

The History and Future of Food Production

In Daniel Suarez's recent novel, "Change Agent", set in the 2040's, the main character is a *degan*, or someone who eats meat, but only "deathless meat". While the concept of someone identifying as a degan may have a futuristic feel, the idea of vat-grown meat is hardly science fiction; multiple companies are already hard at work producing cultured meat, and some have promising early results.

All of what we historically consider food, whether plant- or animal-based, is, at its core, chemicals. That we could eventually figure out the chemical makeup of foods and replace cellular process and recipes stored in DNA with direct chemical processes and recipes stored in computers feels inevitable.

If this were the only disruptive concept in food, it would be plenty. But indoor crop farming has also gained serious traction, and genetic manipulation of plants and animals appears on the verge of another revolution with the advent of CRISPR technology. Result: we are entering a major new wave of technology-driven change in our food systems.

Turning from technical to cultural trends, we face a startling contrast. Culturally we seem to be headed in the opposite direction: "organic", "grow local", and "heritage varieties" hearken back to earlier periods and methods. Even as food production threatens to disconnect from its historical roots, food consumption seems, more than ever, to want to return to it.

So what happens now? Do we bifurcate into a warring "future food" and "past food" clans, or do these coexist in a new, more diverse food system? This paper makes some predictions about how food producing and consumption will play out, but the first step to seeing the future is to see how we got to this point.

(need to discuss somewhere that this is about the developed world, but a leading indicator of everywhere assuming economics stay strong)

How We Got Here: Food Production

The primary focus of manufacturing process improvement is to remove variation, especially ones that cause defects. Pure inputs, precise operations and uniform outputs are the target. Major US companies like Motorola and GE even popularized the statistical measure of variability by using it in the name for their quality initiatives: six sigma, indicating a process that has achieved less than 3.4 defects per million results.

The concept of improvement through minimizing variation accurately describes the historic arc of all farming, whether plant or animal, going back 1000's of years. When some plants crowd each other out, we plant so that each has the same space. When unwanted plants steal resources, we weed so that a field has a single species. When rain is irregular we irrigate. When swings in temperature threaten animals we provide climate-controlled environments. When pasture variation produces different sized animals we produce herd-optimized animal foods. Even human variation gets attention: high-tech tractors have taken over the role of driving tractors since they can use GPS technologies to create straighter rows.

Over time science has advanced and we've learned more about what makes plants and animals grow well, and inevitably this new information is applied to the reduction of variability. Carefully controlled genetics give us predictable, uniformity of the timing of plant maturity. Antibiotics restrict the microbiome to a "favorable" state. Chemical fertilizers create greater uniformity nutrients across fields than nature ever could. DNA-based genetic features and super drugs help fight off wide varieties of pests.

When combined with the efficiency improvements from mechanization, the increases in production and decreases in cost are truly amazing. (include some here?) Land use, sustainability, also improved by many measures.

If the story ended here it would be a happy one, but it is not surprising that major issues have emerged. While we seek to stomp out variation and create homogeneity, nature seems to want the opposite. Even ignoring climate shifts, the variation in weather still periodically ravages crops. Mutations build resistance to the chemical and genetic defenses that we create, rendering them useless, and potentially irreplaceable. Examples: sea lice, antibiotic resistance)

Our quest for homogeneity has led to monoculture and made the plant and animal species more fragile in a genetic sense. Example: bananas.

Don't understand everything yet. Example micro biome around plants and animals

Finally, we're hitting resource limits, and our methods are not without side effects. Examples: water left in US aquifers, and chemical overspill.

In the end we have made tremendous headway and more is possible, but system is not nearly as robust as you would logically think it would be.

How We Got Here: Food Consumption

Millenia-long transition from hunting and gathering to domesticated agriculture to industrial agriculture. Fish is the last large-scale food source that we still regularly “hunt” in the wild, but even there farmed fish has grown to the point that it is larger than wild-caught fish.

Ultimately the food production industry meets the consuming public with the face of any other mass producing industry. Fast food restaurants produce meals with incredibly low variation and cost, and large-scale grocery stores with high quality and predictable products, again at low costs.

This system has supported increasing global consumption as a result of growing population, and also increased family wealth. This latter point becomes an important part of modern food. As income grows families climb Maslov's hierarchy of needs, moving beyond eating in order to stay healthy and alive, to seeking out foods that provide increased personal satisfaction. Move beyond mass consumption: personalized consumption at home, and high-end, differentiated restaurant experiences. Foodies. Vegans, etc.

(note: still those who think we'll run out of food and fall back down the Maslov's hierarchy. I'm not one of them)

But it's not just limited to eating, as income increases well beyond the levels required to stay alive and healthy, cooking can become a serious hobby. The chemistry of cooking, sous-vide cooking.

Farming can also become a serious hobby, including animals in addition to plants.

Cultural pushback is also a “luxury”, and an increasingly major actor in the food industry

- anti-GMO, antibiotic-free
- organic, free-range
- sustainability (energy, CO2, soils, land)
- local

Role of marketing in food. Branding+causes: free-range, anti-biotic free, etc

Where We Go From Here: XXX Predictions

Assumptions:

- steady, global increase in wealth (increased demand, but pickier)
- science marches on
- optimism

We are at the beginning of the Golden Age of Food Hacking

CRISPR + indoor farming and cultured meat. Increasingly able to treat food production as an engineering project, with the tools widely available.

Indoor farming and cultured meat will both take off

This is not a bold prediction by under any circumstances, but useful to discuss in light of historical arc presented above.

Both approaches remove major variations from plant and animal production, moving the system

Plants: indoor farming removes weather as a variable. Improves ability to engineer individual plants, but also grow year-round. Other variables are soil.

Animals: cultured meat removes animal as a variable, as well as many others.

Both have big sustainability boasts, especially with the advent of LED lights.

Growing crops outdoors and traditional animal production will continue at scale, and probably even grow, but it will evolve

- discuss why will make sense to still grown plants and animals as we do today
- move from mass production to mass customization of sorts. Not customized products, but custom sources, i.e. treat each animal and plant (or group of plants) as individuals that need individualized approach
- some practices under attack (widespread use of antibiotics) will be phased out, but others (GMOs) will continue and grow

The microbiome will offer some surprises, and other “unknowns” will emerge

Indoor farming and cultured meat will not create significant new jobs

Existing critiques of food production approaches will get more serious, but some new ones will emerge

Cooking and farming at home will continue as major growth industries

Similarly, “opinionated” restaurants and local farms will be big areas of growth