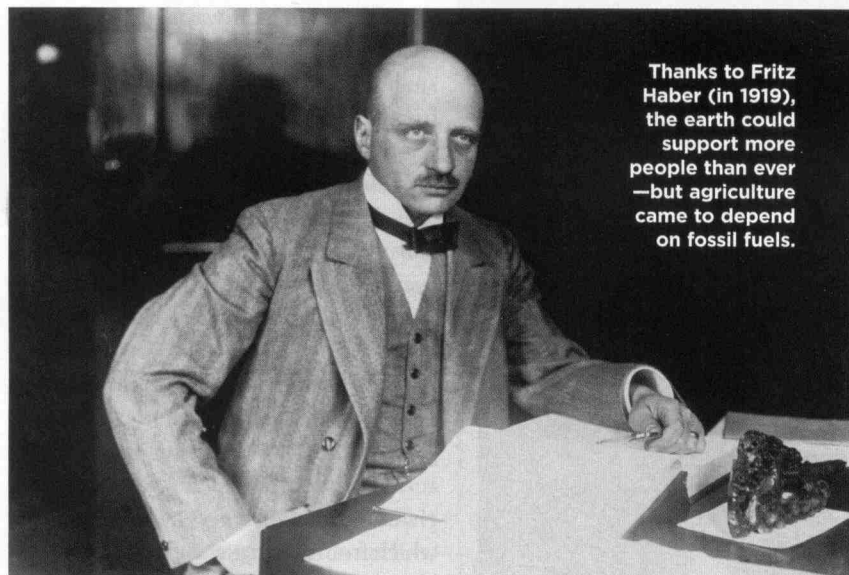
Chemists call this process of taking atoms from the atmosphere and combining them into molecules useful to living things "fixing" that element. Until a German Jewish chemist named Fritz Haber figured out how to turn this trick in 1909, all the usable nitrogen on earth had at one time been fixed by soil bacteria living on the roots of leguminous plants (such as peas or alfalfa or locust trees) or, less commonly, by the shock of electrical lightning, which can break nitrogen bonds in the air, releasing a light rain of fertility.

In his book *Enriching the Earth: Fritz Haber, Carl Bosch and the Transformation of World Food Production*, Vaclav Smil pointed out that "there is no way to grow crops and human bodies without nitrogen." Before Haber's invention, the sheer amount of life earth could support – the size of crops and therefore the number of human bodies – was limited by the amount of nitrogen that bacteria and lightning could fix. By 1900, European scientists had recognized that unless a way was found to augment this naturally occurring nitrogen, the growth of the human population would soon grind to a very painful halt. The same recognition by Chinese scientists a few decades later is probably what compelled China's opening to the West: after Nixon's 1972 trip, the first major order the Chinese government placed was for 13 massive fertilizer factories. 'Without them, China would have starved.

This is why it may not be hyperbole to claim, as Smil does, that the Haber-Bosch process for fixing nitrogen (Bosch gets the credit for commercializing Haber's idea) is the most important invention of the 20th century. He estimates that two of every five humans on earth today would not be alive if not for Fritz Haber's invention. We can easily imagine a world without computers or electricity, Smil points out, but without synthetic fertilizer billions of people would never have been born. Though, as these numbers suggest, humans may have struck a Faustian bargain with nature when Fritz Haber gave us the power to fix nitrogen.

FRITZ HABER? No, I'd never heard of him either, even though he was awarded the Nobel Prize in 1918 for "improving the standards of agriculture and the wellbeing of mankind." But the reason for his obscurity has less to do with the importance of his work than an ugly twist of his biography, which

recalls the dubious links between modern warfare and industrial agriculture: during World War I, Haber threw himself into the German war effort, and his chemistry kept alive Germany's hopes for victory by allowing it to make bombs from synthetic nitrate. Later, Haber put his genius for chemistry to work developing poison gases – ammonia, then chlorine. (He subsequently developed Zyklon B, the gas used in Hitler's concentration camps.) His wife, a chemist sickened by her husband's contribution to the war effort, used his army pistol to kill herself; Haber died, broken and in flight from Nazi Germany, in a Basel hotel room in 1934.



His story has been all but written out of the 20th century. But it embodies the paradoxes of science, the double edge to our manipulations of nature, the good and evil that can flow not only from the same man but from the same knowledge. Even Haber's agricultural benefaction has proved to be a decidedly mixed blessing.

When humankind acquired the power to *fix* nitrogen, the basis of soil fertility shifted from a total reliance on the energy of the sun to a new reliance on fossil fuel. That's because the Haber-Bosch process works by combining nitrogen and hydrogen gases under immense heat and pressure in the presence of a catalyst. The heat and pressure are supplied by prodigious amounts of electricity, and the hydrogen is supplied by oil, coal or, most commonly today, natural gas. True, these fossil fuels were created by the sun, billions of years ago, but they are not renewable in the same way that the fertility created by a legume nourished by sunlight is. (That nitrogen is fixed by a bacterium living on the roots of the legume, which trades a tiny drip of sugar for the nitrogen the plant needs.)

Liberated from the old biological constraints, the farm could now be managed on industrial principles, as a factory transforming inputs of raw material – chemical fertilizer – into outputs of corn. And corn adapted brilliantly to the new industrial regime, consuming prodigious quantities of fossil fuel energy and turning out ever more prodigious quantities of food energy. Growing corn, which from a biological perspective had always been a process of capturing sunlight to turn it into food, has in no small measure become a process of converting fossil fuels into food. More than half of all the synthetic nitrogen made today is applied to corn.

From the standpoint of industrial efficiency, it's too bad we can't simply drink petroleum directly, because there's a lot less energy in a bushel of corn (measured in calories) than there is in the half-

gallon of oil required to produce it. Ecologically, this is a fabulously expensive way to produce food – but “ecologically” is no longer the operative standard. In the factory time is money, and yield is everything.

One problem with factories, as opposed to biological systems, is that they tend to pollute. Hungry for fossil fuel as hybrid corn is, farmers still feed it far more than it can possibly eat, wasting most of the fertilizer they buy. And what happens to that synthetic nitrogen the plants don't take up? Some of it evaporates into the air, where it acidifies the rain and contributes to global warming. Some seeps down to the water table, whence it may come out of the tap. The nitrates in water bind to hemoglobin, compromising the blood's ability to carry oxygen to the brain. (I guess I was wrong to suggest we don't sip fossil fuels directly; sometimes we do.)

It has been less than a century since Fritz Haber's invention, yet already it has changed earth's ecology. More than half of the world's supply of usable nitrogen is now man-made. (Unless you grew up on organic food, most of the kilo or so of nitrogen in your body was fixed by the Haber-Bosch process.) “We have perturbed the global nitrogen cycle,” Smil wrote, “more than any other, even carbon.” The effects may be harder to predict than the effects of the global warming caused by our disturbance of the carbon cycle, but they are no less momentous.

The flood of synthetic nitrogen has fertilized not just the farm fields but the forests and oceans, too, to the benefit of some species (corn and algae being two of the biggest beneficiaries) and to the detriment of countless others. The ultimate fate of the nitrates spread in Iowa or Indiana is to flow down the Mississippi into the Gulf of Mexico, where their deadly fertility poisons the marine ecosystem. The nitrogen tide stimulates the wild growth of algae, and the algae smother the fish, creating a “hypoxic,” or dead, zone as big as New Jersey – and still growing. By fertilizing the world, we alter the planet's composition of species and shrink its biodiversity.

And yet, as organic farmers (who don't use synthetic fertilizer) prove every day, the sun still shines, plants and their bacterial associates still fix nitrogen, and farm animals still produce vast quantities of nitrogen in their “waste,” so-called. It may take more work, but it's entirely possible to nourish the soil, and ourselves, without dumping so much nitrogen into the environment. The key to reducing our dependence on synthetic nitrogen is to build a more diversified agriculture – rotating crops and using animals to recycle nutrients on farms – and give up our vast, nitrogen-guzzling monocultures of corn. Especially as the price of fossil fuels climbs, even the world's most industrialized farmers will need to take a second look at how nature, and those who imitate her, go about creating fertility without diminishing our world.

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