

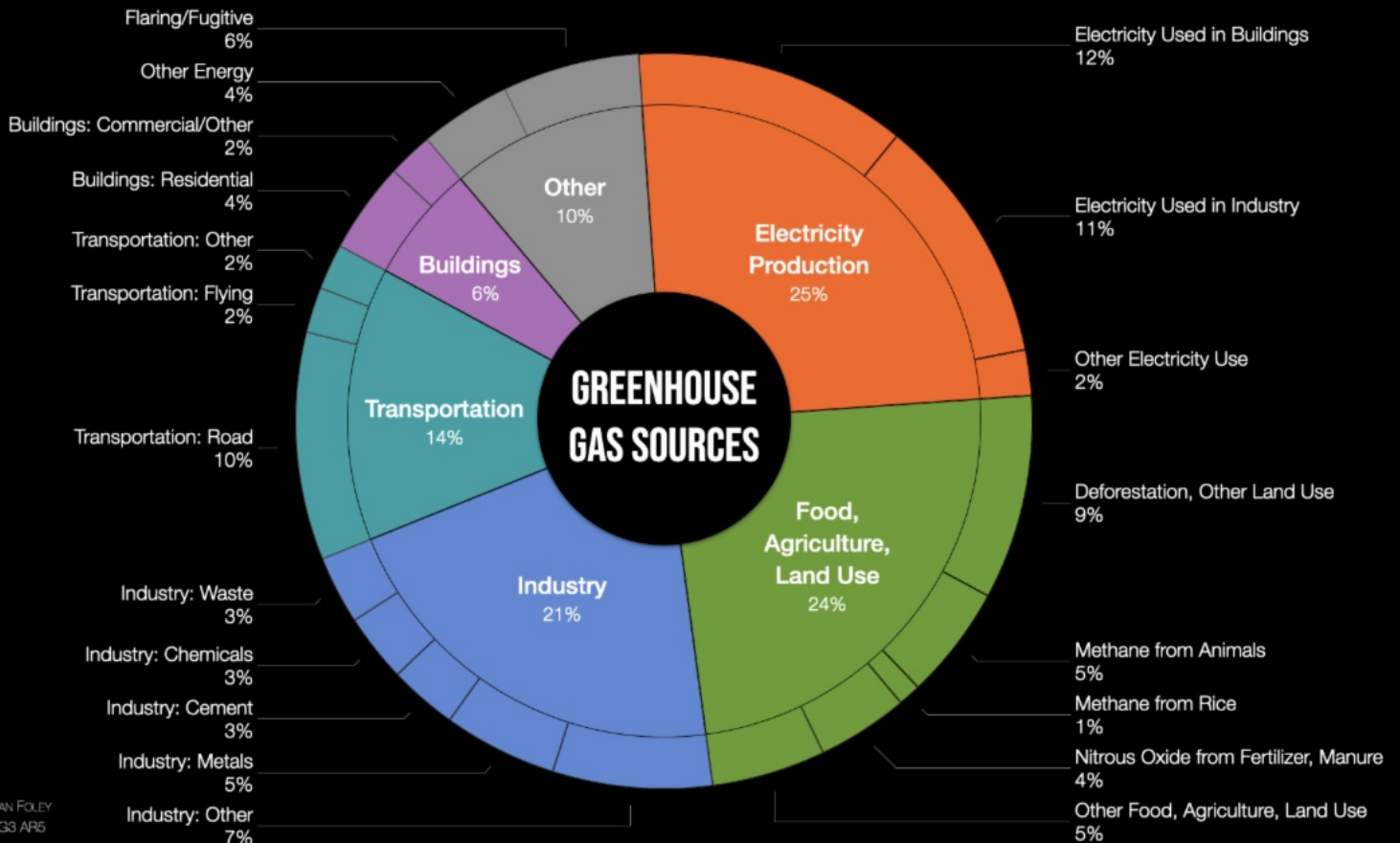


Dispatches From The Wild, Weird World Of Humanity And Its Biosphere

July 28 2021



The Weekly Anthropocene Special Report: Ethical Eating and the Future of Food



The world food system is one of humanity's greatest accomplishments. [Famines](#),

once a recurring theme of human life, are now rare and almost always due to war, not just a bad harvest year. Thanks to the work of a wide range of scientists in the 20th century ([Norman Borlaug](#) among the most impactful, with the fertilizer-making [Haber-Bosch process](#) another key factor), the number of people chronically hungry worldwide has declined-not just in relative terms, in absolute number of people-even as the human population grew rapidly.

However, all of this comes with a cost. [As climate scientist Dr. Jonathan Foley summarizes](#), the world food system is doing an amazing job at keeping billions of people alive, but it's also perhaps the single most destructive aspect of human civilization. Agricultural land covers **37% of Earth's ice-free land surface** (and half of the world's both ice- and desert-free land) having swallowed countless grassland and forest ecosystems to convert to rangeland and cropland. Notably, **about 75% of all that agricultural land is devoted to raising livestock animals and growing plants to feed livestock**, rather than growing plants to feed humans-this will become important later. Agriculture is also responsible for **close to 85% of humanity's consumptive water use** (withdrawing freshwater and not returning it to the same watershed), and the **largest source of water pollution**-mostly due to nitrogen-rich fertilizer runoff, which causes eutrophication and massive [dead zones](#). Furthermore, unbelievably, [94 of all mammal biomass \(excluding humans\) is livestock](#): cows, pigs, sheep and their ilk outweigh all wild mammals by 15 to 1. Perhaps most importantly of all, agriculture and land use change contributes about **24% of all of humanity's greenhouse gas emissions** ([see graphic above, with data from the IPCC Fifth Assessment Report](#)), about the same amount as all electricity generation, making it a major cause of the climate crisis.

Food: greenhouse gas emissions across the supply chain



Land Use Change Aboveground changes in biomass from deforestation, and belowground changes in soil carbon

Farm Methane emissions from cows, methane from rice, emissions from fertilizers, manure, and farm machinery

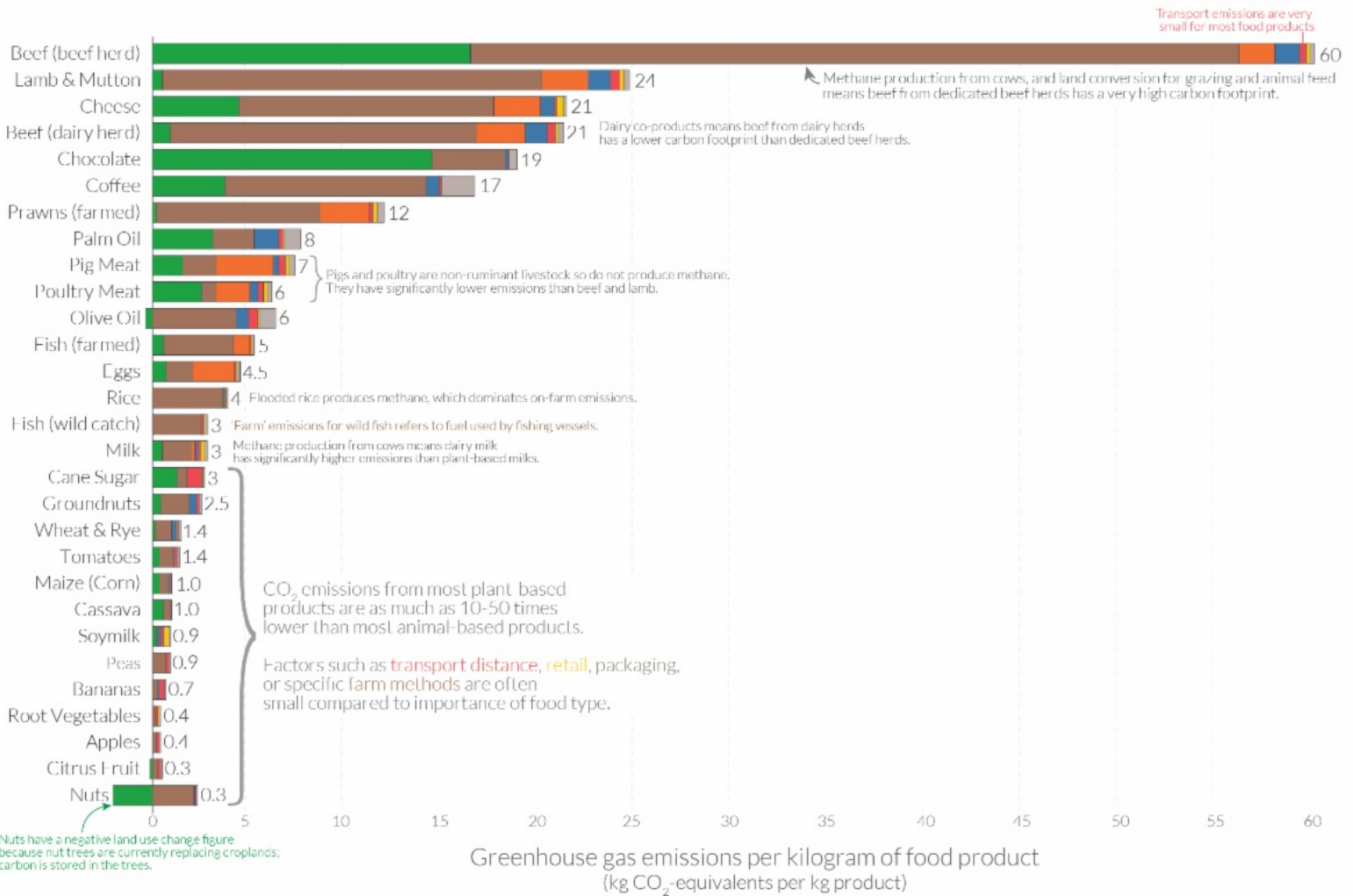
Animal Feed On-farm emissions from crop production and its processing into feed for livestock

Processing Emissions from energy use in the process of converting raw agricultural products into final food forms

Transport Emissions from energy use in the transport of food items in-country and internationally

Retail Emissions from energy use in refrigeration and other retail processes

Packaging Emissions from the production of packaging materials, material transport and end-of-life disposal



Note: Greenhouse gas emissions are given as global average values based on data across 38,700 commercially viable farms in 119 countries.

Data source: Poore and Nemecek (2018). Reducing food's environmental impacts through producers and consumers. *Science*. Images sourced from the Noun Project.

OurWorldinData.org Research and data to make progress against the world's largest problems.

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The [graphic above](#) from Our World In Data ([definitely worth examining in depth](#)) quantifies different foods' emissions and their sources, from land use change through emissions on the farm (including [methane from cattle](#) and [nitrous oxide from fertilizer off-gassing](#), in addition to CO₂) to transport, processing, packaging, and retail emissions. Notably, the vast majority of GHG emissions are from the land-use and farm stages, with transport and retail negligible; that is, it's more harmful to eat beef or mutton from a feedlot in the next state over than to eat vegetables shipped in from the other side of the world.

One obvious solution is for the world to pivot to eating less meat: a vegetarian or vegan diet substantially reduces land, water, and carbon emissions impacts. (Check out the graphic above once more and note that beef in particular is a major cause of greenhouse gas emissions, with more than twice the impact of any

other major foodstuff). However, people really like meat and, understandably, many aren't willing to give it up for abstract planetary-level gains. Vegetarianism as a lifestyle first became a thing in the early 1900s, and [hasn't grown that much in the last few decades](#). This writer has been vegetarian for years, and encourages others to follow suit, but realistically speaking we as a civilization will need substantially more than that to fix the food system and help fight the climate crisis.

Fortunately, there are at least four major categories of technological advancement starting to impact the world food system, at different stages of commercialization, any one of which has the potential to make the world a massively better place for humans and wild ecosystems.

Crop Improvements.

First, there's the latest wave of improvements to crop-yield science. A company called [Agrisea](#) has [developed a strain of rice that can grow in saltwater](#), opening the possibility of floating, ocean-going rice farms. If major rice-growing countries like China develop this en masse, it will massively reduce demand for arable land and fresh water! Perhaps even more impressively, an initiative called [RIPE](#) ([Realizing Increased Photosynthetic Efficiency](#)), funded by Bill Gates (among others, has successfully developed some genetic enhancements that essentially "[hacked](#)" and supercharged photosynthesis, making a key enzyme called [Rubisco](#) more efficient at grabbing carbon dioxide molecules and engineering slightly more efficient chemical pathways at a few other stages. [Here's Gates' commentary on it](#). Early results have this [boosting plant growth by 40%](#)- an amazing breakthrough, and it can be applied to any plant. When-not if-this becomes the standard for major world crops from rice to soybeans, sometime in the next few decades, it will increase yields immensely! This probably won't even be branded differently in supermarkets-it'll just become the standard for crop growing. Great news!

Plant-Based Meat.

In the 2010s, [Beyond Meat](#) and [Impossible Foods](#) ([co-winners of the UN's 2018 Champion of the Earth award](#)) made an incredible breakthrough: they

invented, mass-produced, and sold meat made from plants that tasted like old-style dead-animal meat and that people actually wanted to eat. Using innovative food chemistry, they reconfigured protein from peas and mung beans (Beyond) and soy (Impossible) to match the structure and flavor of



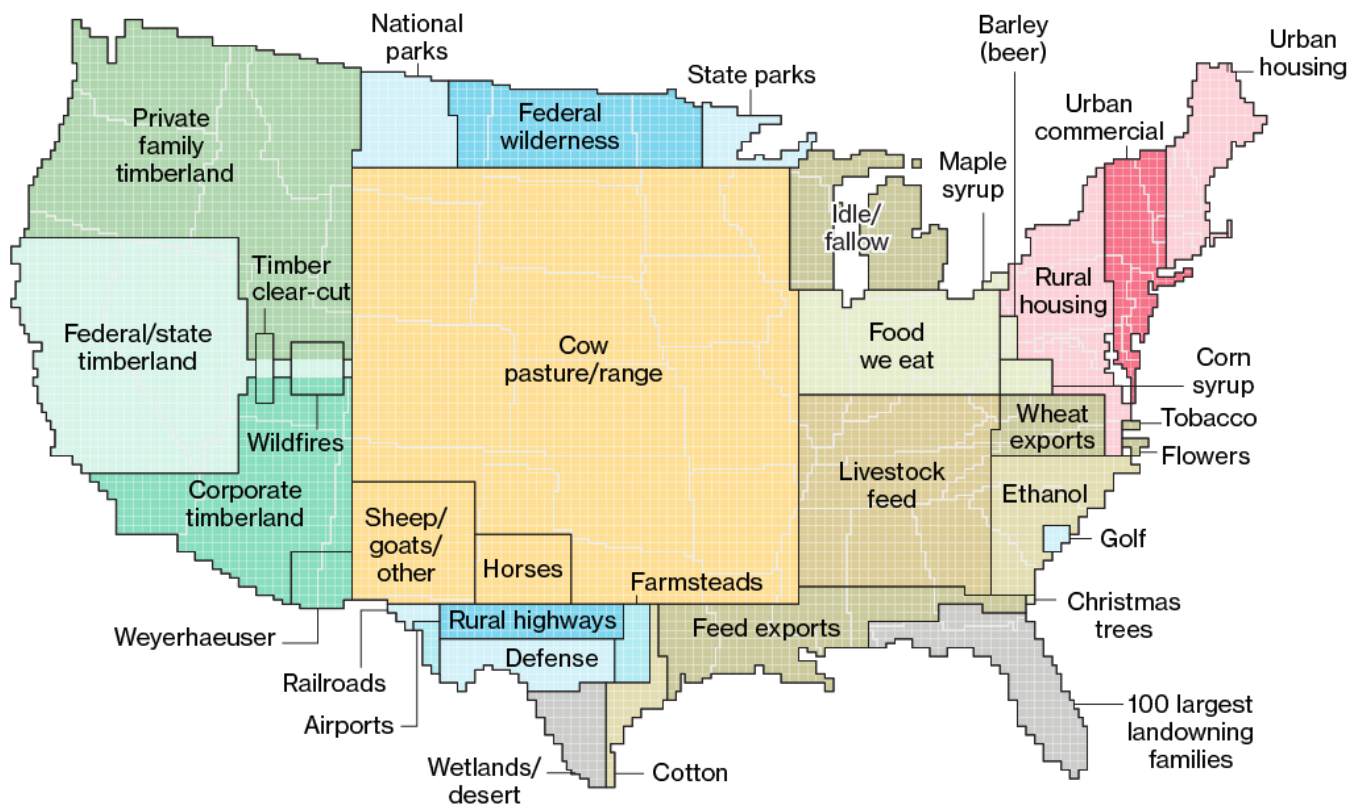
animal muscle proteins. They now sell a wide range of products.

This writer has eaten many a Beyond Burger, and can attest that they're absolutely delicious. Furthermore, [a life cycle assessment by researchers at the University of Michigan](#) found that the Beyond Burger has *"90% less greenhouse gas emissions, requires 46% less energy, has >99% less impact on water scarcity and 93% less impact on land use than a ¼ pound of U.S. beef."* That's a pretty amazing creation!

Fortunately, plant-based meat is growing *rapidly*. Sales of plant-based meat [grew 45% from 2019 to 2020](#), and the companies behind them are only getting started. Beyond just launched a Beyond Chicken product, while Impossible is debuting Impossible Chicken Nuggets. New startup Good Catch is making plant-based seafood (using a base of a wide variety of legumes, and algae oil for that distinctive "fishy" taste). Meat company behemoth Tyson Foods, [the world's second largest processor of chicken, beef, and pork and a notorious environmental and labor rights offender](#), has jumped on the bandwagon with its "Raised and Rooted" line of [plant-based burgers and bratwursts](#). That reminds this writer of when utilities like Xcel Energy, historically a coal-power user, starting committing (and following through) on switching to renewables-when even the amoral mega-companies in the field start doing the right thing, you know the momentum is on your side. It's not just big companies, either: [indie local vegan butcher shops](#) are now a thing!

Beyond the grocery stores, plant-based meat is taking off in restaurants. Starbucks, Dunkin', Taco Bell, Carl's Jr., Little Caesar's, Burger King, Long John Silver's, [Panda Express](#)...heck, pretty much *every* major fast-food restaurant (and a whole bunch of smaller local ones) has a plant-based meat option for sale now, most of them sourced from one of the companies above. The ones that don't yet are planning to roll one out soon (this category includes Subway, with a planned Beyond Meatball sub, McDonalds, with a planned McPlant burger, and KFC, with a "[miracle](#)" custom Beyond chicken).

If we as a society fully made the switch to plant-based meat, it would reduce emissions greatly and free up a *massive* amount of Earth's land area. Check out the map below, [created by Bloomberg News](#) to graphically represent land use in the lower 48 US states. Notice how much is cow pasture, how much is livestock feed, and how little is "food we eat," i.e. fruit, vegetable, and grain crops for humans? If the United States food system transitioned to Beyond Burgers, Impossible Burgers, and all the rest, and beef went the way of coal, we would free up several *states* worth of land, spread across much of the American West and Midwest. Not to mention an immense reduction in carbon emissions, water use, animal suffering, and the other horrible side effects of the current screwed-up meat system, like [fecal dust storms from cattle feedlots smothering towns](#).



Cell-Cultured Clean Meat.

[Cell-cultured meat](#) is essentially real animal meat without the animal; cow, chicken, fish, or anything else cultivated from tissue samples in a vat in a lab, the exact same stuff that normally forms animal muscles but without the need to raise, feed, clean up after, and kill the animal to get it. This has some amazingly utopian implications: a [study found that cultivated meat](#), once economies of scale are reached, could be produced with **99% lower land use, 96% lower water use, and 96% lower greenhouse gas emissions** than conventional meat! Plus, of course, the average consumer would be able to eat authentic animal meat-from any species without any creature having been killed to get it.

This field is already rapidly moving towards commercialization, though it's a few years behind plant-based meat. [Shiok Meats](#) is making cell-based lobster and shrimp in Singapore, with an in-construction production facility preparing for full commercialization in 2022. A [test restaurant in Tel Aviv](#) is selling lab-grown chicken, as is a [different company, Eat Just, in Singapore \(which has emerged as a major hub of the cultured meat industry\)](#). Another company, [Upside Foods](#) (formerly Memphis Meats) has received over \$100 million in investment to perfect their technology, and is [currently seeking](#) regulatory approval to sell lab-grown chicken in the United States. And as with plant-based meats, the companies mentioned in this article are just the highest-profile, farthest-along ones; there are dozens of startups in this space, and any one of them could come out with a new game-changing innovation.

All of the companies named above are scooping in tens of millions in venture capital funding, because investors know that mass-producing no-kill animal protein with low resource needs has *immense* upsides. We've essentially maxed out how fast and how efficiently you can get meat from a cow, but the possibilities to streamline and scale up cultivated meat has barely gotten started.

There are some barriers yet to be fully overcome: as an article in *Nature* discussed, full-scale global commercialization will require need improvements in key components of the clean meat cultivation process, cost-efficient [production of cellular scaffolding and growth media](#) (a key issue here is creating a sufficiently cheap and plant-based fluid for the cells to grow in), but a [wide array of researchers are working on that](#). The article also points out that cell-cultivated meat can work to grow meat from tissue samples of any species, meaning we don't have to stick with animals traditionally farmed. For example, the [zebrafish](#) is a standard "model organism" used in experiments, so scientists are already really good at understanding and cultivating its cells. It's a minnow, so it's not normally eaten, but cultivated and scaled up its meat should taste like cod or haddock.

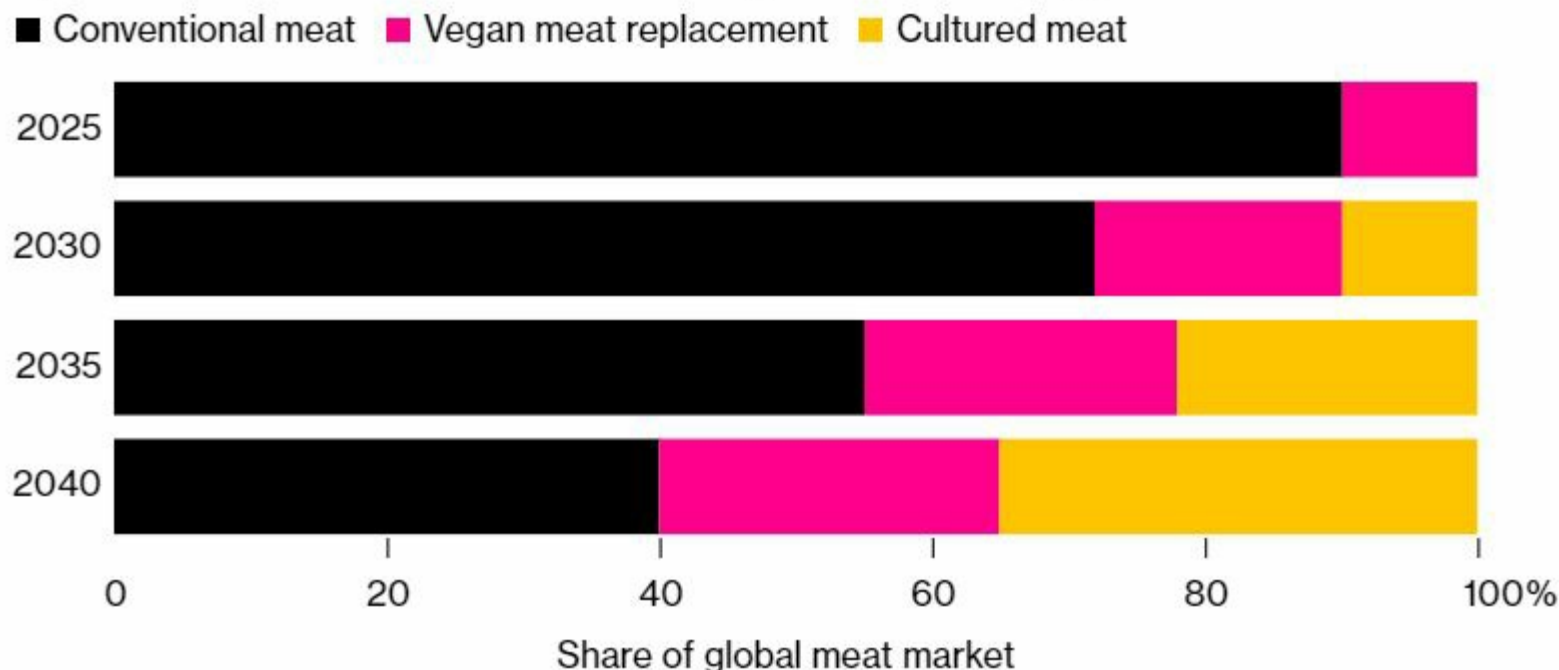
For both plant-based meat and cultivated meat, one huge question is timing: just when will this become the norm? That's a question with big implications for the world's climate and ecosystems, so it's encouraging that the answers range from "relatively soon" to "very soon." [One report estimates](#) that the US and Europe will reach peak meat consumption in 2025, and alternative proteins will capture 11-22% of the market by 2035. [Think tank RethinkX](#) is much more optimistic, anticipating demand for cow products falling by 80-90% by 2035. They're a little more "out there," than most, making several ambitious claims-but they could well be right. After all, a think tank in 2006 reporting on the cultural dominance of smartphones and social media in 2020 would have sounded extreme.

[The graphic below from Kearney](#) (a major world business consultancy, with no

ideological skin in the game), offers an enchanting middle-of-the-road possibility: between plant based "vegan meat replacement" and cultured meat, the old corpse-flesh stuff could be down to 40% of the global market by 2040-even while the global meat market grows to an estimated 1.8 trillion USD by that year.

Where's the Beef?

By 2040, conventional meat could only be 40% of the global market



Source: Kearney

Note: Global meat market, all kinds, is expected to grow from \$1.2 trillion in 2025 to \$1.8 trillion in 2040, according to Kearney.

Microbial Farming.

The fourth major new technology in the food system is microbial farming: growing food not with plants or animals but with single-celled organisms. This may sound out there, but some companies are already making it work: [Calysta](#) uses [methanotroph](#) microorganisms to produce protein to feed farmed fish, and [Quorn](#) sells a human-edible meat substitute based on protein from a single-celled fungus. (This writer tried it and found it quite good, like a more savory tofu). More exciting than either of these existing and rather slow-moving companies, though, is the Finnish startup [Solar Foods](#), which uses a renewable energy-powered bioreactor and some [hydrogenotroph](#) bacteria to produce Solein, a powdered protein ready for inclusion in breads, pastas, smoothies, or anything else. Their process is substantially more efficient, in terms of electricity-to-calories conversion, than *photosynthesis itself*. The company [claims the process emits 1%](#) of the greenhouse gas emissions of equivalent meat production, and they're scaling up a facility in Finland to bring it to supermarkets in the next year. Furthermore, unlike even plant-based crops, Solein production isn't not dependent

on weather-all it needs is electricity and a bioreactor full of bacteria. The company's CEO [boldly claims](#) that it could be cost-competitive with soy, one of the cheapest plant proteins out there, as soon as 2025. And if Solar Foods goes belly-up for some reason, there are a lot of other startups trying to do the same thing, from [Air Protein](#) to [Deep Branch](#).

The efficiency statistics here are *insanely* good. [A recent study](#) found that food-from-air microbial systems similar to those of Solar Foods use 10% of the land used by soybean farming to produce an equivalent amount of protein-and soybeans are some of the most efficient and cheap ways of growing protein that we have. Microbial farming is ten times more efficient than *that*, and so *overwhelmingly* more efficient than beef. This may trigger some "lab-grown dystopian future food!" reflex in some people, but in the real world, making lots and lots of protein with incredibly low land and energy inputs will be an immensely good thing. The Kearney chart above forecasting the potential decline of super-environmentally-damaging "regular" meat doesn't even take microbial farming into account-if Solar Foods or someone else achieves ultra-cheap protein in the next ten years, *on top* of the ongoing momentum in plant-based and cell-cultivated meat, we'll see a transformation in the world food system amounting to a new Agricultural Revolution. If microbial farming achieves its full potential, food might never be scarce again. Anywhere.

The Future.

With all of these technologies growing rapidly, there is potential for a quasi-utopian future of food to emerge even while the world struggles with climate disasters and the energy transition. It's probably a really good thing that this is happening entirely in the private sector: this seems to make it more likely that plant-based meat, cultivated meat, microbial farming and all the rest will follow the rapid-adoption technological trajectory of smartphones rather than the decades-long political slog trajectory of, say, cheaper healthcare. There's also very little downside, as this will likely incentivize more high-end, organic foods as luxuries while dis-incentivizing industrial farming. People in high-income countries will still want to buy heirloom tomatoes and local baked goods, keeping organic farms and farmer's market-type places in business, but the slaughterhouse-and-feedlot "grunt work" of feeding the world could be entirely replaced, and it's unlikely any consumers will miss it or want to pay extra for its products. (Once the McDonalds standard is a cheap cultivated or plant-based burger, who would go "Y'know, I'd really pay extra if I could be sure a cow was killed somewhere for this"?) There's also immense creative potential; *Anthropocene* magazine (name buddies!) envisions a future of [locally rooted unique, independent "carneries"](#), like breweries, but growing their own custom blends of cell-cultivated meat in small-

batch vats.

Of course, as with any major technological advancement, there will be those who lose out from the change, tomorrow's buggy-whip manufacturers and phone-book printers. If all goes well, we'll probably see a rash of concerned media stories in the late 2020s to early 2030s about the people and communities left jobless by the fall of the industrialized meat industry, akin to how coal-dependent communities have declined in recent years. However, it'll be unquestionably worth it, saving billions of animals from a life of torturous suffering, helping stabilize our climate and freeing up vast amounts of land, water, and energy for other purposes. (We should be investing in universal healthcare, retraining/apprenticeship programs, permanent child tax credits, and universal basic income to support all workers left jobless by anything, but that's another story).

Furthermore, some fascinating groups are already working on rewilding disused American farmland; the amazing [American Prairie Reserve](#) is taking shape on former cattle grazing lands in Montana, and [other groups](#) are envisioning a "[Great Buffalo Commons](#)" in which no-longer-farmed plains land is bought up and rewilded into a massive grassland ecosystem, with likely immense benefits for biodiversity and carbon sequestration.

In sum, the next few decades will bring some extraordinary transformations to the world food system! From this writer's viewpoint, the momentum seems unstoppable-there's simply so much to be gained, financially and ecologically, and the technology's already out there.

To be part of this transformation, this writer encourages all readers to check out [where they can buy Beyond](#) and [where they can buy Impossible](#) products (we don't normally encourage people to buy specific things, and we're not receiving any inducements to do this-they're just *that awesome*), to spread the word of plant-based and cell-cultivated meats and microbial farming's incredible potential benefits, and to welcome new food technologies when they arrive in stores and restaurants near you in the coming years!

The Weekly Anthropocene

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