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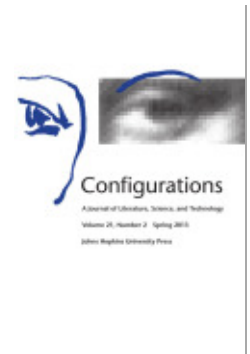
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Growing Meat in Laboratories: The Promise, Ontology, and Ethical Boundary-Work of Using Muscle Cells to Make Food

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ABSTRACT: Over the last decade, several clusters of scientists have been using animal cells in an attempt to grow meat. Known as *in vitro*, or cultured, meat, the technology involves tissue engineering muscle cells for potential consumption as food. Those supporting the technology articulate a diversity of potential benefits in producing meat in this way, which include environmental-, health-, innovation-, and animal-welfare-related benefits. This essay reports on interviews with scientists and animal activists involved in making and promoting *in vitro* meat (IVM). While the technology remains in its infancy, its promotion has assertively been pursued with a set of promissory narratives designed to enroll potential funders, commercial investors, and consumers. The essay explores the *ethical boundary-work*—the drawing of boundaries around what constitutes ethical scientific practice—pursued in the creation of socio-technical expectations around IVM. In particular, it focuses on the emergence of an animal-libratory promissory narrative by exploring how ethically correct practice toward animals is constructed and used to underpin notions of what IVM *is* and what it can *do*. The key contributions of the essay are to provide a detailed analysis of the situated ethics of IVM, and to make explicit the relatedness among ethics, promise, and ontology.

In vitro—or cultured—meat (IVM) involves growing muscle cells to form tissue that can be eaten as meat. This technological innovation is being pursued by several clusters of scientists in the world today who identify a range of important socio-technical challenges that,

they argue, tissue-engineered meat products could help address. In the context of this special issue, the focus of this essay is the promissory narratives associated with the technology that suggest that it can benefit other animals. It uses interview quotations—first from scientists developing IVM, and second from people with an existing association to animal-advocacy positions who have actively supported IVM—to demonstrate the broader articulations of how IVM can deliver a form of liberation for animals. In so doing, it reveals some of the complexities and challenges of establishing this promissory narrative, and how nuanced ethical framings are used by people in the field to deal with these. The distinctive contribution of this essay is twofold: first, it provides a detailed analysis of the situated ethics of IVM by articulating the ethical issues in relation to animals as they are understood by people active in the field; and second, it makes explicit the relatedness among ethics, promise, and ontology, drawing together existing literatures on the sociology of expectations and situated ethical analysis.

IVM is an early-stage technology. The main research laboratories are based in the United States, the Netherlands, Canada, and Sweden. These are typically small research groups of a handful of scientists that are exploring basic mechanisms of muscle formation: in Utrecht, they are trying to derive an embryonic stem cell line from cows; in Gothenburg, they are exploring ways of binding muscle cells to larger starch cells to increase bulk; in Alberta, they are looking to culture turkey fibroblasts; and in Missouri, they are applying three-dimensional printing technology to the production of muscle cells. In all of these cases, only very small quantities of tissue are produced, if any at all. The early-stage technology within the field has led some individuals to argue that the discursive genre of IVM remains, in important respects, a species of projective science fiction.¹ In an effort to address this perception, a team at Maastricht University are (at the time of this writing) working on what is, perhaps, the most high-profile development in the field: the production of the world's first in vitro burger. In the course of over a year, the team has been repeating a process of growing muscle cells taken from cows into small slivers of muscle tissue, which are then frozen down. Once enough is collected, the team plans to thaw the tissue and assemble it in the form of a burger, to be cooked and consumed during a press conference, with the intention of demonstrating to the world that IVM is real and to be taken seriously.

1. Susan McHugh, "Real Artificial: Tissue-cultured Meat, Genetically Modified Farm Animals, and Fictions," *Configurations* 18:1-2 (2010): 181-197.

These claims and counter-claims over the status of IVM reflect the inherent ambiguities surrounding what is a very unusual technological development. The techniques used were developed in biomedical settings in areas such as tissue engineering, stem cell science, and regenerative medicine, which propose to grow healthy tissue from cells to transplant into patients or to understand disease. In such research attempts, culturing, or growing, tissue is quite normal. What makes IVM unusual is the intention to use tissue engineering to produce food for human consumption. Of course, meat production has a long history of scientific intervention,² but up till now all of these approaches have culminated in the killing of a nonhuman animal, which is subdivided into parts, some of which are then eaten. With IVM, there is no whole animal to subdivide in this traditional sense; instead, the tissue is grown from cells. Birth, growth, and death appear in quite different forms to any farming method that has hitherto been used. IVM is unusual from both a biomedical and meat-production perspective.

This capacity to transgress and disrupt the established boundaries around biomedicine and meat production has led me, among others, to point to the ontological ambiguity of IVM.³ This tissue does not easily fit into the categories with which we make sense of meatness and animal kinship. So distinct is this form of meat production from prior methods, that what IVM actually *is*—its status as meat and how it fits with conceptualizations of life and death—remains contested and unclear. This ambiguity underlies Cor van der Weele's observation that IVM provokes both "wow" and "yuck" responses when people are first confronted by the notion.⁴ It is unusual because it is different, but it is also unusual because it lacks a broadly accepted understanding of what it is and what it can do. In this essay, I document some of the promissory and boundary work undertaken by those in the field to assert a meaning, and a vision for productive use, for IVM in relationship to animal liberation.

2. Richard Twine, *Animals as Biotechnology: Ethics, Sustainability and Critical Animal Studies* (London: Earthscan, 2010).

3. Neil Stephens, "In Vitro Meat: Zombies on the Menu?" *SCRIPTed* 7:2 (2010): 394–401; Clemens Driessen and Michiel Korthals, "Pig Towers and In-Vitro Meat: Disclosing Moral Worlds by Design," *Social Studies of Science* 42:6 (2012): 797–820; McHugh, "Real Artificial" (above, n. 1).

4. Cor van der Weele, "In Vitro Meat: Promises and Responses: Cooperation between Science, Social Research and Ethics," in *Global Food Security: Ethical and Legal Challenges*, ed. Carlos M. Romeo Casabona, Leire Escajedo San Epifanio, and Aitziber Emaldi Cirión (Wageningen, the Netherlands: Wageningen Academic Publishers, 2010), pp. 507–512; van der Weele, "A Taboo on Moral Solutions," *Simulacrum* 15:3–4 (2007): 28–30.

Promissory Narratives

There is now a broad literature within the sociology of expectations that explores the role of future orientated visions for the application of new technologies, to the ongoing framing of these technologies in the present. Drawing on this literature, I argue that IVM is what Adam Hedgecoe calls a promissory science, one that “exists more in the speculations and promises of its supporters than in terms of scientific results and marketable products.”⁵ While today, the field is short on published papers and even shorter on edible tissue, it does not lack for speculation or promise. A diversity of promissory narratives have developed rationales for why we should invest in IVM technology: for example, the environmental benefits of meat production with lower greenhouse-gas emissions; land, water, and energy use;⁶ the health benefits of meat with no animal disease or antibiotic buildup;⁷ the space-travel benefits of meat that does not require access to a farm for production;⁸ food-innovation benefits of meat that could have superior appearance and taste, and lower cost, than more traditional sources;⁹ and (the focus of this essay) the animal-liberation benefits of meat, which does not involve killing significant numbers of animals.

Here, I analyze the emergent discourses within the IVM field that seek to justify this animal-liberation-oriented promissory narrative. I highlight multiple accounts of what kind of form the narrative could take and who (human/nonhuman) benefits of it, and detail points of tension that divide the community or make the promissory narrative harder to sustain. In this regard, my work follows themes found in Martyn Pickersgill’s interrogation of the therapeutic promise addressing psychiatric conditions;¹⁰ Paul Martin and colleagues’

5. Adam Hedgecoe, *The Politics of Personalised Medicine: Pharmacogenetics in the Clinic* (Cambridge: Cambridge University Press, 2004), p. 27.

6. Hanna L. Tuomisto and M. Joost Teixeira de Mattos, “Environmental Impacts of Cultured Meat Production,” *Environmental Science & Technology* 45:14 (2011): 6117–6123.

7. Z. F. Bhat and Hina Bhat, “Animal-free Meat Biofabrication,” *American Journal of Food Technology* 6:6 (2011): 441–459.

8. Morris A. Benjaminson, James A. Gilchrist, and M. Lorenz, “In Vitro Edible Muscle Protein Production System (MPPS): Stage 1, Fish,” *Acta Astronaut* 51:12 (2002): 879–889.

9. Isha Datar and Mirko Betti, “Possibilities for an In Vitro Meat Production System,” *Innovative Food Science and Emerging Technologies* 11:13 (2010): 13–22.

10. Martyn Pickersgill, “‘Promising’ Therapies: Neuroscience, Clinical Practice, and the Treatment of Psychopathy,” *Sociology of Health & Illness* 33:3 (2011): 448–464.

discussion of “communities of promise” regarding stem cells;¹¹ and Richard Milne’s study of food-based futures and plant-derived pharmaceutical crops.¹² These essays, along with my own, explore the relationship between the promissory and the material as a set of contextual, contingent, and contested forms of practice. Pickersgill and Milne in particular focus on the ways in which the promissory and the material provoke ontological consideration about what constitutes disease, cures, and food. I build on Robert Chiles’s work by also applying the sociology of expectations to IVM.¹³ Chiles explores the roles of hype, accounts of previous visions of the future, and myths in establishing the range of these expectations; in contrast, I emphasize the centrality of discourses about ethics to only one promissory narrative—that of animal liberation. By drawing on empirical material from both scientists and others associated with animal advocacy, including animal rights and veganism, I demonstrate that the IVM animal-liberation promissory narrative emerges from the discourses of both sets of actors. It is a narrative that, as will be demonstrated, has also been contested by some within the animal rights community. To explore the processes of embedding ethical value within the promissory, I employ the concept of *ethical boundary-work*.

Ethical Boundary-Work

Steven Wainwright and colleagues developed the notion of ethical boundary-work to describe their ethnographic data collected from scientists engaged in embryonic stem cell science, some of whom would destroy human embryos to derive stem cell lines.¹⁴ Wainwright and colleagues extend Thomas Gieryn’s notion of boundary-work to move beyond Gieryn’s focus on establishing the

11. Paul Martin, Nik Brown, and Alison Kraft, “From Bedside to Bench? Communities of Promise, Translational Research and the Making of Blood Stem Cells,” *Science as Culture* 17:1 (2008): 29–41.

12. Richard Milne, “Drawing Bright Lines: Food and the Futures of Biopharming,” *The Sociological Review* 58 (Supplement s1) (2010): 133–151.

13. Robert M. Chiles, “If They Come, We Will Build It: In Vitro Meat and the Discursive Struggle over Future Agrofood Expectations,” *Agriculture and Human Values*, February 1, 2013. http://new-harvest.org/wp-content/uploads/2013/03/rmchiles_2012-if_they_come.pdf.

14. Steven P. Wainwright, Clare Williams, Mike Michael, Bobbie Farsides, and Alan Cribb, “Ethical Boundary-Work in the Embryonic Stem Cell Laboratory,” *Sociology of Health & Illness* 28:6 (2006): 732–748.

rhetorical boundaries between science and nonscience¹⁵ to include how scientists draw the boundaries of ethical scientific activity—or, as the same research group described more recently, how “researchers draw boundaries within science, reflexively ordering practices along a spectrum from ‘more’ to ‘less’ ethical.”¹⁶ In their earlier work, Wainwright and colleagues report “observing the delineation of a positive ‘ethical space’ which scientists occupy”; they identify a process of social demarcation that “simultaneously serves to define and defend the work of scientists involved in ethically controversial science.”¹⁷ The concept has also been employed to study in vitro fertilization (IVF) by Lucy Frith and colleagues,¹⁸ preimplantation genetic diagnosis by Kathryn Ehrich and colleagues,¹⁹ and stem cell science in China by Margaret Sleeboom-Faulkner.²⁰ Two authors have applied the ethical boundary-work conceptualization to human/animal relations, with Tora Holmberg focusing on scientists working with transgenic mice used in research experiments,²¹ and Pru Hobson-West reporting on interviews with researchers conducting animal experiments on a variety of species.²²

The above case studies describe their work as reports of situated ethics, highlighting the importance of documenting ethical complexity as it is understood by those involved in conducting the work.

15. Thomas F. Gieryn, “Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists,” *American Sociological Review* 48:6 (1983): 781–795; Gieryn, *Cultural Boundaries of Science: Credibility on the Line* (Chicago: University of Chicago Press, 1999).

16. Caragh Brosnan, Alan Cribb, Steven P. Wainwright, and Clare Williams, “Neuroscientists’ Everyday Experiences of Ethics: The Interplay of Regulatory, Professional, Personal and Tangible Ethical Spheres,” *Sociology of Health & Illness* 20:10 (2013): 1–16.

17. Wainwright et al., “Ethical Boundary-Work in the Embryonic Stem Cell Laboratory” (above, n. 14), pp. 744, 745.

18. Lucy Firth, Ann Jacoby, and Mark Gabbay, “Ethical Boundary-Work in the Infertility Clinic,” *Sociology of Health & Illness* 33:4 (2011): 570–585.

19. Kathryn Ehrich, Clare Williams, and Bobbie Farsides, “The Embryo as Moral Work Object: PGD/IVF Staff Views and Experiences,” *Sociology of Health & Illness* 30:5 (2008): 772–787.

20. Margaret E. Sleeboom-Faulkner, “Boundary Making and ‘Good’ Stem Cell Research (SCR) in Mainland China: Including Bioethics, Excluding Debate,” *East Asian Science, Technology and Society: An International Journal* 4:1 (2010): 31–51.

21. Tora Holmberg, “Tail Tales: How Researchers Handle Transgenic Dilemmas,” *New Genetics and Society* 29:1 (2010): 37–54.

22. Pru Hobson-West, “Ethical Boundary-work in the Animal Research Laboratory,” *Sociology* 46:4 (2012): 649–663.

This is the position that I also adopt.²³ But my case study also allows for an exploration of the relationship between ethical boundary-work and promissory narratives, and how this invoking of positions along a spectrum running from less to more ethical attempts to establish a productive use of IVM technology—namely, what it can do—and, by extension, also attempts to establish a stable account of what IVM is.

Methods

I write from a science and technology studies perspective, drawing on a tradition of qualitative and ethnographic investigations of scientific knowledge-making in practice.²⁴ The analysis is informed by a methodological relativism that recognizes scientific claims as a product of social negotiation, not allowing the truth or falsity of a scientific claim to be used as explanatory variables for its acceptance.²⁵ I report on ongoing fieldwork—thirty-nine semi-structured interviews with individuals engaged in the field—observations at meetings in the field, and documentary analysis of scientific papers, websites, and other textual and visual forms. The interviews were conducted between 2010 and 2013, before the proposed Maastricht in vitro burger was complete. Interviewees have been offered anonymity in as much as is possible in a small field of this type, and quotes are presented in accordance with this; one interviewee explicitly requested to be identified and consequently has been. The

23. For examples of ethical considerations of IVM that do not adopt a situated ethics approach, see Patrick D. Hopkins and Austin Dacey, "Vegetarian Meat: Could Technology Save Animals and Satisfy Meat Eaters?" *Journal of Agricultural and Environmental Ethics* 21:6 (2008): 579–596; Evelyn Pluhar, "Meat and Morality: Alternatives to Factory Farming," *Journal of Agricultural and Environmental Ethics* 23:5 (2010): 455–468; Stellan Welin, Julie Gold, and Johanna Berlin, "In Vitro Meat: What Are the Moral Issues," in *The Philosophy of Food*, ed. David M. Kaplan (Berkeley: University of California Press, 2012), pp. 292–304; Stellan Welin and Cor van der Weele, "Cultured Meat: Will It Separate Us from Nature?" in *Climate Change and Sustainable Development: Ethical Perspectives on Land Use and Food Production*, ed. Thomas Potthast and Simon Meisch (Wageningen, the Netherlands: Wageningen Academic Publishers, 2010), pp. 348–354; and Emilio José Armaza-Armaza and Julia Armaza-Galdos, "Legal and Ethical Challenges Regarding Edible In Vitro Meat Production," in *Global Food Security* (above, n. 4), pp. 513–520.

24. Edward J. Hackett, Olga Amsterdamska, Michael Lynch, and Judy Wajcman, eds., *The Handbook of Science and Technology Studies*, 3rd ed. (Cambridge, MA: MIT Press, 2008); Karin Knorr Cetina, *Epistemic Cultures: How the Sciences Make Knowledge* (Cambridge, MA: Harvard University Press, 1999).

25. David Bloor, *Knowledge and Social Imagery* (Chicago: University of Chicago Press, 1976); Harry M. Collins, "Stages in the Empirical Programme of Relativism," *Social Studies of Science* 11:1 (1981): 3–10.

quotes presented here have been selected because they represent clear articulations of accounts found in the data. In what follows, interview data is first presented from scientists who are attempting to make IVM, followed by that of individuals associated with animal-liberation activism and who have supported IVM technology.

In Vitro Meat Scientists

As described above, there are emerging discourses of multiple promissory narratives regarding IVM. Typically, the interviewees placed differing levels of emphasis on the narratives that were most important to them personally and that they considered were most likely to foster broader support for the technology. In this section, I present a range of interview extracts with scientists who are, or have recently been, active in IVM research. The quotes draw together two themes: how the interviewees relate their own interest in animal-liberation issues to their IVM research, and how they imagine that the potential benefits for animal liberation may frame the technology's future development. In this way, they bind together both personal ethical reflections and an account of imagined ethical reflections of other people, present and future.

We begin with a response to a question about the role of animal-liberation issues by an individual who has supervised laboratory work on IVM: "I think it's a motivation for a lot of people. Not personally for me because I would be a little bit of a hypocrite if I would say that because I just eat regular meats. . . . I think it's nice that you can help people that are vegetarian . . . [but] it's not a personal motivation for me." This provides a glimpse of how different scientists within the field position the various promissory narratives in different ways. This interviewee acknowledges the animal-liberation narrative, but also demotes it below other promises. He/she also articulates the potential for hypocrisy and the ethical tension that goes with this. The beneficiaries of IVM are people who are vegetarian, but even though it is "nice," it is not essential that it helps them.

This same interviewee continues to identify some of the challenges in asserting IVM as a technology of animal liberation: "The biggest problem at the moment is that the cells are cultured in a medium that contains fetal bovine serum, which is basically blood from calves, and you don't want that if you want to have an animal-free meat." In biomedical tissue engineering, it is not unusual to use fetal bovine serum as a medium to promote cell growth; it contains high levels of growth factors that are conducive to cell division. Producing it involves extracting blood from the fetus of a cow

immediately after the mother's slaughter—also resulting in the fetus's death—usually in slaughterhouses that provide meat for human consumption. Given this, the early stage IVM research described by the interviewee is not slaughter-free; tissue—blood—from animals raised and killed for meat production is used.

When responding to this issue, every scientist I have interviewed explains that alternative forms of medium will be generated in the future, and scientists at the University of Amsterdam have been active in developing a nonanimal-derived alternative based on blue-green algae—an example of the IVM field moving in a different direction from biomedical tissue engineering in an effort to establish a sound animal-liberation narrative and practice. Such accounts draw together the ethical, the imagined, and the material: the ethical being the future capacity of blue-green algae to lessen the role of dead-animal body parts in IVM production; the imagined being future scenarios in which blue-green algae function as a medium within which muscle cells grow productively; and the material being the fetal bovine serum used today.

This interviewee continues by discussing another challenge in presenting IVM as a technology of animal liberation:

Second of all is that we can culture adult stem cells and they are derived from muscle tissue from live animals. . . . [W]e can culture those [cells] for a couple of months, but then they die. That means that you can produce a lot of meat, but in order to continue the process, you would again need to take a biopsy. So you would need to take biopsies at regular intervals, kill an animal and isolate the stem cells from the muscle. That's also not something that you want, so what I would like is that we could culture embryonic stem cells from either a pig or a cow, because they can be cultured indefinitely.

This discussion focuses on the issue of how you get cells from a living animal from which IVM can be grown—quite a different issue from the previous fetal bovine serum one. The practice of getting cells from a living animal is not one that the field hopes to replace with a nonanimal-sourced alternative; instead, these nonhuman animal cells remain the essence of IVM technology, the harnessing of their growth potential central to any animal-liberation narrative. This interviewee is the first of several that position what I call the *cell source animal*: a new, IVM-specific moral entity that IVM proponents seek to demonstrate care and responsibility toward. These cell source animals are typically imagined future animals, and the ways that their lifestyles and well-beings are constructed is vital to the ethical boundary-work underpinning the emergent animal-liberatory promissory narrative.

This scenario echoes familiar debates concerning human embryonic stem cell science that focus on the human embryo as the cell source, with different actors positioning themselves as responsible decision-makers and guardians of tissue with sensitive provenance.²⁶ However, as is made clear in the above, the interviewee positions the relative moral challenges of adult and embryonic stem cells in exactly the opposite way to that which is usual in the human stem cell debates in Europe and North America. Applying Wainwright and colleagues' and Brosnan and colleagues' notions of the ethical spectrum,²⁷ we can describe the human case as one in which adult stem cell research is positioned as less problematic than embryonic derived cells. Cell lines derived from the human embryo are positioned as either so ethically problematic that research on them is prohibited or else as ethically sensitive material that can be used for research, although only under strictly regulated ethical oversight. The IVM scientist quoted above constructs the spectrum quite differently, with the long-term necessity for ongoing biopsies taken from donor source animals—and the resulting animal suffering—identified as the most ethically problematic practice. Embryonic stem cells are presented as ethically preferable because, the interviewee suggests, the destruction of one embryo can result in a cell line that can be cultured indefinitely, implying the potential production of infinite muscle tissue and infinite meat.

As is the case with many of the quotes presented in this essay, the empirical validity of the claims surrounding IVM technology may be questioned; interviewees are typically aware of this, and themselves articulate these challenges. In the above example, we may question the claim that an embryonic cell line can be cultured indefinitely; the significantly larger body of work on human and mouse embryonic stem cell science suggests that cells demonstrate increasing levels of chromosomal changes the more they are cultured. These could impact the stability of the cell line and the outcome of their use. Embedded within the promissory narratives are accounts of technological feats that are currently not possible and

26. Søren Holm, "Going to the Roots of the Stem Cell Controversy," *Bioethics* 16:6 (2002): 493–507; Sarah Parry, "The Politics of Cloning: Mapping the Rhetorical Convergence of Embryos and Stem Cells in Parliamentary Debates," *New Genetics and Society* 22:2 (2003): 177–200; Neil Stephens, Paul Atkinson, and Peter Glasner, "The UK Stem Cell Bank: Securing the Past, Validating the Present, Protecting the Future," *Science as Culture* 17:1 (2008): 43–56.

27. Wainwright et al., "Ethical Boundary-Work in the Embryonic Stem Cell Laboratory" (above, n. 14); Brosnan et al., "Neuroscientists' Everyday Experiences of Ethics" (above, n. 16).

potentially never will be—in Hedgecoe's terms, the work of promissory science, which is a discursive strategy found both here and in many other cases of scientific innovation.²⁸

There can also be tensions between the animal-liberation narrative and research practices today. The embryos used by this group to derive animal cell lines are attained by conducting an IVF procedure utilizing bull or boar semen stocks and unfertilized eggs extracted from the ovaries of cows or sows that have been commercially slaughtered. As with the use of fetal bovine serum, this issue is typically set within a context of ongoing scientific research, potentially leading to future contexts in which these problems are overcome.

A different account of the imagined cell source animal is provided by the next interviewee, who is a prominent spokesperson for the field who eats meat and is based in a different country from the first. Describing his/her own motivations, he/she explains that "I find industrial animal production disgusting. Sure I do. And I really want to contribute to break the back of that production. So [animal liberation] is a very good number two in my motivation [to be involved in IVM], but even without that, the environment would be more than enough for me." Here, the interviewee identifies environmental issues as the dominant cause for his/her interest in IVM, but that animal liberation is a strong second. Further describing his/her preferred technical approach to IVM production:

I think I can feed the world taking the umbilical cords from ten sows per year, give or take. It's just a fantastic potential. I think you get about five million cells from an umbilical cord. And they can definitely develop into muscle cells. . . . But it shows that you can treat these pigs as queens. . . . There's no slaughtering, nothing. They give birth to these piglets. And I think that is a much, much, much better frame for selling this than to say that you have an embryo stem cell culture, which the Dutch people tried to develop. . . . Because you can show pictures of these pigs and animal welfare people see that this is okay. As long as they accept that we keep dogs, they will accept that we keep pigs and just take care of the umbilical cord, which you throw away in any case.

This account contrasts quite distinctly from the previous interviewee's in three important ways: 1) the embryonic cell source is deemed problematic; 2) the interviewee introduces a new cell source to the ethical spectrum of that was not even discussed by the first interviewee, and positions this new option as the most ethical choice: cells from umbilical cords; and 3) the account also places industrial

28. Hedgecoe, *The Politics of Personalised Medicine* (above, n. 5).

animal production as it exists today as the least ethical option. The account also explicitly links a positive ethical status with the capacity to sell the tissue. The interviewee conjures a food production system in which umbilical cord tissue—deemed a waste product—becomes the source of productivity.²⁹ The interviewee recognizes that a successful single embryonic cell line could potentially have a greater capacity to produce muscle tissue than a single umbilical cord. However, single cords are presented as attainable in a less ethically and practically problematic manner than embryonic cells lines, meaning that the umbilical cord cells' lower growth potential per unit can be sidestepped by collecting a larger number of cords. This is premised on an equivalence drawn between the living conditions provided for the sows, who can live as "queens," and those of animals kept in domestic environments as pets. Pet-keeping is identified as a normal, ethically acceptable practice, bound in the same space as umbilical cord-based IVM production in which the pig's reproductive labor can supply umbilical cord in an unproblematic manner.

During my observational work, I experienced another variant on the cell source animal issue based on adult cells taken from living animals. During a conference panel on IVM at the 2012 Tissue Engineering and Regenerative Medicine World Congress, one of the speakers suggested a possible future cell-sourcing system based on "donor herds." The argument presented was that instead of farming large numbers of live animals from which biopsies of a small number of cells would be taken, thus allowing the animals to live, it would be better to have a smaller number of donor herds that are killed and from which all viable cells are used to derive IVM. This version of the animal-liberation narrative suggests that killing a small number of animals in the donor herd for IVM would be better than keeping much larger numbers of animals for it, and that both versions are better than industrial meat production as practiced today. Like the previous two accounts, this version articulates a particular form of IVM industrial production and interlaces ethical

29. The positioning of tissue as either redundant or waste that can then be leveraged for productive value is another recurrent theme in tissue engineering promissory narratives: for example, "spare" human embryos destined for destruction that can be used for deriving human embryonic stem cell lines; human umbilical-cord blood banked for future therapeutic uses; or patients' surgically necessary removal of spleen tissue, which is subsequently used for a commercially viable cell line. See Parry, "The Politics of Cloning" (above, n. 26); Nik Brown and Alison Kraft, "Blood Ties: Banking the Stem Cell Promise," *Technology Analysis and Strategic Management* 18:3-4 (2006): 313-327; and Catherine Waldby and Robert Mitchell, *Tissue Economies: Blood, Organs, and Cell Lines in Late Capitalism* (Durham, NC: Duke University Press, 2006).

judgements within it. The accounts of the first two interviewees, along with that presented at the conference panel, construct their animal-liberation narratives in relation to the differing cell sourcing practices they propose. However, IVM proponents also conjure imagined IVM consumers who are situated as specific types of ethically informed economic decision-makers. The tastes, economic capacities, and ethical preferences of these consumers are embedded within the promissory narratives. The following interview with an early career researcher in the field first identifies the environmental promissory narrative as his/her key interest in the field, and then articulates a version of the animal-liberation narrative that draws on notions of scientific advancement:

The first level is environmental impact. The other level is animal rights, because there's basically no good reason to have a whole cow, a whole chicken, that we bring up and then we kill it and it suffers. So if we just want to have meat, maybe it's just much easier to cultivate what we need. So that in itself is also a motivation. I mean, let's advance. Are we able to achieve something like that? Are we advanced enough to develop a process where we can actually skip or go over the normal nature of animals in general? I mean, every animal, or every meat-eating animal, is feeding on other animals. If we were able to actually come over that part, that would be extremely great.

This account positions the key ethical benefit of IVM as the potential ability of tissue engineering to disaggregate animal bodies—"a whole cow, a whole chicken"—into separate components, which would be beneficial because human society could—"to cultivate what we need," without engendering pain. Scientific technique is positioned as ethically beneficial because it could allow humans to "'go over' the normal nature of animals" by no longer killing other nonhuman animals for eating.³⁰ This formulation is subsequently embedded within a specific vision of imagined consumers and social relationships:

INTERVIEWER: And you think in vitro meat would mean getting over that?

INTERVIEWEE: Not right from the beginning maybe, and I still believe that people will always have normal meat, normal cows, but maybe then more on an extremely high-priced luxury level. I mean, like us today, if you want to have really good meat like Kobe, you have to pay a lot of money. And maybe in the future it will be like that, that if you want to have meat, you really have to pay a lot of money and you don't eat it on a regular basis, but you have in vitro meat instead.

30. "Go over" in this context means "overcome."

This response invokes an imagined consumer who is motivated to purchase IVM because it offers a product without, nonhuman animal suffering, but who at particular times may still choose to consume meat associated with suffering. This is related to a financial decision-making process that links price and occasional luxury to morally legitimate food-buying practices. The interviewee acknowledges that this is only one possible future scenario and that others may exist. This account also raises another issue in the animal-liberation narrative: namely, the ontological ambiguity regarding what IVM actually is. The interviewee suggests that people will continue to consume “normal meat,” and in doing so alludes to the “otherness” of IVM. Concerning animal-liberation narratives, ambiguity over what IVM is—whether it is meat, a meat alternative, or something else altogether—frames whether the narratives challenge or normalize continued meat consumption.

Of the twenty-three scientists I have interviewed to date, five have self-identified as not being meat-eaters. The following quote from a senior team leader provides an articulation of their position on meat-eating, and relates this to both their own involvement in IVM research and other potential consumers for cultured meat:

[Animal liberation] is a very high motivating factor for me and I very easily stopped eating chicken and any fowl products a long time ago because of . . . how they're being produced in the factories . . . it's very disturbing. My not eating meat is not from “Oh it's disgusting, I can't eat another living animal,” it's because of the more animal rights issues about how they're being kept. . . . There is a wide spectrum of vegetarians, and there are vegetarians who said they would eat in vitro meat because they know that no animal was killed in order to make this product. There are others who absolutely wouldn't eat it—I mean why? So why eat another animal? . . . You think there are other people who are like you, I mean everybody wants to be normal. . . . If given a choice [that] here's some meat made by the animals that have been suffering and here's meat made where we haven't had to kill any animal, I think that people, if they can afford it, would buy the meat without suffering [associated with it]. I can't imagine any human being who wouldn't do that. Unless . . . it tastes like crap.

This interviewee clearly identifies a form of animal-liberation narrative as central to his/her own involvement in IVM research: one related to his/her own food-consumption patterns. At the same time, ethical ambiguity is acknowledged concerning the narrative by articulating two alternative accounts attributed to vegetarians—whether they would or would not eat IVM. The interviewee then conjures an imagined set of consumers who align with their own

ethical values and would choose the meat without associated suffering over meat with it, given broader assumptions about consumers' financial statuses and flavor preferences. This hypothetical choice between meat with or without suffering assumes all else is equal, bounding IVM as the same thing as whole-animal-produced meat, the only difference being the relative positions on the ethical spectrum; in so doing, he/she asserts both what IVM can do and what IVM is.

The quotes discussed in this first empirical section have demonstrated a diversity in the framing of IVM as a technology of animal liberation. Clear differences exist in the extent to which animal-liberation narratives motivate individual scientists' involvement in the field, which relate to their own personal understanding of current meat-producing practices and their own ethical subjectivity. Moreover, some relate this to the ethical subjectivity of imagined consumers in complicated ways. For example, two interviewees embedded their own moral assumptions in their conception of IVM as a technology of animal liberation, while another used his/her own current meat-eating practice to identify potential hypocrisy in aligning him-/herself with the animal-liberation narrative. A key component in drawing moral boundaries around IVM that positions it as a technology of animal liberation is an account of the ethical appropriateness of the experiences of the cell donor animal. However, the quotes reveal multiple socio-technical models of how cell donor animals' well-being should be best protected: namely, via cell extraction from adult, embryonic, or umbilical nonhuman animal tissue.

The next section focuses on accounts of individuals who have aligned themselves with a pro-IVM position, but are not trained laboratory scientists and have links to animal-liberation activity beyond their IVM work.

In Vitro Meat Proponents Associated with Animal-Liberation Positions

The terminologies and values of groups associated with forms of animal liberation vary widely in ways beyond the scope of this essay. Diversity also exists in the opinions of people engaged in animal advocacy regarding IVM. This section discusses accounts of the ethics of IVM by individuals who have self-identified as aligning themselves with IVM and have manifested this commitment in some form of practical action. The first set of quotes is from an interview with a key member of the IVM campaign group New Harvest—an individual who does not eat meat and has a history of engaging with issues of vegetarianism. This interviewee relates his/her account of

the cell source animal to critiques of IVM based on the harm caused by cell extraction:

I have seen discussions on this question of whether a single cell taken from a farm animal would be just as bad as having 40 billion animals raised and slaughtered each year. That to me seems really absurd. I think there has been at least some students, I guess, in sort of animal rights, proposing that line of argument. So there are moral theories under which numbers don't really matter, and so if you harm one individual, that's no different than harming a billion individuals. So on that sort of theory, the Stalinist purges or the Holocaust is [*sic*] no worse than, you know, a single death. I think that that sort of moral view seems to have very little credence.

This quote articulates a critique of the IVM animal-liberation narrative attributed to some within the movement that *any* form of animal suffering is unacceptable and, as such, IVM is unacceptable. To counter this, the interviewee invokes an ethical spectrum on which killing 40 billion animals is far worse than taking a biopsy from only one. As the interview proceeds, he/she locates more practices on the ethical spectrum:

But I think the harm to animals that were used for cell donors has to be considered. It matters. But for me, the scale of the benefits [outweigh] the harm to the cell donors, which would be very small. The lives of the cell donors would be very much better than the life of a normal farm animal. Cell donors could be free-range, muscle biopsies can be done with anesthesia, [and] these animals could have lives that are as good as those of a domesticated pet.

Once again, here the life experience of the cell source animal is positioned as equivalent to those of animals kept in domestic environments as pets. The interviewee articulates a form of adult cell sourcing that involves no killing and minimizes suffering through anesthesia; in so doing, he/she provides a very different vision of an adult cell source system than the donor herd vision discussed above.³¹ Thus this interviewee is another example of an individual who personally has ceased meat-eating, but retains IVM-eating in his/her vision of the future and as a key element of animal liberation. The interviewee directly addresses this issue in the following exchange:

INTERVIEWEE: I think we should be eating plant-based proteins.

INTERVIEWER: You feel that it would be easier to move to in vitro meat, or more likely, than [for] people to become vegetarian or vegan?

31. Cf. Holmberg, "Tail Tales" (above, n. 21), on the ethical boundary-work of anesthetized biopsies on transgenic mice.

INTERVIEWEE: Yes, and I think there's strong empirical evidence of that. It is very, very difficult to change people's diets, particularly beyond a certain age and income level.

Here, the ethical spectrum loses its linearity. This account deals with the ethical ambiguity of preferring a vegan-based protein system while supporting IVM-based protein systems by referencing the limited success of vegan-based animal-liberation narratives. Essentially, this account problematizes veganism as a practical strategy for achieving animal liberation, locating it within a realm of ideal though essentially unrealistic approaches to addressing global animal suffering. This is in contrast to IVM that is positioned as a potentially practical long-term strategy. This account of a trade-off between the ideal and the practical, based on a problematization of veganism, is also present in different forms in the following two accounts.

The next interview is with the IVM campaign leader of PETA (People for the Ethical Treatment of Animals), a U.S.-based animal rights organization. Its involvement in IVM involves three facets: the ongoing promotion of the technology; a \$1 million prize to whoever first sells a significant quantity of IVM in the United States; and its funding of a three-year post-doc research post at an American university. Media reports at the time of its announcement of the prize attributed to PETA's then director as saying that the decision to back the technology caused "near civil war" within the organization.³² Addressing this issue, my interviewee responded:

Well, there were a few very vocal people who were opposed to it and, yeah, I mean, "there was a near civil war"? We have spirited internal debates about a wide range of issues and tactics. . . . Everything you choose to spend money on, you're choosing not to spend money on something else. . . . There were two principal objections. One, PETA shouldn't be involved in helping the meat industry to perpetuate itself. And two, meat is meat, so went the argument. I was pretty vigorously on the other side of that discussion.

The interviewee acknowledges a diversity of views within his/her own organization about the appropriateness of framing IVM as a technology of animal liberation. The challenges to the promissory discourse identified invoke problematic economic relations to whole-animal meat production, and that meat consumption of any provenance, irrespective of the involvement of slaughter or suffering in its production, is not suitable for PETA's support.

32. John Schwartz, "PETA's Latest Tactic: \$1 Million for Fake Meat," *New York Times*, April 21, 2008. <http://www.nytimes.com/2008/04/21/us/21meat.html?hp>.

Expanding on his/her personal position on the issue, the interviewee responds to a question about whether he/she would eat IVM should PETA's prize be awarded:

At a press conference, maybe. I haven't eaten meat in twenty-three years, so it's not something that I'm salivating to do. But if we . . . thought that long-term vegans eating in vitro meat would somehow be a useful thing for helping animals, sure. . . . For us, our question in every situation is "What's in the best interest of animals?" And if something is, we would try to put aside aesthetic revulsion and do it. So, obviously, the bar for eating a factory-farmed chicken would be extraordinarily high. The bar for eating in vitro meat wouldn't have to be especially high. There would just have to be a convincing reason for how it would be useful. . . . According to my discussions with [New Harvest] . . . the amount of animal product required was extremely small and the potential benefit, obviously, is beyond anything we can easily imagine.

This account positions "animals" as the beneficiary of IVM technology. It positions IVM, and meat in general, as something that could provoke "aesthetic revulsion" and marks it as a dietary practice that the interviewee would not routinely engage in. Personal consumption would only be considered in the context of a press conference or some other outlet that delivered what the interviewee considers helpful to animals. This is located in a context of significant potential benefit, a vision based on accepting a future imaginary promoted by New Harvest. It draws boundaries around IVM consumption that situates it as not an ethically preferred position for the interviewee him-/herself, although maintaining that it would be good for animals if other people embrace it.

I then asked the interviewee whether he/she felt any ambiguity about aligning with a field in the biosciences in which the individuals involved may also be working on animal experiments, an issue on which PETA strongly campaigns against: "That was significantly less of a concern. Any time that somebody who is an animal experimenter spends doing nonanimal experimentation is a victory. . . . It's less time that they're spending torturing animals." Wainwright and colleagues' original specification of ethical boundary-work argued that scientists destroying human embryos discursively produced a nuanced space in which their actions both acknowledged their complex personal ethical constructions and deemed their actions legitimate.³³ The above quote demonstrates that, more broadly, the IVM animal-liberation narrative involves defining shared spaces in

33. Wainwright et al., "Ethical Boundary-Work in the Embryonic Stem Cell Laboratory" (above, n. 14).

which groups that are sometimes situated in a relationship of hostility, such as the biosciences that can involve vivisection and animal-advocacy groups, can in some form unify around a common promissory narrative and the strategies intended to realize it.

The interviewee then reflected on the issue of the cell source animal and the procedures required to extract cells:

They are obviously to some degree discomfoting, but it's worth remembering that nobody is pure. Even vegan food production is going to cause some suffering. It's going to cause some greenhouse gas promotion. It's going to certainly kill insects and probably kill other small animals. . . . Realistically, the amount of animal suffering [in IVM production] involved is probably not more than the amount of suffering involved in getting iceberg lettuce.

Like the interviewee from New Harvest, the PETA representative provides an account that problematizes veganism. Whereas the New Harvest quotation challenged veganism as a practical strategy for achieving animal liberation premised on the difficulty of converting meat-eaters to plant-based protein diets, this PETA account draws an equivalence between the animal suffering described in vegan practice today and an imagined IVM food-production system. This interviewee positioned the factory farming of chickens on the less ethical end of the spectrum, with IVM situated as more ethical and veganism the most ethical, although not without qualification.

This scenario continues in the account of the next interviewee, Elizabeth DeCoux, a lawyer and vegan who campaigns to establish a form of animal rights in U.S. law. DeCoux asked to be identified in this essay. She attended the first In Vitro Meat Consortium meeting in Norway in 2008 to lend support to the technology and articulate for the community the characteristics that cultured tissue could take to appeal to those associated with animal advocacy. Discussing her thinking at the time, she said that "I thought that I would be able to support [IVM] as not the very best thing, but probably the second best thing that could be done for animals. And if the world was not going to turn vegan in the short term, then the idea of one cow, one pig, one chicken who was not even kept in a factory farm and slaughtered . . . was a very appealing idea." DeCoux reiterates the ethical spectrum rendered in the previous two accounts: that is, veganism as an animal-liberation narrative is critiqued for taking too long; and IVM, as a second-best strategy, is represented as involving low levels of animal use—one cow, one pig, one chicken—that could deliver positive benefits. However, in the years following her involvement in the Norway meeting, DeCoux had a change of opinion, redrawing IVM outside the boundaries of appropriate

animal-liberation strategies. Describing her rationalization for this, she said that

[a]pparently, there is work being done with stem cells. I'm not opposed to work with stem cells in general . . . one approach that's being taken is growing embryos from animal stem cells in order to harvest the meat in some way. And, of course, an embryo is very different from a sheet of cells, to me. . . . I'm not a scientist, but if you're causing embryos to grow, it's not clear to me whether there's any nervous system, circulatory system, what the status is, but I know that the growth of embryos is involved, and that is a deal breaker for me. . . . One of the possible growth mediums was the blood of fetal calves. It has all the horrors of the slaughterhouse.

The interviewee invokes the status of the cell source animal and the use of animal tissue—the blood of fetal calves—to demarcate IVM production as unacceptable practice. DeCoux's account can be criticized as a misrepresentation, in that current laboratory work tries to grow cells from destroyed embryos, as opposed to growing embryos from cells, as the interviewee describes. However, DeCoux's key issue of the status of embryo would be relevant in both versions. Her account emphasizes the potential fragility of the animal-liberation ethical boundary-work during these early stages of development, as a once committed supporter of the field became an equally committed critic. During these early stages, the discursive strategies of describing IVM as a technology for animal liberation are also undergoing a process of development as boundaries are drawn between what are and what are not in the interests of imagined future nonhuman animals in imagined future food-production systems.

Conclusions

The data presented in this essay demonstrate diversity in the understandings and motivations of the individuals involved in the IVM field. While including two broad groups of participants—scientists, and others associated with animal-advocacy positions—there are clear differences within each. Some scientists associated their interest in IVM with their existing nonmeat consumption; others consume meat, but expressed dissatisfaction with current meat-producing practices and identified IVM as an appropriate strategy for addressing this; while still others distanced themselves from, or positioned themselves carefully toward, animal-liberation narratives. Of the three animal activists represented, one shifted from a pro- to an anti-IVM position; all three problematized the animal-liberation narrative of veganism in order to leverage a space for supporting IVM. These positions also worked to produce a shared space

in which bioscientists and animal advocates may align their efforts and ethics on the same socio-technological project.

Ethical boundary-work is evident in the data. Interviewees positioned different approaches to IVM production, as well as to meat-eating and, in some cases, veganism, across ethical spectrums, representing their own preferences and those of imagined future consumers. The interviewees discussed cell source animals: imagined future animals in imagined future food-production systems. The discourses sought to demonstrate, and thereby constitute, appropriate moral guardianship over these animals by focusing on their living standards in comparison to today's industrial farmed animals, and by drawing equivalence to animals kept in domestic environments as pets. While retaining relationships of human control and the normality of animal bodies' contribution to human-centered production, the interviewees identified a significantly improved life experience for cell source animals premised on standards of care, avoidance of slaughter, and significantly reduced numbers of animals involved. However, three alternative technical approaches were discussed that, in turn, were interpreted differently in terms of their ethicality: namely, the embryonic, adult, and umbilical cell sourcing techniques. The embryonic was positioned as the ideal by one interviewee, but was criticized by another, just as the adult approach was characterized by one interviewee as involving killing animals, but was cited by another as permissible with the use of anaesthesia. In practice, in some instances, such tissue is taken from slaughterhouses.

A key theme of the analysis is that the ethical boundary-work found in the emergent promissory narratives engages with the ontological ambiguity about what IVM is and what it can do. In one account, IVM was cited as identical to meat as recognized today, the two only being differentiated by the respective roles of animal bodies in their production and their positions on an ethical spectrum. Here, future consumers were imagined to have specific moral preferences, flavor aesthetics, and financial capacities that would lead them to consume IVM because it is a product that liberates animals. Another interviewee recognized a difference between IVM and normal meat, and the slightly differently configured moral, aesthetic, and financial characteristics of imagined future consumers would lead them to consume IVM most of the time, while occasionally spending more on luxury "normal" meats. Central to the analysis presented here is the observation that both accounts invoke constellations of future technologies, economies, and consumers that assert how IVM would be used—what it does and what it is, the first

positioning it as meat, the second allowing a more open interpretation, with meat and IVM presented as alternatives.

Speculation has a clear role in these accounts, as the interviewees acknowledge. The accounts draw together the ethical and the imagined in a future that all are aware is far from the realities of current IVM technology. However, some of the accounts have more explicitly drawn together the ethical, the imagined, and the material as experienced today, which, in turn, requires other forms of ethical boundary-work and again ties the promissory to the ontological. A key example is the mismatch between fetal bovine serum currently in use and the narrative of animal liberation: as one interviewee remarked, “you don’t want that if you want to have an animal-free meat.” The use of this serum troubles the account of what IVM can do and what it is. In response to this, the ethical boundary-work of binding IVM to both an imagined future in which blue-green algae functions as a replacement and the material reality of the existing early stage blue-green algae research in Amsterdam is a repeated element of the current IVM animal-liberatory promissory narrative. Promise, ethics, and ontology are coproduced.

The relationship between promise and ontology has been elaborated elsewhere in the sociology of expectations literature. Pickersgill’s account of the therapeutic promise of neuroscience presents a case in which the promise of the technology—neuroscience—is used “to make clear the ambiguous ontology of personality disorder and, consequently, to provide an account of how it might be treated.”³⁴ Milne’s account of genetically modified crops used to produce pharmaceuticals demonstrates that “boundaries between food and non-food are renegotiated” as researchers work to address safety fears that pharmaceutical and food crops could be confused in an “attempt to re-establish the promise of the technology.”³⁵ Both case studies overlap with the IVM case while also exhibiting key differences. In Pickersgill’s case, the site of ontological ambiguity is the problem to be addressed (personality disorder), and the authoritative stability of the imagined technology (neuroscience) is used to make this clear; in Milne’s, the researchers work to assert that their pharmaceutical-producing crops are ontologically distinct from food, and therefore cannot be confused with food to establish their safety. With IVM, in contrast to Pickersgill’s case, it is the technology that is ontologically ambiguous; and in contrast to Milne’s case, the IVM researchers work to assert that their technology is food,

34. Pickersgill, “‘Promising’ Therapies” (above, n. 10), p. 458.

35. Milne, “Drawing Bright Lines” (above, n. 12), p. 143.

although some ambiguity remains over its status as meat. Yet in all three accounts presented here, the promissory, the material, and the ontological work together.

The ongoing ethical boundary-work concerning IVM is complicated and nuanced. While participants in the field accept as unproblematic the notion that IVM will improve the situation of nonhuman animals, the exact form that this animal-liberatory narrative will take is still undergoing a process of negotiation. This is occurring in a context in which the technology remains in an early stage and may or may not be ultimately developed to a level where it could deliver on any of the various promises associated with the technology today. Any robustness brought to the promissory narratives of IVM will result from socio-technical learning and will contribute to bringing ontological meaning to what IVM is, in any of the multiple forms it could take.

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