On Resurrected Nuggets and Sphincter Windows: Cultured Meat, Art, and the Discursive Subsumption of Nature.

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Abstract

In this article, I scrutinize three art, design, and architecture projects engaging with "cultured," or "in vitro," meat (primarily muscle cells cultured outside of bodies) to illuminate the entanglements of academic and extra-academic environments that have characterized cultured meat's history to date, and the conversations that this technology has spurred. In envisioning new ways of eating, and living, these projects (a book of hypothetical recipes, The In Vitro Meat Cookbook, Catts and Zurr's bioartistic engagements with tissue engineering, and Terreform1's tissue-house prototype "The In Vitro Meat Habitat") illustrate cultural practices thought to be enabled by cell culturing's new applications. Emphasizing such visions and conversations allows me to highlight an inattention to discursive dynamics within research on natures subsumed to industrial production processes (Boyd, Prudham, and Schurman 2001). But engaging with the "subsumption of nature" framework simultaneously allows me to problematize artistic visions presenting nature as fully malleable.

Keywords: Art, biotechnology, discourse, meat, representations, subsumption of nature

Introduction

Set against the attention that animal agriculture's environmental impacts attract (Baroni et al. 2007; Gerber et al. 2013; Weiss 2013), "cultured" (Datar 2016) or "in vitro" meat (meat produced outside bodies; *in vitro*: Latin for "in glass") is today promoted as a technology for rendering meat sustainable (Post 2014a; Mattick et al. 2015; Moritz, Verbruggen, and Post 2015; Tuomisto and Teixeira de Mattos 2011). The guiding vision is to remake meat production's material basis to allow meat eaters to continue to consume meat—only in more environmentally friendly forms. Such a vision fits well with this special issue's focus on the "subsumption of nature"—how nature-based industries strive to work around or rework nature for their benefits (Boyd, Prudham, and Schurman 2001). It is closely related, as well, to analysis of the increasing importance of environmental concerns in co-determining how nature is subsumed (Carton et al. this issue; Cooper this issue).

However, spectacular scenarios for the food culture that meat culturing could enable often sit alongside visions for sustainable meat production. Activist-*cum*-entrepreneurs speak of culturing meat at gastro-pub-like "carneries" (Datar and Bolton 2014), while academics speculate that "in the future we might all have a pig in our backyard or in our local community, from which some stem cells are taken every few weeks in order to grow our own meat, either in a machine on our kitchen sink or in a local factory" (van der Weele and Driessen 2013, 655). Through circulation of such scenarios, cultured meat becomes "a communication technology that brings publics into communion around environmental issues of food production" (O'Riordan, Fotopoulou, and Stephens 2017, 160).

By scrutinizing how artists, designers, and architects have engaged with cultured meat, I center this article on this "communication technology" element. This allows me to illuminate cultured meat-centered visions and debates, as well as the entanglements of academic and extra-academic environments that have characterized cultured meat's history (see also Stephens and Ruivenkamp 2016; Jönsson 2017). The projects analyzed—*The In Vitro Meat Cookbook* (van Mensvoort and Grievink 2014), Catts and Zurr's (2005, 2008, 2013) bioart, and Terreform1's "In Vitro Meat Habitat" (Joachim 2010; Joachim and Tandon 2014) — span from the first cultured muscle cells ever served as food to a book involving designers and design students alongside world-leading cultured meat researchers to a cultured house prototype. Together, these exemplify how artistic explorations enmesh cultured meat with hopes for humane, sustainable, and exciting animal products, and with debates on biotechnology. In line with science and technology studies (STS) scholars underlining the importance of future visions within biotechnology (Brown 2003; Cooper 2008; Fortun 2012; Taussig, Hoeyer, and Helmreich 2013), I underscore the importance of speculation, stories, and conversations. Thereby, my analysis of artistic engagements enables furthering a discussion on the subsumption of nature.

In developing the subsumption of nature framework, Boyd, Prudham, and Schurman (2001) emphasized how nature-based industries, through what they called the "formal" subsumption of nature adapt to the biophysical and geophysical properties of the kind of nature worked with or, through what they call the "real" subsumption of nature, instead remake nature to "work harder, faster, and better" (Boyd, Prudham, and Schurman 2001, 564). Herein, cultured meat can seem like a clear-cut example of how nonhuman animals' bodies are remade (or rather, made away with) for the benefit of (post)animal agriculture. But in contrast to how Boyd, Prudham, and Schurman (2001) accentuated industries intermittently adapting to, striving to control, and materially remaking natures, exploring cultured meat's art and architecture presence also enables underscoring discourse's role in the subsumption of nature (Bumpus 2011; Robertson 2012).

The projects analyzed in this article offer more than stories of cultured meat, however. Through engaging in cell-culturing attempts of their own, some artists in a very direct way illuminate tensions between techno-optimist hopes and the material realities of cell culturing. Although proponents frequently describe cultured meat as a successful real subsumption of animal bodies (Datar and Bolton 2014; Joachim and Tandon 2014), such depictions clash with how cultured cells cannot be fully controlled (Landecker 2009, 2016).

Where my first ambition concerns relative silences within the Boyd et al. framework, this second ambition offers an opportunity to draw on one of their framework's strengths, invoked in the introduction to this issue as a "layered ontology of nature" (Carton et al. this issue). Transcending sometimes repetitive debates on whether nature is "socially" constructed (Smith 2008; Vogel 2015), Boyd et al. instead offer an opportunity to take the possibilities and limitations inherent to particular political–economic, geophysical, and biophysical processes seriously within a framework where nature can be simultaneously socially produced and impossible to fully socialize.

In the next section I discuss the subsumption of nature literature. This is followed by an introduction to cultured meat, in the third section. The fourth section explores how cultured meat figures in the three projects examined here. In the fifth section, and in the conclusion, I return to what my account means for further discussions on cultured meat, and on the subsumption of nature. The article is built on a close reading of the three art and design projects, including how they have been presented by their creators. In this analysis, I also draw on participant observations at workshops, seminars, and conferences on cultured meat, and 20 interviews with researchers and cultured meat proponents, conducted for a 3-year research project on cultured meat's political ecology.

The Subsumption of Nature, Biotechnology, and Speculation

Sixteen years ago, drawing an analogy to Marx's (1976) notion of the real and formal subsumption of labor under capital, Boyd, Prudham, and Schurman (2001, 556) developed their notion of the real and formal subsumption of nature to account for how nature "matters to the dynamics of industrialization" as a set of "obstacles, opportunities, and surprises."

Arguing against nature as socially produced, they strove to emphasize the importance of natural resources' physical properties, claiming that the "social production of nature" school (Williams 1980; Smith 2008) tended "to minimize the influence of nature as a material force" (557). But simultaneously they took issue with how attempts to explore the difference nature made to political–economic processes (O'Connor 1988; Benton 1989) tended to "see nature as a set of relatively rigid constraints or obstacles facing capital[,] understood primarily as a feature of the firm's external environment rather than as part and parcel of the basic problem of organizing and implementing production" (557, 561).

Following the Boyd et al. framework, nature is not simply "produced" (Smith 2008), or "built" (Vogel 2015), but neither is it merely an external, limiting, factor. Rather, various kinds of nature are understood as co-determining how particular firms operate—dialectically shaping and shaped by the actions of laborers, capitalists, and scientists. In underlining the necessity of empirical work "to unpack the actual process of social and environmental change in nature-based industries and to relate those processes to specific industries, in specific places, during specific historical periods" (567–68), Boyd et al. (2001) in essence urge scholars to take both political economy and nature seriously, while moving beyond a focus on Nature and Capitalism as (all-too-)broad, monolithic, categories (see also Sunder Rajan 2012).

For their framework, a distinction between biologically based and non-biologically based industries is central. In the former, natures encountered are transformed and thus subsumed in real terms. In the latter, firms instead "confront the biophysical world as an exogenous set of stocks or flows, biophysical processes, and material characteristics" (Boyd, Prudham, and Schurman 2001, 562). A distinction is thus made between sectors (e.g., mining) where firms adjust to natures, and those where nature is, again, "(re)made to work harder, faster, and better" (564). Herein, firms not only successfully confront, but (from their standpoint) improve processes.

Boyd et al. place breeding and biotechnology at the "extreme" end of such transformations. To them, "the primary vehicle driving the real subsumption of nature is the manipulation of the genetic program, both through traditional breeding programs and, more recently, through the application of new biotechnologies, such as recombinant DNA techniques" (Boyd, Prudham, and Schurman 2001, 564).

Reshaped animals thereby become prominent illustrations of the novel life forms that the real subsumption of nature generates. Shifting to newer biotechnologies, we additionally encounter dreams of purposefully engineered nonhuman animals whose bodies are no longer primarily functional for them or their kind, but for humans (Twine 2010; Fish 2013). Herein, also, cultured meat provides an evident example of biotechnology as "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use" (United Nations 1992, 3).

The subsumption of nature framework has inspired scholars to provide empirical examples— such as Prudham's (2003; 2005) work on how firms and state bodies adapt to Douglas fir trees within North American silviculture—and to further develop the framework. Here, it is the latter that have inspired me to highlight the subsumption of nature as a material-discursive process; this is largely overlooked in Boyd, Prudham, and Schurman's original account. In their article, Boyd et al. drew on conceptualizations of how natures (co) determine production processes to argue that "every industry is ultimately 'nature-based'" (Boyd, Prudham, and Schurman 2001, 567; see also Benton 1989; Castree 1995; O'Connor

1998). But they neglected how every industry is ultimately also discourse based. They thereby neglected how storytelling "is in no way … opposed to materiality. But materiality itself is tropic; it makes us swerve, it trips us; it is a knot of the textual, technical, mythic/ oneiric, organic, political, and economic" (Haraway 1994, 63).

Some scholars drawing on Boyd, Prudham, and Schurman's framework do focus on materiality and meaning-making alongside each other, however. Semiosis is remarked in Robertson's (2012) account of the creation of "a world of ecosystem services" made possible through "a group of committed thinkers dedicated to the problem of defining and debating new technologies for quantifying value" (Robertson 2012, 390). Here, Robertson (2012, 397) explicitly warns against how bracketing "nature as 'material' or as an unmediated force in capitalist accumulation prevents us from discerning the struggle over the creation of value-bearing abstractions from its materiality." For ecosystem services, instabilities can consequently arise "at the point at which we (scientists, stakeholders, etc.) retract our consent to the adequacy of social abstractions as bearers of value" (Robertson 2012, 396).

Similarly, Bumpus (2011), situating the Boyd et al. study alongside Robertson's (2004, 2006) work on natures made legible to capital, surveys two Hondurian offset projects. Commenting on how offset commodities are produced through "socionatural-technical complexes," he identifies such commodities as "at once both material and discursive, relying on the actions and agency of a number of actors and components of 'nature' in order to construct emissions reductions and turn them into tradable commodities" (Bumpus 2011, 630). Bumpus thus underscores the tensions between socioecological relations at sites where offset projects are implemented and the forces that "through a representational and physical (discursive and practical) cut … create units of nature that are deemed socially useful (i.e., credits that represent a tonne of emissions reduction)" (Bumpus 2011, 619). Again, emphasis lies on natures materially remade because they are discursively subsumed under capitalist environmentalism.

As mentioned in the introduction, representations are also central to the field that Boyd et al. underscore as a prime example of nature's real subsumption: biotechnology. Here, Brown and Michael (2003, 4) emphasize how "new and emerging aspects of biotechnology commonly exhibit intense and competing discussions about their future promise." With biotech companies frequently gaining attention before producing any commercially available products, projects can instead become geared toward producing attractive scenarios (cf. Brown and Michael 2003, 16). Writing around the time of the early-21st-century biotechnology boom, Fortun (2001, 143) similarly underlined genomics stocks as "story stocks" "whose value even more so than 'regular' stocks, is contingent upon the kind of narrative that can be spun around them." In the social sciences and science studies literature on biotechnology, "hype" (Brown 2003), "promise" (Fortun 2012; Rose and Rose 2014), "potential" (Taussig, Hoeyer, and Helmreich 2013), or even a "biorevolutionary delirium" "where speculative mediations on the future of the life on earth are never far from the agenda" (Cooper 2008, 20) are underscored. Biotechnology could therefore simultaneously be regarded as "the primary vehicle driving the real subsumption of nature" (Boyd, Prudham, and Schurman 2001, 564), and a field where crafting future visions and new narratives can become as important as materially remaking natures.

Returning to Fortun's (2001, 417) emphasis on "story stocks," he stressed how their value relies "not only on genetic technologies but on that other set of technologies for simultaneously producing and evaluating anticipated, contingent futures: literary technologies." Highlighting the relationship between the inner workings of laboratories and the extra-laboratory world (Latour 1987, chap. 4; Sunder Rajan 2012, 17), we should remember that such literary technologies are seldom researchers' exclusive property. Rather, a whole raft of actors construct stories and scenarios, meaning that "participants in debates about new developments in science, technology and medicine can themselves become 'risk

factors', from the point of view of companies promoting these developments, with potential implications for regulatory approval, market acceptance and profitability" (Tutton 2011, 425).

Beyond biotechnology, emphasizing such dynamics also forms a continuation of a longer discussion on the relations between emerging technologies and the stories that are spun around them. As Belasco (2006, 96) comments for the history of food-centered future visions, "fiction and nonfiction engage in a constant dialogue and dialectic, a feedback loop of influence and reinforcement." Or, as Latour (1996, 23) argues, a technological project is, by definition, initially "a fiction, since at the outset it does not exist, and there is no way it can exist yet because it is in the project phase" (Latour 1996, 23).

Entanglements of fiction and nonfiction, of artistic appreciation and technological development, are perhaps most famously expressed in the Italian Futurist manifesto's call for patriotic poetry declaring "a roaring motor car which seems to run on machine-gun fire … more beautiful than the Victory of Samothrace" (Marinetti 1909). But a similar appreciation can also be seen in how machines in the 19th-century United States were "considered to be part of the sublime landscape[,] included in pastoral paintings as a harmonious part" (Nye 1994, 59). For railroads, such depictions were actively encouraged by owners and managers, "commission[ing] paintings of the landscapes visible along their lines" (59). Artistic engagement, then, should not be considered an issue of secondary importance vis-à-vis technological developments. For cultured meat, both the stories artistic engagements have generated and artists' more hands-on work with cell culturing could rather be considered central.

Introducing Cultured Meat

A prime reason that stories and artistic explorations could be considered central to cultured meat is that most people have only ever encounter cultured meat as a set of stories (cf. Jönsson 2016). This is, to follow Latour (1996), technological projects still mostly in their fictional stages. But at the same time, stories often surface as responses to scientists' attempts to turn meat culturing less fictional, establishing it as a new nature-based industry. To provide a sense of what stories comment on, I therefore devote this section to the history of meat culturing.

The first in vitro meat patent was issued in the Netherlands in 1999 (van Eelen, van Kooten, and Westerhof 1999), while the first cultured meat (if fish is considered meat) was produced by NASA-funded researchers in the United States shortly thereafter. These researchers cultured goldfish muscle explants to explore the possibility of utilizing in vitro technologies for supplying fresh animal muscle protein (and thereby maintaining crew morale) during a hypothetical 4-year expedition to Mars (Benjaminson, Gilcriest, and Lorenz 2002). Sometimes falsely credited with producing the first edible cultured meat (Catts and Zurr 2014), results of their experiments were merely presented to a four-person panel who deemed them acceptable based on the appearance and smell of cooked explants (Benjaminson, Gilcriest, and Lorenz 2002, 885).

In 2004, a state-funded Dutch in vitro meat consortium was founded, conducting research at three universities (Technical University Eindhoven, Utrecht University, and University of Amsterdam), 2005–2009. Though researchers involved in this consortium successfully cultured mouse cells, they did not generate any edible products (Haagsman, Hellingwerf, and Roelen 2009). Research building on the consortium's work, however, led to what became known as the world's first "lab-grown" burger (BBC 2013). In August 2013, this €250,000 beef burger was served to Maastricht University Vascular Physiology professor Mark Post (the head of the team producing the burger), journalist Josh Schonwald, and

nutritionist Hanni Rützler, who were subjected to tasting the burger in front of an audience at a ceremony also broadcast online. Such a conscious "'media show" was motivated by how the Dutch government had proven unwilling to extend funding to the in vitro meat consortium due to what it perceived as insufficient interest from both the private sector and the public (Post 2014a, 1040).

The 2013 burger was funded by Sergey Brin, Google co-founder; subsequent work by Post's team has partly been funded by money sourced through New Harvest, an increasingly influential North American nongovernmental organization (NGO). Especially since 2014, venture capital has also become prevalent. This shift from public to private funding, with a concomitant necessity to attract prospective investors' and donors' attention, has been identified as an important reason for both current research priorities and the often spectacular scenarios researchers and proponents circulate (Jönsson 2016).

In terms of how meat-culturing researchers attempt to subsume nature, three strategies can be discerned. The NASA-funded researchers cultured goldfish skeletal muscle explants "not only composed of muscle fibers, but also contain[ing] all the cell types generally associated with muscle in vivo" (Benjaminson, Gilcriest, and Lorenz 2002, 880). The 2013 beef burger was instead made by culturing muscle-specific stem cells (myosatellites) (Maastricht University 2013; Post 2014a). Such cells are "typically" cultured in media containing 20% fetal bovine serum, 10% horse serum, 1% chicken embryo extract, 1% antibiotics, and 4 m*M* of the amino acid L-glutamine (Rutjens 2015). Removing antibiotics and animal-derived inputs is, however, an explicit priority (Post 2014a). A frequently envisioned potential production technology, finally, is three-dimensional (3D) printing. Previously mostly associated with in vitro leather researchers of Modern Meadow, the ambition to produce 3D tissues has lately been emphasized also by Mosa Meat, a Maastricht University spinoff based in the research that generated the 2013 burger (interview, cultured meat researcher, October 2016). To be able to culture steaks indistinguishable from those taken from slaughtered livestock has become something of meat culturing's Holy Grail. Based in high hopes for 3D technologies, proponents and developers depict a future where nature could be remade to the extent that a steak, what Barthes (1972, 62) called "meat in its pure state," could be produced without slaughtering animals.

On Cultured Meat in Art

The preceding section provided a brief description of the emergence of cell culturing as a food production strategy built on radically remaking animal agriculture's material basis. In this section I turn to some of the ways that artists, architects, and designers have explored cultured meat to accentuate both cultured meat as a "communication technology" (O'Riordan, Fotopoulou, and Stephens 2017) and how artistic engagements relate to the research conducted. This should provide a foundation for reconnecting the material (real or formal) and discursive subsumption of nature in the next section. I begin with *The In Vitro Meat Cookbook* (van Mensvoort and Grievink 2014).

This lavishly illustrated book, bound in a tomato-red cover, was initiated by the Next Nature Network, a Dutch nonprofit exploring "how our technological environment becomes so omnipresent and autonomous, that we start to perceive it as a nature of its own" (van Mensvoort and Grievink 2014, 191). Initially engaging eight design students for 6 months, which at the time meant "doubling the amount of people in the world working on in vitro meat" (interview, editor, October 2015), members of the Next Nature Network strove to explore the creative potential of in vitro meat as an answer to what they perceived as a lack of attention to food culture among meat-culturing scientists. Over time, more than

100 students came to comment on in vitro meat through this initiative, with some students' proposals further developed for *The In Vitro Meat Cookbook* (interview, editor, October 2015).

The book compiles 45 recipes alongside three essays on what meat culturing could enable and an interview with the aforementioned Mark Post. Illustrating the prominence of spectacular scenarios, puns, and provocations within cultured meat discourse, in this interview he expresses visions for creating "hybrids of flamingos and giraffes, a minotaur, or a lamb with a rabbit head" (Post 2014b, 51). In the book, recipes and essays are organized in four chapters focusing on issues that the editors feel cultured meat could target: "Growing meat sustainably," "Avoiding harm to animals," "Preventing food shortages," and "Exploration of new food cultures." Though the book includes an essay criticizing meat culturing (Agapakis 2014), contributions thereby primarily create an enthusiastic depiction of future meals. While van Mensvoort (2014, 7) remarks that the book's aim "is not to promote lab-grown meat," it therefore (in line with the Next Nature Network's philosophy that nature "changes along with us") becomes a catalogue of techno-curious accounts of a world where meat eating is rendered resource efficient, animal friendly, and, perhaps above all, fun.

Readers encounter moldable, colorful, "magic" meatballs geared at "playfully familiarize [ing] children with the concept of in vitro meat" (van Mensvoort and Grievik 2014, 31), and a Kid's Cooking Kit as a "kid's version of mom and dad's countertop bioreactor" where a "window into the bioreactor chamber lets children keep track of their meat as it develops" (33). They encounter "Painless Foie Gras," making a "once-rare food … . abundant and affordable" to the extent that "pump jugs of pate de foie gras may appear alongside ketchup and mayonnaise at fast food joints" (59), and, in the recipe giving this article part of its name, nuggets made from cells sourced from the Oxford University Museum of Natural History's dried dodo bird specimen (57). All recipes are, moreover, accompanied by illustrations in red and white (and in some cases a photograph of what a finished product could look like), an ingredient list, and an evaluation of their technological feasibility. Cultured meat researchers' attempts to subsume animal bodies to animal-agricultural priorities hence translate into speculative visions for new food cultures.

These recipes are undoubtedly playful, but dismissing them as mere jokes would be a mistake. Speculation and spectacular statements are, again, central to biotechnology (Cooper 2008; Fortun 2012), while essays included in the book are authored by actors at the epicenter of cultured meat research and development. Besides Mark Post, New Harvest's Executive Director Isha Datar contributes by co-authoring an essay on how cultured meat could be made and served in "carneries" (Datar and Bolton 2014). This, Datar and Bolton argue, could dress "carniculture" "with similar connotations and aesthetics to the craft brew and farm-to-table movements" (155). Emphasizing the importance of stories to the fate of cultured meat, in the same essay they stress that the "new science of carniculture must be developed responsibly, driven by discourse from the beginning" (159).

While clearly a work of fiction, the ambition was, as one editor stressed, that the book should be fiction grounded in reality. The one- to five-star feasibility scale accompanying each dish was constructed through discussions with scientists. In developing their ideas, editors and students were furthermore collaborating with cultured meat researchers: Mark Post and Daisy van der Schaft, who were both working at the Technical University of Eindhoven at the time (interview, editor, October 2015).

In my second example, tissue-engineering technologies are instead applied in building construction. The "In Vitro Meat Habitat" was developed in 2010 by Mitchell Joachim, Eric Tan, Oliver Medvedik, and Maria Aiolova for Terreform1, a Brooklyn-based "Nonprofit Organization for Philantropic Architecture, Urban þ Ecological Design" (Terreform1, n.d.) as a way to "start thinking about what the future would be if architecture and biology became one" (Joachim 2010). Intended as "a 'victimless shelter', because no sentient being was

harmed in the laboratory growth of the skin," the "In Vitro Meat Habitat" was "an architectural proposal for the fabrication of 3D-printed extruded pig cells to form real organic dwellings" (Terreform1, n.d.). Such experimentations made Terreform1 the first architectural office to put in a molecular cell biology lab (Joachim 2010), while culturing pig tissue in this lab resulted in a 11 x 3 x 7 inch model that, according to its producers, "looked like a punctured football" (Joachim 2014, 30).

Predated by a project where Joachim pleated branches to form a house's structure, and followed by a chair made from cellulose secreted by genetically engineered *Acetobacter xylinum* bacteria, the house formed part of Joachim's vision for "bio-design" as "the next step toward a resilient harmony where humankind and nature seamlessly blend" (Joachim 2014, 33). Such ambitions included utilizing bodily functions as habitat functions. The In Vitro Meat Habitat, for example, included an idea to utilize the self-closing potential of sphincters (Joachim 2010), the cylindrical muscles found throughout animal bodies, from bloodflow-regulating precapillary sphincters, to eyes, anuses, or whales' blowholes. This function is, however, neither implemented in the prototype nor possible to achieve in cultured tissues today. Consequently, the house above all became a basis for discussions on architecture.

> It's important to declare that the maquette is both a vehicle for propaganda and a mechanism for awareness of the potentials for building with cells. It's as much a parody of yesterday's bioformalist architecture, as it is factual biological material. It is not meant to be actualized as a full house, but it serves as a highly informed case study for growing large volumes of in vitro material en masse. (Joachim 2014, p. 30)

Rather than a realizable prototype, the "primary goal of the meat house was to set the minds of industrial designers and architects on fire" (Joachim 2014, 32). Cells were coaxed to generate a maquette rather than pig tissue, hence providing a vivid example of the real subsumption of nature. But they were subsumed in order to elicit dreams ("a resilient harmony where humankind and nature seamlessly blend") and conversations, rather than to directly "work harder, faster, and better" (Boyd, Prudham, and Schurman 2001, 564) for nature-based industries.

Alongside fictional accounts and prototype construction, bioartists, "mixing artistic and scientific experimentation with the DIY [do-it-yourself] ethos of home chefs and backyard gardeners" (Carruth 2013, 89), have also produced edible cultured tissues. In 2003, Catts and Zurr served "frog steaks" (a *Xenopus* cell line grown over biopolymers; Catts and Zurr 2005) at the *L'Art Biotech* exhibition in Nantes. Such "steaks," the artists accentuated, should poke "fun at French taste and their resentment towards engineered food, and the objection by other cultures of the consumption of frogs as food" (Catts and Zurr 2014, 22). A full decade before Maastricht University's famous cultured meat burger, artists thus already served cultured meat, and their experiments have been acknowledged by scientists working on cultured meat (Langelaan et al. 2010). Artistic engagements should hence not be conflated with fiction-based engagements. Rather, both artists and researchers have engaged in both material manipulations and discourse. Underlining the multiplicity of various kinds of actors and actions involved in the development of technoscience (Latour, 1987), we could emphasize how Datar and Post both strive to further cultured meat research and development (Datar as the leader of the arguably most important NGO proposing cultured meat, Post as the head of a world-leading research team) and to provide spectacular accounts of what cultured meat could enable (see Datar and Bolton 2014; Post 2014b).

Like Joachim and Terreform1, Catts and Zurr also wanted to initiate discussions. Through producing what they denoted "semi-living" objects—"things that are both animate and inanimate, both part of an organism and outside it"—the artists wanted to call "into

question long-held belief systems and our perceptions of life and death" (Catts and Zurr 2002, 366):

> The realization that parts of the body (cells/tissues) can be sustained alive outside of the body and be made to grow into artificially designed shapes can lead either to a (false) sense of complete control over living materials (which seems to be the ideology governing the biotech industry) or to the understanding of the importance of communities and collaborative effort in the construction of complex systems (from the single cell to global society).

Similar to Terreform1's prototype, Catts and Zurr's work amounted to the real subsumption of nonhuman animals' tissue to artistic ends. The relevance of such work for discussions on nature's subsumption to capital and the relevance of the subsumption of nature framework for discussions on artistic explorations is what I devote the remainder of the article to.

The Nature of Artistic Subsumption

Punctured footballs, resurrected nuggets, semi-living frog steaks. The natures represented or remade through the projects accounted for in this article take different forms, and are intended to elicit different reactions. They also shed light on how the real subsumption of nature is not necessarily always about processes remaking nature to fit nature-based industries' requirements (cf. Boyd, Prudham, and Schurman 2001). In light of how they problematize techno-optimism, Catts and Zurr's bioartistic engagements, for example, sit uneasily with a capitalist–industrial ambition to increase nature's efficiency.

The three scrutinized projects furthermore engage with cell-culturing in media-specific ways. While the *In Vitro Meat Cookbook* allowed a full discursive subsumption where authors freely wove stories of meals yet to come, the In Vitro Meat Habitat had architects constructing a skin-cell model. Going further still, Catts and Zurr cultured cells for human consumption. In their experiments, cells' biophysical requirements affected the kind of stories that emerged.

In line with their ambition to unveil biotech-ideology's "(false) sense of complete control" (Catts and Zurr 2002, 366), Catts and Zurr's art undermines depictions of cultured meat as a successful real subsumption of nature. Unsurprisingly, therefore, some cultured meat proponents consider Catts and Zurr's work as leading attention away from cultured meat's potential environmental benefits, and thus consider their work detrimental to the development of meat-culturing (interview, New Harvest representative, June 2015). In sharp contrast to the *In Vitro Meat Cookbook*'s "avoiding harm to animals" theme or Joachim's visions for a "victimless shelter," Catts and Zurr are open about the less savory aspects of their work, underscoring how their art has involved extensive use of fetal bovine serum. For them, culturing 10 g of meat would require "serum from a whole calf (500 ml), which is killed solely for the purpose of producing the serum" (Catts and Zurr 2008, 133).

That cell culturing requires animal inputs illustrates a crucial obstacle when artists go beyond representations, where what is represented can otherwise be "reduced to the permanent status of the recipient of action, never to be a co-actor in an articulated practice among unlike, but joined, social partners" (Haraway 2004, 87). When artists and architects culture cells, these become co-actors, with nature as "time" (Prudham 2005) providing obstacles. As da Costa (2008, 371) emphasizes, "Little or no immediate feedback is received when you're working in a wet lab, no error message, no debugging software assisting you in correcting your mistakes." The increase in time this generates "usually means an increase in money as well" (da Costa 2008, 371). Consequently, while telling new stories might be

inexpensive, remaking natures can prove expensive. For example, Catts and Zurr approximated the production costs for the frog tissue served at *L'Art Biotech* at $650/gram (Catts and Zurr 2013).

This reconnects to one of Boyd, Prudham, and Schurman's (2001) core arguments for taking the way nature matter seriously: to stress how research on nature-based industries must avoid forms of pure social constructivism that overlook "the significance of the biophysical world" (Boyd, Prudham, and Schurman 2001, 557). In problematizing their account, my ambition has certainly not been to simply supplant their emphasis with an emphasis on nature as idea. That I emphasize the importance of stories should not be read as a disregard of the biophysical properties of the nature (nonhuman animals and their cells) that these stories depict. Like Robertson (2012) or Bumpus (2011) before me, I hope to have shown how the subsumption of nature can productively be viewed as a materialdiscursive process where neither the materiality of nature nor how nature is represented should be overlooked. My ambition has here been both to explore speculation and visions as underemphasized features within the subsumption of nature framework, and to problematize those representations that reduce cultured cells to passive "recipient of action" (Haraway 2004). This latter tendency becomes evident when some depictions place cultured meat in a firmly cell-based worldview. As Joachim and Tandon (2014, 6) argue:

> The main builders and workhorses within the robust, adaptable biological world are cells. These are the most basic structural and functional unit of all known living organisms, the smallest unit of life that is classifiable as a living thing: nature's building block.

In their cookbook chapter, Datar and Bolton (2014, 153) offer a similar framing, arguing that "[r]ather than raise an entire complex organism only to harvest these tissues, why not start at the basic unit of life, the cell, to produce meat?" To speak of cells as "nature's building blocks" or as the "basic unit of life" is undoubtedly a powerful way of asserting cultured meat's viability. Discourse here functions as a force suggesting that nature can be fully subsumed because it can be built, block by block, "from the cell up rather than the organism down" (Datar 2015).

Underscoring full control, such metaphors sit well both with a long-standing modernist belief in mastering nature (Nye 1994; Scott 1998) and with hopes of deliberately fine-tuned life forms prominent in biotechnology (Rose and Rose 2014). But one should remember that there is an immense difference between cells as building blocks and, say, bricks as building blocks. The latter can be stored away for long periods. whereas the former require sustained attention. As Catts and Zurr (2005, n.p., emphasis in original) comment, their "*semi-living* rely on the nurturer/constructor to care for them." Though seductive, building-block metaphors thus overlook how no living entity could survive outside of its relations with the rest of the world (Levins and Lewontin 1985, 89).

While the cultured meat prototypes that have hitherto surfaced (produced by artists and tissue engineers) signal the real subsumption of nonhuman animals, they could therefore "merely" amount to the formal subsumption of cells. At the cellular scale "the productivity of natural processes remains unchanged" (Boyd, Prudham, and Schurman 2001, 567), which is precisely why cultured cells require care. The real subsumption of nature here rather becomes a scalar reorganization of nature's formal subsumption, with cell-culturing researchers and bioartists alike forced to adapt to cells' requirements (see Landecker 2016).

Conclusions

In this article I have discussed three examples of artists, designers, and architects engaging with meat culturing to illustrate how cultured meat, as simultaneously a biotechnology and a "communication technology" (O'Riordan, Fotopoulou, and Stephens 2017), both provides a prominent example of the (seemingly) real subsumption of nature and becomes the technology at the center of conversations on what meat could become.

In artistic explorations remade animal tissues, as nature subsumed, become the foundation for envisioning new ways for families to interact in cooking (Kids Cooking Kits and Magic Meatballs) or for setting "the minds of industrial designers and architects on fire" (Joachim 2014, 32). But cultured meat also becomes a way to criticize the biotech industry's governing ideology of "a (false) sense of complete control over living materials" (Catts and Zurr 2002, 366). Rather than a neat story unfolding, artistic engagements thus generate stories that sit together somewhat uneasily. Just as material nature "poses a unique set of obstacles, opportunities, and surprises" (Boyd, Prudham, and Schurman 2001, 556), obstacles, opportunities, and surprises here arise from how stories make reshaped natures (and attempts to reshape nature) legible to capital, consumers, or critics (cf. Robertson 2006; 2012).

In such stories, comments on current meat-culturing developments matter. But so do depictions of what is currently impossible, such as reviving dead dodo tissue or engineering sphincters as habitat features. Such spectacular (if perhaps never realizable) visions can offer research directions, attract attention, and shape companies' fortunes (Fortun, 2001; Brown 2003; Tutton 2011). Fiction and nonfiction, art and technology, can thereby become part of the same simultaneously material and discursive processes through which natures are subsumed (cf. Bumpus 2011).

While it is too early to tell just how stories and scenarios might shape cultured meat's future, we can conclude that they are deemed important enough for key figures within cultured meat development to engage with. This is unsurprising. Stories can add hype, vital when researchers hunt for venture capital (Post 2014a; Jönsson 2016). Speculation is unarguably integral to capitalist development. However, if problematizing techno-optimist visions, stories can also undermine researchers' and developers' efforts (Jönsson 2017). As Robertson (2012) remarked, materially remaking nature hinges on consent concerning how nature should be treated, and artistic explorations of the kind dealt with in this article can contribute to making or breaking such consent.

For cultured meat artistic engagements can, as shown here, be pushed even more to the forefront. Meat culturing is not only a nature-based industry commented on by artists; meat-culturing scientists acknowledge that artists served cultured meat before they did (Langelaan et al. 2010). Subsuming nature to initiate debates predated attempts to subsume nature to postanimal food production. As Catts and Zurr's work vividly illustrates, artistic engagements are not fictional. The conversations their bioartistic explorations initiate arise from how they run up against the same obstacles and opportunities as cell-culturing researchers. This returns us to the continued usefulness of Boyd, Prudham, and Schurman's (2001) emphasis on material nature—within an account emphasizing stories, "literary technologies" (Fortun 2001), and the potential impact of "participants in debates"(Tutton 2011).

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