

The CAFO in the Bioreactor: Reflections on Efficiency Logics in Bio-industrialization Present and Future

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Abstract

A 2020 report published by the think tank RethinkX predicts the “second domestication of plants and animals, the disruption of the cow, and the collapse of industrial livestock farming” by 2035. Although typical of promissory discourses about the future of food, the report is otherwise unusual in focusing on the gains of efficiency and near limitless growth that will come by eradicating confined livestock and aquaculture operations and replacing them with protein engineered at a molecular level and fermented in bioreactors. While there are many reasons to disrupt industrialized livestock production, lack of efficiency is not one of them. This article examines to what extent this so-called second domestication departs from the radical transformations of animal biologies and living conditions to which it responds. Drawing on canonical texts in agrarian political economy, it parses animal bio-industrialization into sets of practices that accelerate productivity, standardize animal life and infrastructures, and reduce risk.. It then shows these practices at work through recent ethnographic accounts of salmon aquaculture and pork production, to illustrate how efforts to override temporalities and contain species in unfamiliar habitats, in the name of efficiency, may be the source of vulnerability in such production systems rather than their strength.

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A 2020 report published by the Silicon Valley-style think tank RethinkX boldly predicts “the second domestication of plants and animals, the disruption of the cow, and the collapse of industrial livestock” farming by the year 2035.¹ The report describes a future in which highly centralized confined livestock and aquaculture operations, and implicitly many other defining

¹ Tubb and Seba, *Rethinking Food and Agriculture 2020-2030*. This quote is on the title page of the report.

features of contemporary food production, have been left behind and replaced by a system in which food will be engineered by scientists at a molecular or cellular level and fermented in bioreactors. Producing food this way, the report asserts, will be immensely cheaper as well as environmentally benign, both stemming from a promise of multifold increases in efficiency.²

This report is in one sense fairly typical of the promissory discourses circulating about the future of food, especially regarding what has come to be short-handed as “alternative protein.”³ Similar visions of molecularized protein production are often articulated in Silicon Valley and other hubs of “disruptive innovation,” at events, in reports, and on the websites of a plethora of start-ups. As part of a collaborative research project examining Silicon Valley’s recent forays into food and agriculture, my team and I have had the opportunity to attend many such events and review these materials. In these spaces and texts, promises abound about meat without the cow, eggs without the chicken, and fish without the sea - generally in the name of eliminating the inhumane practices of livestock industrialization, halting global climate change, using fewer resources, and ensuring food security, as the planet lurches toward a population of 10 billion.⁴ As these promissory discourses go, the RethinkX report has a particular bent that makes it distinctly interesting. Unlike others, which tend to cover the gamut of concerns to which the alternative protein sector is responding, this one dwells on promises of efficiency (often posed as economic efficiency) and near limitless growth, and actually says very little about current production practices and their consequences. In particular, the report draws attention to what the authors call the second domestication and its foundational raw materials of fungi, bacteria, algae, and cells - biological matter that, the report posits, can infinitely reproduce and thrive, while taking up only a fraction of the land, water, oceanic, and mineral resources that crops, fish, and livestock do.

There are many reasons to disrupt and probably eradicate industrialized livestock production instantiated in Confined Animal Feeding Operations, or CAFOs, and their oceanic counterparts, but their lack of efficiency is arguably not one of them. Indeed, as I will argue in this piece, industrialized livestock (and crop) production has long been underpinned by a logic of

² Tubb and Seba, *Rethinking Food and Agriculture*, 7.

³ On that terminology, see Jönsson, Linné, and McCrow-Young, “Many Meats and Many Milks?”; Sexton, Garnett, and Lorimer, “Framing the Future of Food.”

⁴ Stephens parses out the benefits of cellular meat in similar terms. “Growing Meat in Laboratories, 162.

efficiency.⁵ This logic can be seen in prior developments in what I will call agricultural bio-industrialization, a term first used by Goodman, Sorj, and Wilkinson in a seminal book on agrarian political economy to connote the radical transformations of plant and animal biologies in the interest of maximizing production of human food.⁶ Yet it is this logic which has wrought many of the negative consequences to which alternative protein putatively responds. So to hinge imaginaries of the future of food on the goal of efficiency substantially misses the mark. The report is further striking for excluding an explicit rationale for its focus on efficiency, as if the objective goes without saying. Here, though, the report is not unique, as efficient use of resources is often conflated with environmental benefit in a whole host of current prognostications of optimal food futures. It may be, as Gianella has argued, that since productivity and efficiency are what tech can offer, it becomes a proxy for the morality that Silicon Valley often lacks.⁷ Or it may simply be that it is those forwarding efficient solutions to the world's food problems who lack imagination of what a better future of food might hinge upon.

To explore these concerns, I begin with a closer look at the predictions of the RethinkX report, which mainly serves as market-making hype but whose content nevertheless illustrates how even extreme efforts at efficiency are imagined as beneficial. With that as a springboard, I next work with a select group of canonical texts in agrarian political economy to elaborate the defining features of bio-industrialization which I take to be the intentional standardization, spatial containment, and speeding up of life processes, all of which have been in the works for a long time. I then apply these definitions to two examples of highly intensified animal agriculture, as told through recent ethnographies of salmon and pork production, to show how these exact features, and their underlying logics of efficiency, are in fact contributing to some of the very conditions that the food tech sector aims to disrupt, rendering the underlying bio-logics, as it were, neither novel nor necessarily beneficent. I conclude by suggesting that notwithstanding the possibility of substantial disruptions in existing industrial livestock production, the commonalities of this second domestication with its conventional foil present cause for concern.

⁵ Recent work on this includes Blanchette, *Porkopolis*; Campbell, *Farming Inside Invisible Worlds*; Gálvez, *Eating NAFTA*; Reisman, "The Great Almond Debate."

⁶ *From Farming to Biotechnology*.

⁷ Gianella, "Morality and the Idea of Progress in Silicon Valley."

The second domestication predicted

While particularly hyperbolic in terms of its timeline, as a text the *Rethinking Food and Agriculture* report exemplifies performative future-making so emblematic of the tech sector, the bioeconomy, and the future industry itself. Writing on the bioeconomy, Rajan explains that “to generate value in the present to make a certain kind of future possible, a vision of the future has to be sold, even if it is a vision that will never be realized.”⁸ Writing on the futures industry, Powers argues that forecasting trends is more than an exercise in prediction; forecasting helps usher in particular futures by making them appear inevitable, while foreclosing other possible futures.⁹ Founded by a Silicon Valley thought leader cum entrepreneur and a London-based tech investor, whose backgrounds in the energy sector might partially explain their efficiency focus, its sponsor, Rethink X is “an independent think tank that analyzes and forecasts the speed and scale of technology-driven disruption and its implications across society.” It claims to produce “impartial, data-driven analyses that identify pivotal choices to be made by investors, businesses, policymakers, and civic leaders.”¹⁰ Its report is written very much in that performative vein described by Rajan and Power, claiming “that the disruption of food and agriculture is inevitable – modern products will be cheaper and superior in every conceivable way” and that all that stands in the way are the policymakers, investors, businesses (especially incumbents) and civil society actors that can slow progress.¹¹

Yet, as those scholars writing specifically on new alternative proteins have shown, attempting to enact their specific material promises involves a great deal of discursive, regulatory, and ontological work. Alternative proteins must be positioned as substantially similar to meat, milk, seafood and eggs, while at the same time shown to be different enough in their production practices to make good on the array of promises they make related to human health, environmental sustainability, climate change, and animal rights and welfare that are their raisons

⁸ Rajan, *Biocapital*, 115-16.

⁹ Powers, *On Trend*.

¹⁰ Tubb and Seba, *Rethinking Food and Agriculture*, 3; “Meet the Team,” <https://www.rethinkx.com/meet-the-team> (accessed October 12, 2020)

¹¹ Tubb and Seba, *Rethinking Food and Agriculture*, 9.

d'être.¹² It is in this last respect that the RethinkX report's content is significantly different than the usual fare about alternative protein, instead drawing nearly singular attention to the socioeconomic benefits of alternative protein, along with some downsides. The Executive Summary, for example, begins with the bold assertion that "we are on the cusp of the deepest, fastest, most consequential disruption in food and agricultural production since the first domestication of plants and animals ten thousand years ago." The main disruption, it goes on to state, will be in the domain of protein – and it will be "driven by economics." "The cost of proteins will be five times cheaper by 2030 and 10 times cheaper by 2035 than existing animal proteins, before ultimately approaching the cost of sugar. They will also be superior in every key attribute – more nutritious, healthier, better tasting, and more convenient, with almost unimaginable variety." But, there will be losers in this technological disruption, and "the impact of this disruption on industrial animal farming will be profound. By 2030, the number of cows in the U.S. will have fallen by 50% and the cattle farming industry will be all but bankrupt. All other livestock industries will suffer a similar fate."¹³ Moreover, according to the report, over 1.7 million jobs could be lost in livestock and fishing industries in the U.S. alone, only partially offset by the 1 million jobs expected to be created in this industry.¹⁴

The report then details many of the developments making this future possible, reflecting the technoscientific promises of the bioeconomy more generally. Defining "precision biology" to "encompass the information and biotechnologies necessary to design and program cells and organisms, including genetic engineering, synthetic biology, systems biology, metabolic engineering, and computational biology,"¹⁵ it is

the result of rapid advances in precision biology that have allowed us to make huge strides in precision fermentation, a process that allows us to program

¹² Broad, "Making Meat, Better; Chiles, "If They Come, We Will Build It;" Jönsson, "Benevolent Technotopias and Hitherto Unimaginable Meats;" Jönsson, Linné, and McCrow-Young, "Many Meats and Many Milks?"; O'Riordan, Fotopoulou, and Stephens, "The First Bite;" Sexton, "Alternative Proteins and the (Non) Stuff of "Meat;" Sexton, Garnett, and Lorimer, "Framing the Future of Food;" Stephens, "Growing Meat in Laboratories;" Wurgalt, *Meat Planet*; Stephens and Ruivenkamp, "Promise and Ontological Ambiguity in the in Vitro Meat Imagescape;" Mouat and Prince, "Cultured Meat and Cowless Milk."

¹³ Tubb and Seba, *Rethinking Food and Agriculture*, 6.

¹⁴ Tubb and Seba, *Rethinking Food and Agriculture*, 54, 50.

¹⁵ Tubb and Seba, *Rethinking Food and Agriculture*, 17

microorganisms to produce almost any complex organic molecule. . . . This model ensures constant iteration so that products improve rapidly, with each version superior and cheaper than the last.¹⁶

Micro-organisms such as bacteria, fungi, algae, and protozoa are thus central to RethinkX's predicted second domestication. After acknowledging the role micro-organisms have played in the first domestication, for example by breaking down nutrients in the cow's digestive tract, the report states that in the future, "we" will bypass macro-organisms entirely and manage the micro-organisms directly. These

new technologies [will] allow us to manipulate micro-organisms to a far greater degree than our ancestors could possibly have imagined. We can now unplug micro-organisms entirely from macro-organisms and harness them directly as superior and more efficient units of nutrient production The first domestication allowed us to master macro-organisms. The second will allow us to master micro-organisms.¹⁷

Strikingly, this wholesale transformation in how food might be produced was foreseen in the 1980s. In their highly prescient *From Farming to Biotechnology*, Goodman, Sorj and Wilkinson wrote of a tendency they called "substitutionism," in which factory production would increasingly substitute for rural products, making production cheaper, more controllable, faster, and less land dependent. Noting a long term transition in substitutionism from preserving (canning, refrigeration) to imitating (margarine) to synthetic substitutes (Saccharine, Olestra) to fractioning and fabricating, they foresaw the possibility that ongoing technological change in food production would culminate in the disaggregation of food into molecular parts. Through fractionation, fermentation, and cellular technologies, that is, the biological processes and rural production sites associated with plant and animal production could be all but eliminated such that

¹⁶ Tubb and Seba, *Rethinking Food and Agriculture*, 6

¹⁷ Tubb and Seba, *Rethinking Food and Agriculture*, 13

at most rural products would become inputs to these industrial processes.¹⁸ Goodman et al.'s more analytical prognostications are now the stuff of promise in the RethinkX report.

Yet, as opposed to Goodman et al, who foresaw a simultaneous intensification of rural production in a process they called appropriationism,¹⁹ the Rethink report imagines a complete eradication of current modes of rural production, including animal-based food production

which has all but reached its limits in terms of scale, reach, and efficiency. As the most inefficient and economically vulnerable part of this system, cow products will be the first to feel the full force of modern food's disruptive power. Modern alternatives will be up to 100 times more land efficient, 10-25 times more feedstock efficient, 20 times more time efficient, and 10 times more water efficient. They will also produce an order of magnitude less waste.²⁰

Although the RethinkX report is near singularly focused on efficiency, it is important to note that it is not alone in casting the environmental benefits of plant-based protein in efficiency terms. Along with claims of reduced water and land use relative to protein produced, a common discursive thread within the alternative protein space regards the poor feed conversion ratios or carcass utilization of meat production, highlighting a (faulty) premise about cellular meat in particular that the sole output of livestock is the meat and not the whole animal.²¹ In any case,

¹⁸ Goodman, Sorj, and Wilkinson, *From Farming to Biotechnology*.

¹⁹ In describing the tendency of appropriationism, they recognized that factory and laboratory production of food could not really occur without the (rural) production or extraction of raw ingredients, a point that RethinkX and others seem to obfuscate. Appropriationism denoted the discrete technologies that would enhance productivity and reduce risk on the farm – they deemed it appropriation because these technologies would be produced in factories and then sold back to farmers, stripping farmers of some of the value they produced. Although they recognized appropriation to be seemingly at odds with substitutionism which pushed rural production toward obsolescence, ultimately they saw biotechnology (broadly speaking) as unifying these two tendencies, even bringing synergies, since enzyme technologies and tissue culture, along with genetic engineering of plants and animals could custom-make them for the nutritional and processing requirements of factory fabrication.

²⁰ Tubb and Seba, *Rethinking Food and Agriculture*, 6.

²¹ For example, Stephens et al. say, "When considering food waste, traditional carcass utilisation within the commercial meat industry is the single biggest problem in the context of waste management. Cultured meat provides a new opportunity, whereby the prime cut alone is produced for consumption or processing rather than the whole carcass." "Bringing Cultured Meat to Market, 158. For varying expressions of skepticism see Mattick, Landis, and Allenby, "A Case for Systemic Environmental Analysis of Cultured Meat;" Jönsson, "Benevolent Technotopias and Hitherto Unimaginable Meats;" Wurgaft, *Meat Planet: Artificial Flesh and the Future of Food*.

such claims show that wastelessness is another aspect of claimed efficiency. Questions of labor efficiency are notably absent from the report, however.

Finally, the report avers that precision technologies, along with these “virtually limitless inputs” will allow for a “move from a system of scarcity to one of abundance,” “from a system of extraction to one of creation.”²² Here the promise extends from efficiency to limitlessness. Cooper’s astute analysis of the bioeconomy provides the historical underpinnings of this particular aspect of the imaginary, an imaginary that formed in response to 1970s discussions about limits to growth. Then it was hoped that investment in the life sciences would allow geochemical production to be “replaced by the much more benign, regenerative possibilities of biomolecular production”²³ Biology, that is, could allow for limitless growth – something from almost nothing. The RethinkX report is not alone, however, in reigniting this aspiration of limitlessness. As noted by Jönsson, a raft of promissory publications have touted a cornucopian future of “clean” (read: cellular, or in vitro) meat, “evoked through depictions of how a single biopsy could theoretically feed the world.”²⁴

In short, the RethinkX report’s focus on limitlessness, wastelessness, and dramatic efficiency may in part reflect the report’s sponsors and authors in the energy sector, but it also exemplifies a widespread sensibility that efficiency is tantamount to environmental benevolence, that using less and producing more is a recipe for sustainability that goes without saying. It is a sensibility that pervades the alternative protein sector, particularly manifest in statements about feed conversion and carcass utilization. Efficiency, as it happens, is also engrained in the Silicon Valley mindset which views any kind of inefficiency “as an obstacle to be overcome.”²⁵ But efficiency, if not limitlessness, has long been a goal of industrial agriculture, taken to the limits in contemporary systems of livestock production, where the consequences have not been benign.

²² Tubb and Seba, *Rethinking Food and Agriculture*, 14.

²³ Cooper, *Life as Surplus*, 23; see also Helmreich, “Blue-Green Capital, Biotechnological Circulation and an Oceanic Imaginary.”

²⁴ Jönsson, “Benevolent Technotopias and Hitherto Unimaginable Meats,” 735. Exemplary publications include Datar, Kim, and d’Origny, “New Harvest: Building the Cellular Agriculture Economy;” Post, “Cultured Meat from Stem Cells;” Shapiro, *Clean Meat*.

²⁵ Morozov, *To Save Everything, Click Here*, 13-14; Gianella, “Morality and the Idea of Progress in Silicon Valley.”

Animal bio-industrialization defined (and refined)

It is telling that in its historical account of the evolution of agriculture, the RethinkX report neglects the significance of the industrialization of agriculture. Instead, it regards the history of animal agriculture as taking place over three grand historical periods, punctuated by the two revolutions of the first and second domestications. After a pre-history of hunting and gathering, the first domestication began 10,000 years ago, when “humans no longer hunted and gathered their food, but began controlling its production, selecting the best traits and conditions for growing these organisms.”²⁶ The revolution it aspires to bring into being, the second domestication of micro-organisms, presumably begins now. While this periodization is clearly a trope, it is a trope that effectively conflates early livestock domestication, when small herds were bred and pastured, with the industrialized agriculture of today, the latter involving CAFOS in which thousands of animals are made to live together in highly confined, and often otherwise barren spaces to be fertilized, fed, medicated, and milked, collected from, or slaughtered with great rapidity. The conditions of livestock CAFOs roughly apply to aquacultures, as well. Given the promises of technologies that involve intense biological manipulation, these more recent ways in which animal biologies and habitats have been manipulated or radically transformed for agricultural purposes merit careful attention. Following Goodman, Sorj, and Wilkinson, I refer to these processes as bio-industrialization to indicate that they involve more than the factory-like labor processes and mechanization often connoted by the industrialization of agriculture.²⁷

This change in kind from early domestication has been noted by others. Tsing, for example, has argued that the abstraction of plants, animals and microbes from their habitats, as well as the ensuing simplifications of monocultures helped achieve scalability that was central to capitalist modernization of agriculture.²⁸ In contemplating agriculture’s role in the Anthropocene, Haraway, building on the writing of Tsing and others, suggest that changes in the scale, rate/speed, synchronicity, and complexity of agriculture were so marked that their advent, rather

²⁶ Tubb and Seba, *Rethinking Food and Agriculture*, 13.

²⁷ *From Farming to Biotechnology*.

²⁸ Tsing, *The Mushroom at the End of the World*.

than the industrial revolution, can be read as the inflection point of human-made ecological catastrophe.²⁹

To interrogate the aspiration of efficiency that animates the RethinkX report and at times the alternative protein sector more generally, it is useful to parse out the different elements of bio-industrialization into four specific sets of practices, even though they are closely related: One set has been aimed at improving productivity, either by increasing the size or number of units, overall output, or accelerating the production cycles of organismic lives. Breeding and increasingly genetic engineering have been the primary approaches to make animals grow faster, bigger, or reproduce more abundantly, but not the only ones.³⁰ Nutrition and pharmaceutical treatment have hastened and amplified the growth of livestock.³¹ Bovine growth hormone has increased milk output in dairy cows.³² Exposing laying chickens to 24-hour lighting has ensured egg production on a 24 hour cycle and year round.³³ This last example is but one of many practices that smooth or even eliminate seasonal productive and reproductive rhythms, so that production becomes continuous.

Continuous production is implicated in a second strategy of animal bio-industrialization, which is the standardization of animal bodies and infrastructures. Animals that can be made to grow at the same speeds to become the same size and have virtually identical characteristics do more than produce food of similar flavor and aesthetics. They can be held in pens or cages of the same size, fit seamlessly into milking machines or the various nodes of disassembly lines, where they are slaughtered and taken apart. In other words, their bodies can be made to accommodate and even facilitate industrial labor processes or uses of machinery, although as we shall see sometimes labor processes have to accommodate the altered bodies of animals. Breeding has certainly allowed for animal standardization, but so have other practices such as artificial

²⁹ Haraway, "Anthropocene, Capitalocene, Plantationocene, Chthulucene, 159; Haraway et al., "Anthropologists Are Talking—About the Anthropocene." Note here that I avoid their evocative language of the plantationocene, which has drawn critique for privileging multi-species charisma over substantive engagements with the racial politics of the plantation.

³⁰ Boyd and Watts, "Agro-Industrial Just-in-Time."

³¹ Boyd and Watts, "Agro-Industrial Just-in-Time"; Blanchette, *Porkopolis*; Overstreet, "'A Well-Cared for Cow Produces More Milk.'"

³² Overstreet, "'A Well-Cared for Cow Produces More Milk;'" Kleinman and Kinchy, "Why Ban Bovine Growth Hormone?"

³³ Freidberg, "The Triumph of the Egg."

insemination, which not only ensures that animals have the desired genetic make-up, but also regularizes the temporality of reproduction.³⁴

A third set of practices aims to reduce the risks inherent to the production of life forms, risks that often heighten due to efforts in advancing the other two aims. The prolific use of antibiotics and other medications in animal agriculture are risk reduction practices, as are facilitated reproduction (through artificial insemination and more). An increasingly prevalent practice is containment itself. Containment actually serves multiple purposes: it enhances productivity by eliminating competition with other species and it clearly contributes to more efficient labor processes. But it is most arduously employed as a strategy of biosecurity. Infrastructures of containment from fish pens, to feed lots, to indoor animal housing are built to keep commodity species from being contaminated by other species and to prevent the leakages of commodity species from contaminating others.³⁵ Taking containment to an arguably absurd logic, land-based aquaculture is already in the works, and proposals for sea-based vertical farming are not unheard of.

Anticipating the technologies of the second domestication, recently a fourth aim of bio-industrialization has emerged: altering the function of plants and animal biology to produce materials deemed useful to humans. Amounting to “living factories,” genetically engineered goats produce spider silk in their milk, while chickens produce human growth hormone in their egg whites.³⁶ The techniques of precision biology that have produced such living factories have also transformed animal bodies in the interest of environmental protection. Witness the engineering of cow guts so they burp and fart less methane or the now defunct Enviropig, whose salivary glands were genetically modified to help pigs digest phosphorus in feedstuffs to reduce phosphorus pollution in the environment.³⁷ The objects of these interventions are macro-organisms but they nonetheless fully embrace precision biology in order to alter function.

³⁴ Blanchette, *Porkopolis*.

³⁵ Mather and Marshall, "Biosecurity's Unruly Spaces;" Schoot and Mather, "Opening up Containment;" Lien, *Becoming Salmon*; Hinchliffe et al., "Biosecurity and the Topologies of Infected Life."

³⁶ Fish, *Living Factories*, 49.

³⁷ Walker, "Scientists Might Reprogram Cow Guts So Cattle Burp Less;" Science Daily, "Scientists Improve Transgenic 'Enviropigs.'"

In aiming to accelerate and augment growth, standardize output to create factory-like conditions, and contain risk, these four sets of strategies are surely undergirded by a logic of efficiency. For, what is the point of these efforts if not to maximize food output while reducing costs and the use of scarce (and hence costly) resources? Indeed efficiency has long been critical for food producers to survive in the low margin, competitive business of agriculture, who adopt yield-enhancing technologies precisely to stay in business. In a dynamic the agricultural economist Willard Cochrane described as a treadmill, farmers are virtually compelled to adopt technologies that bring higher yield and/or reduce cost. Early adopters initially make greater-than-normal profits from selling more. However, such yields eventually negatively affect crop prices because other farmers join in and price competition ensues, driving those who are not efficient out of business entirely. The majority of farmers lose out but consumers may win, as food becomes increasingly cheap.³⁸ This theoretical depiction of agri-food system dynamics still holds today, with the consequence that the number of farmers continues to decline, while food is increasingly cheap.³⁹

While perhaps obvious, it is also important to note that this logic of efficiency has been coupled with a biopolitics that fundamentally favors human life over plant and animal life and specifically favors abundance and cheapness in order to sustain human life in its current formations. Yes, the human life that bio-industrialization aims to sustain has always been selective. Indeed, in the service of abundant agricultural production, some human lives have been made quite disposable.⁴⁰ To grasp this point, one need look no further than the rates of COVID-19 incidence in the US among food and farming workers who were deemed “essential” but were otherwise given virtually no protection while the pandemic raged. But this does not obviate the salient anthropocentrism of bio-industrialization. As put by eco-modernist Nordhaus, “agricultural systems that do not both increase the productivity of land under cultivation and capture as much of that productivity for human consumption as possible will be neither practical nor sustainable.”⁴¹ The problem, of course, is that many of these developments undergirded by a

³⁸ Cochrane, *The Development of American Agriculture*.

³⁹ Food prices are affected by dynamics other than farm prices, however, and retailers especially have great latitude in consumer pricing.

⁴⁰ Guthman, “Lives versus Livelihoods?”; Li, “To Make Live or Let Die?”

⁴¹ Nordhaus, “The Environmental Case for Industrial Agriculture.”

logic of efficiency have produced all manner of violence to environments, humans and non-human animals, as well as set up the conditions for formidable blow-back on any number of fronts: pesticide resistant pests and diseases, antibiotic resistance among human and animal populations, biodiversity losses, honey bee colony collapse, water and air quality deterioration, climate change, and the rest. Efficiency has consequences, as the following two examples of exceptional bio-industrialization, drawn from recent ethnographies, make abundantly clear. Countenancing these consequences may give cause for skepticism about the hyper efficient, means of protein production envisioned explicitly in the RethinkX report and present in many future food promises.

The salmon and the pig

In *Becoming Salmon: Aquaculture and the Domestication of Fish*, Marianne Lien describes the highly controlled salmon fisheries of the Norwegian fjords. Hers is not a treatise on bio-industrialization – for her the operative word is, interestingly, domestication – and her aim more generally is to model a multi-species ethnography of practice. But her insights about scalability are relevant and roughly analogous to my treatment of bio-industrialization. In these operations, salmon are raised in netted pens that reach out into the fjords, each containing from 50,000 to 80,000 genetically identical salmon, which swim in circles and are fed with pellets several times a day. In this system standardization is critical for efficiency. For example, undersized fish are disposed of because otherwise they will be incorrectly punctured when they go through the vaccination machine. Sanitation is critical as well: dead fish are quickly removed, and all human visitors must dip their boots in disinfectant before reaching the salmon domicile.⁴²

These are highly scaled up operations, but for Lien scalability is decidedly not about the extensification of production over space. It is about the smoothing of temporalities so as to allow continuous production – what she calls “detachments.” In the hatcheries, temperature-controlled water and specialized infrastructures of tanks and trays are used to simulate the conditions of riverbeds where wild salmon seasonally spawn. Blackened roofing materials and electrification are used to block out seasonal changes so smolts can be delivered to the fjord operations twice a year. Scalability also entails the extraction from context and the erection of infrastructures that

⁴² Lien, *Becoming Salmon*.

allow spatial consolidation and containment of fish production, enhancing efficiency and attempting to minimize risk.⁴³

But keeping fish in a consolidated place and smoothing temporalities in the name of efficiency is not seamless. For one, it requires bringing material from elsewhere. Outside the frame of the wholly contained fishery are the dehydrated fish pellets used as feed that are transported from as far away as the South Pacific and Peru. There are also leakages of containment: some fish escape into the surrounding fjord, breeding with river salmon and also infecting them with sea lice, a parasite that is assumed to flourish with the concentrated operations.⁴⁴ For that matter, sea lice are treated with chemicals harmful to workers' bodies.⁴⁵ As Lien argues, sustaining life in these conditions, requires constant observation and tinkering, making it a "fragile miracle" where much can go wrong.⁴⁶

What can go wrong in bio-industrialization is even more salient in Alex Blanchette's *Porkopolis: American Animality, Standardized Life, and the Factory Farm*. The industrial pig described in *Porkopolis* is a product of a cross of multiple historical breeds of boars and sows to make "genetic" boars and sows which are then mated, through artificial insemination, to produce the standardized "commercial" sows. In addition to producing commodities that garner higher prices in global wholesale markets, "standardized life," as Blanchette puts it, "can reduce labor costs by enabling more machine-driven automation in slaughterhouses" and "generate biochemically consistent animals to build more commodities from their bodies."⁴⁷ Standardized porcine bodies also just fit into the highly cramped pens that populate the massive indoor barns where thousands of pigs are housed. To minimize the risk of catching disease, the pigs never set a hoof on soil, and their feed contains a cocktail of antibiotics. Workers themselves specialize in very specific tasks and are separated for biosecurity. Yet, what is perhaps most striking about the

⁴³ Lien, *Becoming Salmon*.

⁴⁴ Lien, *Becoming Salmon*, 30, 41. Writing about *Campylobacter* disease in the UK's confined chicken operations, Hinchcliffe et al argue that disease outbreaks tend not to result from invasions of hostile species crossing space; rather they stem from convergences of events within confined and temporally compressed spaces that intensify relationships among organisms, bringing immanent qualities to the surface to create pathological conditions. "Biosecurity and the Topologies of Infected Life." See also Mather and Marshall, "Biosecurity's Unruly Spaces."

⁴⁵ Lien, *Becoming Salmon*, 53.

⁴⁶ Lien, *Becoming Salmon*, 73.

⁴⁷ Blanchette, *Porkopolis*, 17.

bioindustrialized production system that Blanchette describes are the human interventions in the reproductive processes of pigs in the interest of productivity. Take the processes of artificial insemination: Workers manually stimulate the boars to ejaculate, and rather than rely on injections, workers also stimulate uterine contractions in the sows by straddling them to simulate a boar mounting. Thanks to selective breeding, “hyperprolific sows” routinely give birth to more piglets than they have nipples to nurse them, contributing to a widespread problem of runtting. Human workers find themselves manually nursing the runts in sometimes futile attempts to nurse them back to health.⁴⁸ Indeed, much of Blanchette’s account is about the ever more specific and care-laden labor processes to attend to the standardized hogs who, like Lien’s fish, are quite fragile.

It bears emphasizing that there is virtually no waste in the production system described by Blanchette, as just about every byproduct, including pig shit, is recycled into something: pet food, plastic coverings, the cement below our feet. Except for the invisible, everything from the pig becomes a source of value, made possible precisely because of the scale of these operations.⁴⁹ Even the “off-animals,” those that fail to standardize, are sold to niche butchers. In fact, engineers of this system aspire to a completely closed loop system, designed to eke out profit in an ever cheaper meat world.⁵⁰ But there is leakage in this system, too, and lots of it, as indicated in the deformed piglets, the antibiotic-laced air from desiccated manure, the smells that permeate the town, and the human bodies morphologically transformed to conform to very specific tasks of pig care.⁵¹

Blanchette and Lien, in short, not only bring into sharper focus the logics and practices of bio-industrialization. They also illustrate some of the limits: feed and other inputs that escape scrutiny, leakages of containment, efficiencies so great they produce death and deformity. What both texts make clear is that work to override temporalities and contain species in unfamiliar habitats, in the name of efficiency, may be the source of vulnerability in such production systems

⁴⁸ Blanchette, *Porkopolis*.

⁴⁹ Blanchette, *Porkopolis*. See also Cooper, *Life as Surplus*, 46-47; On transforming waste into value, see Landecker, “A Metabolic History of Manufacturing Waste.”

⁵⁰ Blanchette, *Porkopolis*.

⁵¹ Blanchette, *Porkopolis*. Also Blanchette, “Living Waste and the Labor of Toxic Health.”

rather than their strength. For Blanchette, in particular, the drive of efficiency is precisely the problem, making everything subservient to profit rather than to human and non-human flourishing.

Conclusion: continuity in the second domestication?

The kind and extent of bio-industrialization described by Lien and especially Blanchette present a formidable moral foil for current day alternative protein imaginaries. The practices and effects of livestock production are particularly horrific and not only for the animals and the ensuing food products, but also for the workers and surrounding communities. Cheap meat, as they say, comes at a high cost.⁵² So the vision of a food production system that avoids these practices is a compelling one. But is this the one?

There is no doubt that food production techniques that are lab-based, not farm-based, that involve micro-organisms, not sentient animals, and that enroll micro-organisms which reproduce infinitely more quickly and painlessly than livestock and fish differ substantially from bio-industrialization as we know it - indeed different enough to threaten major displacements of animals and humans. Nevertheless, several of the logics of alternative protein production, especially as expressed in RethinkX's predicted second domestication, appear continuous with contemporary bio-industrialization.⁵³ For the premises of this entire approach – what promises to make food cheap and abundant – is complete detachment from temporalities and habitats to allow continuous production to take place in the confined, presumably riskless spaces of the bioreactor instead of the CAFO or aquaculture pen. Rather than bothering with animals and their pesky reproductive, developmental and seasonal requirements and their situatedness in habitats and space, their life building blocks and surrounding microbial ecologies can be extracted, molecularized, and managed with precision. Yet like its conventional foil, the supplementations and leakages that are part and parcel of such systems are often out of view. The predictions and promises do not discuss from where its inputs will come, nor where its wastes will go, nor the

⁵² Carolan, *The Real Cost of Cheap Food*; Patel and Moore, *A History of the World in Seven Cheap Things*.

⁵³ Spackman similarly suggests that lab grown meat potentially replicates the logics of industrial agriculture although her focus is the molecularization of food ingredients and its impact on human health. "The Problem with Lab-Grown Meat."

resource intensive infrastructures that are required to build and maintain bioreactors.⁵⁴ Just like the pork companies do, promoters of this new vision for food production, portray a closed loop system, neglecting that some of the most pernicious waste is that which is not acknowledged or reused at all. It is as if, as Metcalf puts it in relation to cellular meat, its production would have no impact whatsoever - “molecularly tuned flesh with no body and thus no apparent ecology.”⁵⁵

Nor is this vision a wholesale departure from the biopolitics of bio-industrialization. The RethinkX report may be unusual in not discussing animal welfare or rights issues in its vision, but it shares with others in the alternative protein sector a hubristic sense that life can and should be managed on humanity’s behalf. At the same time, reflecting bio-industrializations prior, it is rather callous regarding the implication of this transition for human producers. Estimating a loss of 1.7 million jobs in US livestock and fisheries by 2035, the report imagines this will be cushioned by “job creation for fermentation farmers, bioengineers, protein engineers, metabolic engineers, cell biologists, computer scientists, IT workers, food scientists and designers, nutritionists, and other similar professions” – as if these kinds of jobs are interchangeable with today’s food and farmworkers.⁵⁶ For that matter, in representing a world free of manual labor, inclusive of only the mental labor of so-called professionals and scientists, it neglects that even bioreactors require maintenance, including filling, cleaning, sanitizing, and waste removal, undoubtedly under extreme temperatures and unnatural light, and that food distribution of any kind requires the routine labor of packaging and shipping. As Blanchette’s work shows, highly efficient animal production can mean intensely strenuous work for those not automated out of their jobs.⁵⁷ This future of abundance, much like that of the past, caters to those who value cheap food, not workers who want to flourish with adequate income, minimum exposure to harmful substances, and the avoidance of working conditions that alter their own bodies.

⁵⁴ Guthman and Biltekoff, “Magical Disruption?” To this point, Life Cycle Analyses (LCA) of cultured meat, necessarily anticipatory since the technology has not yet been commercialized, have thus far shown uncertain environmental benefits, precisely because LCA attempts to incorporate cradle-to-grave supply chains. Mattick, Landis, and Allenby, “A Case for Systemic Environmental Analysis of Cultured Meat;” Mattick et al., “Anticipatory Life Cycle Analysis of in Vitro Biomass Cultivation;” Santo et al., “Considering Plant-Based Meat Substitutes and Cell-Based Meats;” Stephens et al., “Bringing Cultured Meat to Market.” LCA has its limits, as well, as an assessment tool of sustainability. See Freidberg, “It’s Complicated.”

⁵⁵ Metcalf, “Meet Shmeat,” 75.

⁵⁶ Tubb and Seba, *Rethinking Food and Agriculture*, 65. Jönsson notes that questions of labor are entirely absent in discussions of scaling up cellular meat in Jönsson, “Benevolent Technotopias and Hitherto Unimaginable Meats.”

⁵⁷ Blanchette, *Porkopolis*.

The vision most accentuated in the RethinkX report, however, is its underpinning logic of efficiency. In many discussions of the future of food, the value of efficiency reflects a kind of environmentality which imagines that the reduction of space, time, and resources devoted to unseemly things will allow the good things to happen somewhere else, and do so without friction.⁵⁸ This is a very different environmentality than one involving mixings of diverse species living in situ and managed with attentiveness to species needs – what Lorimer calls a probiotic sensibility of living-with – which may be imperfect but also more realistic in the long run.⁵⁹ This latter environmentality is that of agroecology and regenerative agriculture, neither of which are countenanced in the visions of food production expressed in the RethinkX report and, for that matter, much of the agricultural and food technology space.

RethinkX conveys a particular imagination that sees highly abundant microorganisms fermented in bioreactors as the only alternative – an alternative driven by technoscientific knowledge about what *can* be done, underpinned by values that appear to go without saying. Those writing in the vein of critical future studies warn against imaginations of the future that are intensifications of the present because they can foreclose other possible futures.⁶⁰ As this article has suggested, already existing intensification in agriculture has produced great fragility, because biology is not always so controllable. It is hard to know the exact points of vulnerability of the CAFO in the bioreactor, but it is hard to imagine they will not exist. So, regardless of whether the techniques are new, and that they will involve micro-organisms that presumably experience far less pain than livestock animals, there is no guarantee that they will be more ecologically benign than that currently on offer. The humanist utilitarianism of efficiency has rarely made things so. The differences in technique and practice should not obviate the possibility that the logic of efficiency may be the problem, and rethinking the rethinking may well be in order.

⁵⁸ This in essence is the argument for “land sparing” versus “land sharing.” See ecomodernist Ted Nordhaus for a defense of industrial argument based on this argument. “The Environmental Case for Industrial Agriculture.”

⁵⁹ Lorimer, “Probiotic Environmentalities.”

⁶⁰ Goode and Godhe, “Beyond Capitalist Realism;” Vint, “Introduction to ‘the Futures Industry;” Powers, *On Trend*.

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