

# Evidentiary Symbiosis: On Paraethnography in Human–Microbe Relations

ALEX NADING

*Social Anthropology, University of Edinburgh, Edinburgh, UK*

**ABSTRACT** *Though microbial infections are central concerns for public health workers in urban Nicaragua, health workers there rarely if ever speak of the existence of a ‘microbiome’ when they address such problems. Among scientists and the public in the United States, on the other hand, the microbiome, seen as the ‘internal ecosystem’ that regulates the workings of human guts, is a regular topic of conversation. This raises questions about how one might go about doing a social study of the microbiome in places where it does not (yet) exist as a category of expert practice or public discourse. Evidence from Nicaragua and the United States highlights two sites at which experts engage people in research and discussion about microbial ecologies. In their work, U.S. microbiome scientists and Nicaraguan public health workers both engage in ‘paraethnography,’ the practice of collecting and analyzing qualitative information that does not fit into statistical or other kinds of scientific models. In the United States, paraethnography has driven both traditional scientific experiments on the microbiome and online, crowd-sourced experimental platforms for collecting and analyzing information about gut microbes. In Nicaragua, hygienists generate paraethnographic evidence through word-of-mouth, radio, and print media. A comparison between the work of U.S. scientists and that of Nicaraguan hygienists suggests three different ways (commensal, parasitic, and mutualistic) in which the cultural/interpretive evidence of paraethnography interfaces symbiotically with the quantitative/statistical evidence of bioscience. Attention to evidentiary symbiosis provides insights into the operations of publicly oriented science under conditions of bodily and planetary uncertainty.*

**KEYWORDS:** microbiome, Nicaragua, hygiene, food studies, science communication

---

*Correspondence Address:* Alex Nading, Social Anthropology, University of Edinburgh, 15a George Square, Edinburgh EH1 9LD, UK. Email: alex.nading@ed.ac.uk

© 2016 Process Press

## Introduction

The study of the human microbiome entails genetic analysis of the bacteria, viruses, fungi, and other creatures that occupy human guts, skin, ears, and genital orifices. The year 2013 marked the conclusion of the Human Microbiome Project, a U.S.-based endeavor to map the genome of this collection of creatures (FASEB, 2013). In what Heather Paxson (2008) has called a ‘post-pasteurian’ turn, microbes, long-considered foreign enemies to human bodies, are being reimagined as rightful—even righteous—constituents of the human body, aiding in digestion, fighting infection, and promoting infant development (Gordon, 2012). In public discussions, scientists and reporters now frequently talk of an internal ecological ‘community,’ or ‘personal ecosystem.’

In this paper, I take such talk as a chance to revisit a question that has long percolated in social and cultural studies of science, namely that of what makes microbes social (Dunn, 2008; Helmreich, 2009; Koch, 2011). I address this question by comparing human–microbe relations as described by (mostly North American) microbiome scientists to those described by state hygiene workers in urban Nicaragua. At first blush, the hygiene division of the Nicaraguan Ministry of Health (Ministerio de Salud, henceforth MINSa) looks quite different from the world of North American microbiome science. The latter uses online forums, sophisticated genomic analysis, and controlled experiments to study microbial ecologies, while the former tracks microbes through a comparatively limited communicative infrastructure. But like the work of American microbiome scientists, MINSa’s hygiene work is far from crisp pasteurianism. Rather, sanitary work in conditions of severe resource limitations is also a process of establishing livable social, economic, and ethical arrangements that transect human and nonhuman life.

This comparison raises a more specific question: how might one do a social study of the microbiome in places where it does not (yet) exist as a category of expert practice or public discourse? Strictly speaking, the microbiome, as a category of scientific and public interest, has been limited to the Global North. One option for social scientists who want to track the future of microbiome science is to follow genomic and dietary studies as they move to the Global South (see Benezra *et al.*, 2012; Lin *et al.*, 2013). An anthropologist, for example, could ask how concepts like ‘microbial community’ or ‘personal ecosystem’ spread, and how they articulate with ‘local’ ideas.

In this paper I suggest an alternative approach. I do so out of a concern that when applied to a problem like the microbiome, cultural interpretation and social documentation of scientific practice are overly passive techniques. Those techniques risk reducing the social significance of microbes to that of the cultural or symbolic, deferring an understanding of their material significance to the declarations that emanate from the work of natural scientists. Medical and environmental anthropologists have been critical of just such reductionism and

deferral, both in the treatment of indigenous ideas about health and the environment and in the uncritical embrace of nonhumans such as microbes as ‘agents’ (e.g. Nadasdy, 2007; Langwick, 2011; Paxson and Helmreich, 2014, p. 169). Science and technology studies (STS) and cultural studies scholars can and should do more than wait for the microbiome’s arrival in the Global South. We should rise to meet it.

Avoiding cultural or scientific reductionism requires taking seriously not only the technoscientific claims that experts make about microbes in scholarly papers but also the qualitative claims (those about the existence of a ‘microbial community’ as well as those about the human ‘publics’ within which they circulate) that they make in blogs, popular writing, and public engagement. These qualitative claims—easily written off as hype or simplification—are, I argue, *evidence*. Human–microbe relations can sometimes be measured numerically, but they cannot be fully explained with quantitative tools. Bacteria and viruses mutate, they avoid capture, and they destabilize social orders. In Nicaragua, an overworked and under-resourced public health system simply cannot control, much less account for, the foodborne pathogens and other microbial threats that beset the population (cf. Bingham and Lavau, 2012). In the United States, food scares are also of concern, but microbiome science has focused much more on the long-term evolutionary effects of antibiotics and antimicrobial chemicals. Such effects defy simple quantitative calculations.

Amid such uncertainty, what U.S. microbiome scientists share with MINSA hygienists is that they generate and disseminate qualitative evidence about human–microbe relations. This evidence might take the form of linguistic or religious norms, or knowledge of social or political conditions. Such qualitative evidence is what anthropologists Holmes and Marcus (2005, 2008) call ‘paraethnographic.’ In brief, paraethnographic evidence, or paraethnography, names the cultural material collected by those normally considered quantitative or statistical experts. Paraethnography has what I call a ‘symbiotic’ relationship to technoscientific evidence. This relationship, while not unique to microbiome science and hygiene, is particularly visible in these two areas. Attention to ‘evidentiary symbiosis’ is one way of avoiding not only cultural reductionism but also a ‘passive’ approach to the social study of the microbiome.

Anthropologists and sociologists are trained to ‘listen in’ to the work of the people, including scientists, into whose lives they insert themselves. Qualitative research requires us to tack back and forth between the ‘natives’ point of view’ and our own (Helmreich, 2009). In this paper, then, I am not aiming for an exhaustive theory about science and public health, or even of microbially oriented science and public health. Rather, I am focused on the manner in which scientists and hygienists, as makers of evidence, apprehend the human–microbial world. It is here that the ‘para’ in ‘paraethnographic’ has use as an analytic. Both American microbiome scientists and Nicaraguan hygienists make evidence on behalf of particular publics, including funders, supervisors, and laypeople. Just as ethnographic

research subjects ‘host’ anthropologists, these publics ‘host’ scientists and hygienists. Symbiosis, then, operates both at the level of human–microbe relations and of research itself.

In social engagements with microbes, paraethnography can play several roles. It can circulate alongside technoscience, having no measurable impact on it. It can be disruptive, weakening technoscientific claims. Finally, paraethnography can be an enabler, making natural science more powerful than it might be on its own. Following the terminology elaborated by pioneering microbiome scientists, I call these three kinds of evidentiary symbiosis *commensal*, *parasitic*, and *mutualistic* (see McFall-Ngai, 2008). By using the concept of symbiosis to describe the relationship between paraethnographic and technoscientific knowledge claims, I suggest that a view of microbes as social beings is more than an act of metaphorical or linguistic translation from experts to publics and back. In an age in which intimate bodily and global environmental concerns seem to be collapsing into one another, evidentiary symbiosis is crucial to the formulation of ethical action.

### Paraethnography and Evidentiary Symbiosis

In Nicaragua, as in other areas of the Global South, a day of preparing food, caring for children, and even going to work rarely passes without talk of *microbios*. As in the early days of Northern germ science, experts, technicians, and publics work to substantiate the presence of microbes in the landscape. Yet Nicaraguans live in a world that is not fully ‘pasteurized’ (Latour, 1988; Paxson, 2008). As in the United States and Europe, people and microbes in Nicaragua are co-inhabitants. In the North, co-inhabitation has lately come to revolve around the cultivation of ‘good’ bacteria in yoghurt, cheese, or over-the-counter probiotic pills. In Nicaragua, co-inhabitation is more pragmatic. Cheese and other fermented foods are key parts of the diet, but perhaps more importantly, in a vastly under-resourced public health system, microbial infections are routine parts of everyday life. Sanitarians face the problem not of how to make microbes ontologically present, but how to make them work as social, economic, and ethical tools. They possess technical aids (thermometers, pH strips, and the like), but these are never sufficient. Hygienists—like most frontline public health workers—rely upon the collection and organization of qualitative evidence in order to do their work.

Holmes and Marcus argue that paraethnography tends to become most visible and most potent when the limits of quantitative reason are reached: when numerical and statistical evidence lose their edge (Holmes and Marcus, 2005). To develop the concept, they studied how the people who run large financial institutions harness ‘fugitive social facts’ about the moods, hopes, and fears of economic actors in order to set monetary policy (Holmes and Marcus, 2005). They recount how former Federal Reserve chairman Alan Greenspan would feel ‘a pain in the stomach’ when he found himself coming close to mischaracterizing the state of the economy (Holmes and Marcus, 2005, pp. 240–241). What we

might call Greenspan's 'gut feelings' came not from numbers but from paraethnographic evidence. Holmes and Marcus insist that it is possible to use the paraethnographic claims of people who are ostensibly experts in quantitative reason to open up new lines of critical inquiry. 'To make ethnography of the paraethnographic' is to invite 'bridging' contact between social inquiry and other forms of expert practice (Holmes and Marcus, 2008, p. 241). Engaging with paraethnography requires experimentation.

This suggestion underpins the rather unusual comparison that occupies the bulk of this paper. Taken on its own, it would be difficult to view the labor of MINSA hygienists as related to that of North American microbiome researchers, but it would be equally difficult to study the role of qualitative evidence in northern microbiome science without drawing on what we know about its role in spaces like Nicaragua's health system. In different ways, both microbiome scientists and MINSA hygienists are experimenting. Both are working under what Kim Fortun calls

complex conditions ... involving many nested systems—technical, bio-physical, cultural, economic—and thus a multiplicity of interactions, which keep the parameters of 'the problem' from ever settling down. Complex conditions resist explanation in available terms. (2012, pp. 451–452)

Paraethnography tends to become salient amid such complexity, where standard forms of evidence leak into one another. This paper, then, examines such moments of leakage, or 'evidentiary symbiosis.'

A blurring of the lines between kinds evidence is a hallmark of many contemporary environmental health problems, including microbial ones, as well as global climate change, extinction, and epigenetics (Lock, 2013; Van Dooren, 2014). For example, evidence of the effects of toxic chemicals on bodies is difficult to muster within the rules of either environmental or biomedical science, which tend to insist on quantitative measures (Murphy, 2006; Mansfield, 2008; Fortun, 2012; Guthman *et al.*, 2014; Shapiro, 2015). In environmental justice struggles, claims about the linkages between toxins and bodily disorders are frequently undone by counterclaims by industry that those same disorders are the result of particular cultural behaviors such as smoking or diet (Fortun, 2011). Such industrial counterclaims are one kind of paraethnographic form. While an interplay of qualitative and quantitative evidence is thus central to a variety of scientific practices, my focus here is on the 'tactical' quality of the paraethnographic.

Microbial encounters are of course quite distinct from industrial chemical exposures, but recent scholarship on microbes has led to a reconsideration of both natural scientific theories of evolution and immunity and social theories on kinship and political action (Helmreich, 2009; Hird, 2009; Kirksey and Helmreich, 2010; cf. McFall-Ngai *et al.*, 2013). Paxson and Helmreich (2014) have

suggested that microbial communities have become ‘model ecosystems,’ ‘tokens of how organisms and human ecological relations with them *could, should, or might be*’ (Paxson and Helmreich, 2014, p. 168). In their telling, microbial ecosystems give the likes of artisan cheese makers and astrobiologists not just new ways of thinking about the trophic dynamics of nature but ‘promising’ moral models for future life on Earth. Paxson and Helmreich see these models as constitutive of an ‘optimistic’ ethical vision, but they are careful to delineate between different kinds of environments, livelihoods, and states of well-being. They note that an optimistic vision is open only to ‘those people who no longer have to worry about smallpox, polio, cholera, and other agents of infectious disease’ (Paxson and Helmreich, 2014, p. 183).

Though people can ingest artisan cheese cultures and explore outer space, these remain distinct from the microbial worlds that concern American microbiome scientists and Nicaraguan public health workers. Still, the notion that microbial ecologies offer prescriptive ethical models is compelling. In my analysis of where and how evidentiary symbiosis takes place, I want to put the notion of the model ecosystem, with its emphasis on the speculative and imaginative possibility presented in nonhuman ecology, into conversation with the concept of paraethnography, with its emphasis on the interpretive evidence that experts muster to ask ostensibly technical questions.

Much social analysis has emphasized the simultaneously disruptive and productive power of the *para-site*, particularly as elaborated by philosopher Michel Serres (Serres, 1982; see Kirksey and Helmreich, 2010; Lezaun, 2011; Kelly, 2012). In microbiological terms, however, parasitism is just one form of symbiosis. My analysis thus adopts microbiological terminology in order to ford a conceptual caesura between natural science and cultural studies. By identifying commensal, mutualistic, and parasitic evidentiary relationships, I do not aim to name typical or ideal features of the social relations of Americans and Nicaraguans with microbes. Instead, following Marilyn Strathern’s comparative studies of Melanesian and Euro–American kinship, I see symbiosis as a useful analytic for illuminating some important aspects of evidence as a working practical category (Strathern, 1992). Evidentiary symbiosis, I argue, is not just a sign that microbes are social beings. Rather, evidentiary symbiosis is the form that microbial sociality takes. In other words, microbes become social when people draw them into explanations about behavior, health, politics, and economics.

Holmes and Marcus’ work on paraethnography is part of a broader conversation about how qualitative social science might work productively alongside other kinds of expert practice to confront knowledge about problems of broad public interest (see Boyer, 2008). As Marcus (2013, p. 201) explains, attention to paraethnography can spark a ‘recursive’ critique, one that

[moves] situated discourses . . . around . . . in unusual configurations. This movement and posing of arguments out of the places where they are

usually made, heard, and reacted to, are distinctive acts of ethnographic fieldwork that are political, normative, and sometimes provocative, in nature.

It is this kind of recursive critique that I am attempting here. One immediate benefit of such critique is that it addresses what appears to be an increasing distance between the open environmental view of food favored in microbiome science and its speculative applications, and the narrow nutritional and governmental one favored in the practice of hygiene. That distance is not as great as it would first appear. Seen alongside a speculative high-tech science, hygiene, especially in the Global South, appears less a process of rigid state control over risk than an environmentally oriented effort to ‘live with’ what Solomon (2015, p. 178) calls in his discussion of food safety in Mumbai ‘patterns of reliable and unreliable foods.’

Accepting Marcus’ invitation to create ‘unusual configurations,’ this paper is part ethnography, part digital media analysis, and part book review. For a period of just over a year, I followed and documented the publications and public statements of American microbiome scientists in several virtual spaces. Foremost among these is the American Gut Project (AGP, [www.americangut.org](http://www.americangut.org)), a participatory online network of citizens and scientists. Advertising itself as the ‘world’s largest open-sourced science project,’ it was designed to produce and share knowledge about the human microbiome. The project allowed researchers to situate ongoing studies of the microbiome, which are relatively small in scale, within a broader biological and social context (cf. Candea, 2013). It did this by soliciting donations of cash and fecal samples from volunteers around the United States.

I also analyzed the public work of Jeff Leach, an anthropologist involved with an AGP-affiliated endeavor called the Human Food Project, which takes a similarly public approach to examining the long-term relationship between diet and microbiome diversity. Finally, I examined popular and scientific work by Dr. Martin Blaser and members of his laboratory. Blaser is an AGP collaborator and perhaps the best-known microbiome scientist in the United States. Blaser’s 2014 book, *Missing Microbes*, links the rise of antibiotic-resistant bacteria such as *Clostridium difficile* and methicillin-resistant *Staphylococcus aureus* to global climate change. Introducing the book, he writes that ‘Just as the internal combustion engine, the splitting of the atom, and pesticides all have had unanticipated effects, so too does the abuse of antibiotics,’ antiseptics, and sanitizers (Blaser, 2014; cf. Landecker, 2015). He characterizes the state of the modern gut as nothing short of a ‘disaster.’

AGP has collected over 9,000 microbial contributions through online social networking. The two Nicaraguan hygienists with whom I have worked as an anthropological participant-observer in Ciudad Sandino, just outside Managua, track microbes through a population of over 100,000 people through a combination of ‘old media’ (mostly radio and print) and word of mouth. I have done field

research with Ciudad Sandino's hygienists since 2006, conducting interviews with them and with the food distributors they monitored, shadowing them in their daily field inspections, and analyzing Nicaraguan sanitary regulations. I will now put this long-term anthropological research into conversation with more experimental research on AGP and its affiliate scientists.

### **Evidentiary Commensalism**

Many of the bacteria that reside in the human gut have a commensal relationship to their human hosts. These microbes survive by digesting the foods that people eat but cannot metabolize. For some time, people have been understood to 'eat at the same table' with these microbes, without either helping or harming the other (McFall-Ngai, 2008, p. 789). In many cases, the relationship between qualitative and quantitative or interpretive and positivist evidence in the study of microbes is also commensal.

One typical AGC blog entry, for example, reports on a study of the effects of fasts, yoghurt diets, and other nutritional cleanses on microbial diversity. Scatterplots, YouTube videos, and .gifs zoom in on findings about the impact of one diet, the Dr Oz fruit and vegetable cleanse, on three volunteers. The post includes a careful explanation of the study's main conclusion: 'How a person's gut responds to dietary changes may have just as much to do with the individual and their starting gut microbiome as the dietary intervention itself' (Thompson, 2014). As a piece of public scholarship, this post is in many ways exemplary. The prose is crisp and direct. Complex procedures are well explained.

But consider the way that the problem is framed in the opening lines of AGP's dietary cleanse blog post:

Few things typify Boulder, Colorado like doing a dietary cleanse to detox your body and restore your digestive health. Walk through the aisles of Whole Foods Market and you're likely to hear someone discussing their 'juice cleanse' or 'master cleanse.' Many of us assume that these cleanses have some beneficial effect on digestion and health—but what do they actually do to your gut microbiome? (Thompson, 2014)

These brief lines situate a relatively small piece of research in the context of an industrial American economy in which consumers are concerned not so much about microbes as about toxins. The location of the vignette in Whole Foods Market, a high-end retail chain specializing in organic foods, offers familiarity for American readers not steeped in microbial ecology. The concerns of Whole Foods customers about toxicity are what Holmes and Marcus (2005) call 'fugitive social facts'—quantitatively immeasurable yet compelling.

This vignette is more than mere window dressing for the more recognizably scientific findings that follow it. It is a paraethnographic tactic. The use of inverted

commas around the terms ‘juice cleanse’ and ‘master cleanse’ should not be dismissed as subtle mockery. As a space for the collection and dissemination of knowledge, AGP takes seriously the interests of ‘all comers,’ including devotees of fruit and vegetable cleanses (AGP, 2015). For AGP to work as public science, what were once fringe convictions must become mainstreamed. Indeed, even as the inventor of the fruit and vegetable cleanse in question, Dr Mehmet Oz, has been publicly ridiculed by his fellow physicians at Columbia University, proponents of his methods are included in AGP’s collaborative project (Izadi, 2015). Notably, however, at no point do the AGP scientists involved in the study actively advocate for or against any particular diet. Its study’s conclusions are rendered exciting, but the authors caution that it is necessary to know much more before saying anything definite about what cleanses do for or against human health.

What the AGP study does aim to do is provide a picture of how human microbial communities respond to disturbance. More familiar disturbances might include antibiotic use, long-term exposure to antimicrobial soaps, or cases of food poisoning, such as those frequently encountered by the MINSAsanitariums with whom I worked in Nicaragua. For example, in a case that received newspaper and radio coverage in 2008, students at a school lunch program (*comedor infantil*) in Ciudad Sandino became ill due to food poisoning (Gomez *et al.*, 2008). Accusations of poor food management, or worse, of harmful negligence, circulated around town for days afterwards, as the roughly 100 affected children were treated and released from the small emergency medical ward in town.

When I discussed the event with the two hygienists tasked with sorting out the origins of the incident, they were quick to deploy paraethnographic tactics. The *comedor* was operated by a well-respected international Roman Catholic solidarity mission. Since the late 1990s, it had provided food and schooling to children in Nueva Vida, Ciudad Sandino’s poorest section, located near the city’s dump. Its role in the nutritional life of the population was, overall, a positive one. Indeed, one purpose for opening a *comedor* in the neighborhood was to prevent children from scavenging for spoiled food in the nearby dump. It was a well-known fact that a local meat-packer, for example, offloaded its outdated inventory there once a week. If the food at the *comedor* was adulterated, the cause was not negligence, but bad luck. They knew of other schools and restaurants where foodborne illness was common. Indeed, they knew of stores and restaurants that sold expired meat and other foods.

As in the AGP case, the Nicaraguan health workers used paraethnography to define themselves in relation to an imagined public. Like most Nicaraguan health workers, the two hygienists were both devout Christians (one was a Roman Catholic and one was an evangelical Christian). Both were also veterans of the protracted Revolutionary struggle, led in the 1980s by the Sandinista National Liberation Front, to establish an effective primary care system in Nicaragua after decades of dictatorship. But while one hygienist (the evangelical)

identified as a Sandinista, the other (the Catholic) was one of a handful of non-Sandinistas who worked in the Ciudad Sandino branch of MINSA. Framing the problem as a confluence of an imperfect food system and a positive local history of Christian base community activism was a tactic for creating a common, workable technical space. It was important, as in the AGP's treatment of trend dieting, to separate the microbial incident from the social intentions and actions of those involved. Paraethnographic context served to reinforce, rather than call into question, the importance of collective action in the face of widespread poverty and hunger.

In the example about shoppers at the Boulder Whole Foods, the question of bodily toxicity was actually epiphenomenal to the study about microbes and cleansing diets. The study actually had nothing to say in quantitative terms about toxins. It simply used a shared 'gut feeling' to test a question about dieting and its effects on ecology (Holmes and Marcus, 2005). AGP's scientists use an interest in diets to make common cause with devotees of diet gurus like Dr Oz. The fact that one group is interested in microbial ecologies and the other in inorganic toxins does not foreclose a productive relationship. In the example from Nicaragua, the health workers' paraethnographic insights about the good intentions of the charity workers who served the tainted food were not designed to further an investigation into the food poisoning event. Instead, they were designed to frame outside interpretations of the investigation—to draw or 'loop' members of a public (or, indeed, sympathetic ethnographers) into the work (Fortun, 2012). As a framing device, commensal paraethnographic evidence in both examples creates an acceptable medium for inquiry.

### Evidentiary Parasitism

Paraethnographic evidence about human–microbe relations can also behave parasitically with respect to technoscientific evidence, in the sense that the former can sap explanatory authority from the latter. Parasites are perhaps the microbial symbionts with which scientists and the public are perhaps most familiar. In Nicaragua, *parasitos* including giardia and *Escherichia coli* are well-known hazards. While the simultaneous infection of 100 children with a microbe at the *comedor infantil* was a significant public event in Ciudad Sandino, most cases of parasitism in Nicaragua pass without much significant public notice. In the United States, on the other hand, reports about food parasites tend to cause massive public anxieties.<sup>1</sup> What I am calling 'evidence' in this section includes acts that might be mistaken for hype, gossip, or rumor, but as Holmes and Marcus suggest, this kind of communication is a key evidentiary tactic in conditions of epistemological uncertainty (2005).

For example, in late 2007, a MINSA worker from Ciudad Sandino appeared on a local radio program and publicly denounced a meat vendor in the local market for selling pork that, she alleged, was tainted with trichinosis. The MINSA worker

claimed that this particular vendor had been purchasing pork from an illegal abattoir (*matadero clandestino*), and that the vendor had bribed the two MINSA hygienists to keep that fact quiet. These accusations appeared just as MINSA was beginning a seasonal *Mercado Limpio* ('Clean Market') campaign designed to raise public awareness about foodborne illness. *Mercado Limpio* campaigns tend to occur in the run-up to Christmas, a time of increased meat consumption. Pork is a key ingredient in many traditional Nicaraguan dishes, and in Ciudad Sandino, families frequently spend the months leading up to the New Year raising and fattening pigs for slaughter. Some of these pigs are consumed at home, but others are sold.

After the report, I walked with the two inspectors to the *matadero clandestino* in question. The accusations of regulatory corruption had made the inspectors' supervisor, a medical doctor and the city's head epidemiologist, suspicious. He was fairly new to his post, and concerns about public officials on the take were a perennial topic of conversation in this and other state outposts. The doctor insisted on joining us. We approached the *matadero*, which was located in a family house on a crowded street, in a roundabout fashion. One of the hygienists happened to know that the family that lived on the end of the street closest to the MINSA office were relatives of the pig-butchers we were going to visit. She thought it best to avoid giving the relatives a chance to tip off the butchers. Inside the *matadero*, we found five pigs, one recently slaughtered. Its epidermis lay drying like laundry in the back of the patio, while the rest of its skin was chopped into a pile of raw *chicharron* awaiting a heating fryer next to the assembled viscera. I spied two of its feet tucked under an overturned bowl in an outdoor sink. The doctor gave the hygienists, who normally led such interventions, little chance to speak. After a brief assessment, he ordered the occupants to cease and desist, since slaughtering was illegal in 'urban spaces.' One of the hygienists filled out and stamped the order.

Back at the market, the doctor again led the investigation. But while the operators of the *matadero* had little to say in the way of protest, the accused vendor was indignant. 'I depend on the trust of my customers,' she insisted.

Her customers knew that she—not MINSA—could tell what good meat should look like, no matter its provenance. She asked to see the results of the tests the doctor said had been performed on her pork, but she knew that such tests were unlikely to transpire. In point of fact, they never did. The presence of *microbios*, even in this socially 'pasteurized' place, was difficult to substantiate technically due to economic limitations.

Turning to her own paraethnography, the vendor surmised that the problem was not one of corruption or bribery but of misplaced arrogance. It was a well-known fact that testing meat samples, blood samples, and other biological material required having someone transport them to a laboratory nearly an hour away. Many residents of Ciudad Sandino who had been to a consult at the local clinic had experienced lost blood work and long waits. Under these conditions,

regulation would not work when MINSA officials like the doctor, in the vendor's words, 'acted superior,' trusting the stories told by colleagues on the radio more than stories told by those who knew meat best. How could the doctor act superior when he could not bring her evidence? How, she continued, could the person who made the accusation be trusted? The vendor turned the same paraethnographic anxiety that started the conflict—anxiety about MINSA's bureaucratic corruption and technical incompetence—back on itself, resisting a clean resolution.

An example of evidentiary parasitism in AGP's work also relates to the consumption of meat. An offshoot of AGP is the Human Food Project, started by an evolutionary anthropologist, Jeff Leach. Leach has argued in venues as varied as *Nature* and *Paleo Magazine* that so-called 'primitive' people—in his case, the Hadza of Tanzania—possess microbiomes of greater diversity and resilience than those of 'modern' people, particularly Americans (Leach, 2013, 2012). He has gathered evidence for this claim by sampling the microbiomes of his Hadza informants and their environments, including the meat they consume: 'a dizzying number of animals ranging from Greater Kudu, Impala, Dik Dik, Zebra, various monkeys and birds, and so on' (Leach, 2014). Leach has also participated along with the Hadza in hunting and gathering expeditions (Leach, 2013). Leach's interest is in how the seasonal shift from wet to dry conditions affects the Hadza microbiome. As he puts it:

The impact of seasonality on the Hadza and their microbial environment is an interesting and possibly important question as it relates to what a healthier microbiome *might* have looked like before the niceties and medications of late whacked the crap out of our gut bugs in the so-called modern world ... [D]oes the reality of our seasonal past reveal that our gut microbiome is a shape shifting metabolic organ pulling the strings on our health and well being in a bi- or even tri-annual circadian-like rhythm? (Leach, 2014)

Leach paints a picture of a Hadza culture (seen here as hunting and gathering practices) that is in tune with its environment, and by extension its microbes.

Martin Blaser makes similar arguments in *Missing Microbes*, a combination research memoir and call-to-arms written for a popular audience. He suggests that the microbiomes of New Guinea highlanders 'allow their hosts to live on a diet that is 90 percent sweet potatoes' (Blaser, 2014, p. 54). Despite the fact that sweet potatoes are themselves low in protein, these microbes "'fix" nitrogen found in the highlanders' guts to make amino acids' (Blaser, 2014). Later in the book, he recounts the work of Gloria Dominguez-Bello, who collected microbiome samples from the Yanomami people of Venezuela. He describes Yanomami people as 'essentially from the Stone Age, with no written language, no mathematics, no contact with the modern world ... .In a sense, their microbes [are] living fossils' (Blaser, 2014, p. 324). 'Someday,' Blaser suggests, the microbes present in Yanomami guts 'might be used to protect our children from

the modern diseases now plaguing them' (2014, p. 325; see Obregon-Tito *et al.*, 2015). The Hadza and the Yanomami are not the only groups to be portrayed in this way. The prominence of cacao in the diet of the island Kuna of Panama, for example, has long been credited with giving them unusually good cardiovascular health (Howe, 2012).

Paraethnographic tales like these are, like the stories on the AGP site about Whole Foods shoppers, intended to draw a public into scientists' microbial genetic sequencing projects. As tales about 'model ecosystems,' they engage them as citizens and (in Leach's case) as concerned eaters (Paxson and Helmreich, 2014). Notably, that public does not include Hadza or Yanomami people. If readers of blogs and books cannot readily digest complex genetic science, they can connect with these tales about ecologically tuned 'ancient' cultures. Work like that of Leach and Dominguez-Bello has been criticized by historians and science writers, but not for its ethical or methodological merits. As the science writer Ed Yong cautioned in 2015, the problem is with the division between its public and its research subjects:

The Hadza ... are not ancient people, and their microbes are not 'ancient bacteria' ... They are *modern* people, carrying *modern* microbes, living in *today's world*, and practicing traditional *lifestyles*. It would be misleading to romanticize them and to automatically assume that their microbiomes are healthier ones. (Yong, 2015, emphasis in text)

The quality of this kind of research appears undermined—rather than reinforced—by the scientists' emphasis on the ancient-ness of the data, a concern that has been echoed elsewhere (de Wolfe, 2015). Similarly, biocultural evidence suggests that it is in fact a combination of a low-fat diet and strenuous labor, rather than a reliance on cacao, that keeps Panama's indigenous Kuna population in relatively good cardiovascular health (Howe, 2012).

The paraethnographic basis for assertions that Hadza or Yanomami possess a more diverse microbiome than 'us' is by definition exclusionary. Here, paraethnography plays a nostalgic role. Ecological nostalgia is selective; it engages with the bodies of colonized others while insisting that they occupy a space beyond 'global' environmental or economic life (West, 2006). By denying coevalness between expert and research subject, paraethnography here acts in a parasitic fashion. It drains explanatory power from the ecological and genetic analysis of different microbiomes.

In Nicaragua, the accusations that some vendors received meat from *matadores clandestinos*—even if such accusations were true in some cases—reinforced what hygienists and vendors alike saw as a damaging social divide between doctors and frontline health workers, and between state bureaucrats and working people. The accusations of corruption undermined the hygienists' attempts to carry out the *Mercado Limpio* campaign. The doctor's heavy-handed approach parasitically

invaded the hygienists' professional space, undermining the relationships they had cultivated with market workers and turning them into para-health workers, or auxiliaries. The allegations leveled over the radio by the MINSA worker against the Ciudad Sandino market vendors and her own co-workers drew not on nostalgia but on fears familiar to Nicaraguans—fears about corruption, but also about the daily risk of food poisoning. Yet in both the public discussions of 'ancient' microbes and of the Nicaraguan food scare, these tales, once released into the public domain, had the opposite of their intended effect.

In both the evolutionary anthropologist's effort to pinpoint an original state of human–microbial harmony and the hygienic investigator's effort to locate the origin of a 'food scare,' parasitism creates explanatory 'black boxes' (Yates-Doerr, 2012). In the former case, culture—seen narrowly as the organizational process of acquiring food—becomes the mechanism by which a 'healthy' microbiome is produced. In the latter case, the unscrupulous meatmonger is presumed to be the source of the scare. Tactically, paraethnography serves to '[consolidate] technical and historically contingent ideas about . . . dietary practices into seemingly unproblematic terms' (Yates-Doerr, 2012, p. 294). The broad category of health becomes reduced to the narrow domain of food (Guthman *et al.*, 2014). The historical entanglement of 'traditional' cultures, including those of hunter-gatherers, with 'modern' life is well known in anthropology, even if the Yanomami in particular are more familiar as a case example for debates about the origins of human–human aggression than of interspecies harmony (Ferguson, 2001). Similarly, the reduction of 'food scares' to pathological behavior occludes their deep political and economic origins. Such scares are produced, in part, by the parallel intensification of local and global production (Friedberg, 2004). Places like Ciudad Sandino are unevenly connected to a global food system. In Ciudad Sandino's market, meat from illegal abattoirs sits alongside meat produced by multinational corporations. Both are available as sustenance, but also, in this case, as parts of a broader celebration of Christmas.

### **Evidentiary Mutualism**

In nature, parasites can be quelled by mutualists, those beings that provide benefits to their symbionts and whose symbionts provide benefits to them. Indeed, microbiome studies have shown that the resilience of healthy individuals in the face of parasitic intestinal infection is largely due to the presence of mutualists in the intestinal infrastructure. Similarly, as the parasitic claims about tainted meat and 'primitive guts' circulated through Nicaragua and in the online microbiome community, those claims called other kinds of knowledge into being. In both places, evidentiary parasitism was held in check by evidentiary mutualism.

Initially, the investigation into the accusations of tainted meat in the Ciudad Sandino market dramatically reproduced a categorical division between potentially corrupt hygienic bureaucrats and virtuous, authoritative medical doctors.

Sanitary technicians, butchers, and market vendors were all placed under a pall of suspicion when the city epidemiologist took the lead in the investigation. Yet while the accusations leveled on the radio and reinforced in the doctor's investigation opened up the question of how spoiled meat got into the bellies of unwitting consumers, they failed to produce a resolution.

It would be unsurprising if the situation had remained at this stalemate, but something intriguing happened. 'The problem,' as Fortun might put it, refused to 'settle down' (2012, p. 452). This same group of actors (a maligned pair of MINSA sanitarians, a physician-epidemiologist, a slandered meatmonger) continued their dialogue. Over stacks of prepared meat that could be weighed but not tested, refrigerated but still not eaten, they continued to try to understand one another.

Later on the morning of the investigation, the doctor assembled meat, milk, and cheese vendors in the offices of the market. Again, he explained that it was illegal to buy animal products from unauthorized sources. Due to the coming of Christmas, he cautioned against the temptation to buy them more cheaply and thereby capitalize on the higher volume of business. Lest they think he was an unfeeling technocrat, he added, 'You all are workers (*trabajadores*) just like us. We're all workers.' In Nicaragua, even nearly 30 years after the Sandinista revolution (1979–1990), recognition as a *trabajador* still meant something. The development of a common class-consciousness, and the conversion of artisans and the urban poor (many of them women) into recognizable producers of capital was a central feature of revolutionary politics (Field, 1999; Babb, 2001). Even nearly 20 years after the end of the Revolution, the doctor's invocation of the category *trabajador* calmed the room. It even appeared to thaw the tension between the doctor and the sanitarians, who had been forced to spend the day working as his auxiliaries.

The doctor's tactic here might be written off as rhetoric, just as the allegations about the meat might be written off as gossip. Still, it seemed to give the vendors a sense that a cultivation of 'trust' between themselves and their customers might be met by a similar trust from MINSA. When I interviewed her later, the accused pork vendor told me that, despite her emphasis in the meeting on 'trust,' technical capacity—the kind that was so glaringly absent in her case—remained important. She insisted, to my surprise, that Nicaragua's health and safety laws and the (mostly hypothetical) techniques for enforcing them were essential to the functioning of the meat market. A fully equipped public health infrastructure—a key promise of the Revolution—was something good to aspire to, but in our interview, she echoed the tenor of the meeting. The doctor and the sanitarians were workers 'just like' the meat vendors.

I want to pause again, however, on the figure of the MINSA doctor, one moment a divisive, 'superior' technocrat and the next a conciliatory fellow *trabajador*. As technical work, paraethnographic practice casts experts like these in sometimes conflicting roles. While Blaser and Leach's claims about ancient microbiomes

have perhaps undercut the explanatory power of the studies they want to publicize, in other cases they and other microbiome scientists have managed to use paraethnography to make common cause with a concerned public.

In these cases, meat and the food system figure prominently. In *Missing Microbes*, Blaser devotes a chapter to ‘The Modern Farmer,’ spinning a story about the aggressive use of antibiotics in American pork, chicken, and beef production that would be familiar to most food quality activists, not to mention Whole Foods shoppers (Blaser, 2014, pp. 126–131). Blaser explains that antibiotics can prevent infection in animals that live in the close quarters of high-density feedlots, but that antibiotics also promote rapid weight gain. Blaser suspects (2014, p. 137) that the fattening effects of antibiotics on farm animals might also be visible in American children, among whom obesity is rising.

The connection he draws here, between animal bodies and human bodies, is part material, part metaphorical. Certainly, consumers of non-organic meat in the United States do ingest low doses of the antibiotics fed to the animals they eat, but the direct dosing of children with antibiotics is a separate process. To test what might happen when children receive antibiotics at early ages, Blaser and his students examined the effects of early life-course antibiotic dosing on microbiome development in ‘germ-free’ mice. (Germ-free mice are bred to possess a microbial population of zero.) After the dose, one group of mice was fed a high-fat diet, and that group gained significant weight. Samples of that group’s microbiome were then transferred to another group of germ-free mice, and that group, too, gained significant weight (Cox *et al.*, 2014).

The Blaser Lab’s experiments on antibiotics in mice stemmed from what can best be described as a paraethnographic sense of a pathology within the industrial food system. The organic and ‘natural’ foods movements actually preceded the technology that permitted the Blaser lab’s study by decades. A pathological food system, however, is nearly impossible to measure directly. The relationship between a paraethnographic observation about the relationship between meat and bodies and the technoscientific mouse experiments is one not just of translation, but of mutual evidentiary reinforcement. The mouse microbiome is itself a kind of materialized metaphor. Studies like this one forge a publicly and scientifically digestible connection between the production of animal bodies and the production of human ones.

If the conversation about microbes and health in the Ciudad Sandino market took place over the corpses of never-to-be-eaten pigs, a conversation about antibiotics in America is now taking place over those of experimental mice. Though antibiotics have long been used in the industrial food system, with uncertain long-term health effects, the structure of scientific publicity, in which evidence must move from species to species, has long prevented direct commentary on capitalism or industrialism. For Blaser, the ‘germ-free mouse’ legitimizes his paraethnographic thinking—indeed, a trenchant critique—of broader social and economic conditions. While elsewhere Blaser and his

colleagues might show an insensitivity to history in their haste to invoke the image of microbial ‘noble savages’ in the Amazon or Africa, in their work on antibiotics, they manage to make common cause with critics of the mainstream agro-food system.

In both Nicaragua and the United States, technical experts and publics are using knowledge about the social situations in which human–microbe relations emerge to facilitate a reflexive social critique. In Nicaragua, a meat controversy permitted these actors to contemplate the common struggles of market workers and state workers. In essence, they were forced to learn about one another’s labor—to form alliances, and contemplate ways to collect evidence about foodborne illness through a kind of evidentiary ‘looping’ (Fortun, 2012). In evidentiary mutualism, the search for ‘patterns’ of reliability and unreliability in the foodscape is one of pragmatism rather than technical precision (Solomon, 2015, p. 178). Mutualism reverses the black-boxing effect of parasitism by opening up the status of food, turning it into an environmental rather than nutritional factor in human health (Landecker, 2011; Solomon, 2015). Mutualistic paraethnographic practice appears, however, fleetingly, to embed the microbial world ethically and morally into the human one.

## Conclusion

I began this paper by asking: how does one study the microbiome as a social phenomenon in a place where it does not (yet) exist as a category of expert practice or public discourse? To answer this question, I compared the ways in which Nicaraguan hygienists produce qualitative evidence about the relationship between microbes and human health. Following Holmes and Marcus (2005, 2008) I view such qualitative knowledge production as a form of paraethnography. As I suggested, paraethnography is significant not only in under-resourced public health systems but also in the experimental spaces of American science. In both hygiene and microbiome science, paraethnography is a tactic that is adopted by experts and technicians in spaces where the rules and tools of scientific observation and analysis break down (Fortun, 2012; Marcus, 2013). Paraethnography may not only be relevant amid such breakdown, but breakdowns are poignant reminders of a broader ‘evidentiary symbiosis’ in scientific practice.

In these seemingly disparate spaces, different forms of evidence can, and indeed must, coexist. Since it is the result of tactical (i.e. unstable and opportunistic) actions on the part of citizens, experts, and microbes themselves, in the cases I examine, ‘evidentiary symbiosis,’ can take multiple forms, which I call *commensal*, *parasitic*, and *mutualistic*. I have argued that the study of human–microbe sociality through *ethnography*, the expert domain of anthropologists, sociologists, and other social students of science, entails more than tracing linguistic conventions (i.e. the habit of referring to microbial ecosystems as ‘communities’), or a documentation of how microbiome science travels. In their work on ‘model

ecosystems,' Paxson and Helmreich (2014, p. 169) sound a precautionary warning to social scientists engaging the microbiome. The ethnography of human–microbe sociality requires going beyond the mere recognition that microbes have 'agency.' Such a recognition is exciting, but it risks taking scientific evidence at face value, rather than engaging that evidence as the product of active, contingent experimental practices.

The three types of evidentiary symbiosis I identify here correspond to three types of human–microbe relationships, but they also provide productive ways of thinking about how public health and environmental research might be done in Nicaragua and elsewhere across the Global South as antimicrobial and antibiotic resistance take hold. Paraethnographic tactics are crucial for scientists like Blaser, as well as the Nicaraguan hygienists and doctor I profiled—what Marcus (2000, p. 5) would call 'moderately empowered people'—to making sense of the 'powerful social processes' in which they are implicated. It is tempting to label the kinds of paraethnographic material I described in this paper derogatively as economic or moral rationalizations, as gossip, or as hype. Instead, I have emphasized the ways in which qualitative evidence coexists with, undermines, and empowers technoscientific claims. Evidentiary symbiosis, I suggest, is what makes microbes social. In the specific case of human–microbe relations, evidentiary symbiosis removes food from its nutritional 'black box' (Yates-Doerr, 2012). As Strathern (1988, p. 294) argues with regard to food in Melanesia, 'Eating does not necessarily imply nurture; it is not an intrinsically beneficiary act . . . Rather, eating exposes the . . . person to all the hazards of the relationships of which he/she is composed.' Both Strathern (1992) and Marcus (2013) highlight the power of 'recursive critiques,' cutting across cases that do not immediately seem comparable. Understanding evidentiary symbiosis requires this kind of critique.

The interchangeability of evidentiary relationships is a key aspect of public science not only amid the post-pasteurian turn in human–microbe relations but also in other areas in which the tools of normal scientific inquiry break down. These include, most prominently, human-induced climate change, in which uncertainty is rife yet public concern is essential (Ogden *et al.*, 2013; Blue and Medlock, 2014). Beyond food, evidentiary symbiosis can open up other 'black boxed' phenomena, from carbon in the atmosphere to lead in drinking water. Reading the work of two disparate knowledge communities through one another helps show how microbial activity becomes evidence of the embodied effects of a changing environment. Despite the contingency and complexity of microbial and planetary systems, it is through the production of evidence that those effects are translated into ethical and political action. Insofar as every complex organism on Earth contains a unique ecosystem of microbial creatures, the microbiome is a global phenomenon (Orzech and Nichter, 2008). But like the bankers Holmes and Marcus (2005) studied, those who work with or on the microbiome (including

anthropologists) are still developing a shared discourse for talking about what the ‘global’ means.

Cultural and social students of science, perhaps more famous for taking critical positions than for pushing novel experimental terrain, would do well to dwell on this kind of evidentiary work. Indeed, as eaters in the Global North and Global South begin to demand more of science and the state, science studies should embrace and perhaps take part in the tactical, sometimes contentious qualitative experiments of other experts. My ultimate aim in this paper, then, is to suggest that critical science studies can anticipate, rather than simply await, the emergence of global categories of action and inquiry.

### Acknowledgements

I would like to thank Les Levidow, Kean Birch, and two anonymous reviewers for their thoughtful commentary during the various stages of editorial review. I am grateful for the feedback I received on earlier versions of this paper from Jamie Lorimer, Beth Greenhough, and the *Life After the Anthropocene* forum at the University of Oxford, as well from Ann Kelly, Christos Lynteris, and the other organizers and participants at the 2015 *Association of Social Anthropologists* meeting at the University of Exeter.

### Disclosure Statement

No potential conflict of interest was reported by the author.

### Funding

Funding for the original research was provided by the Social Science Research Council, Fulbright Hays, and a National Science Foundation Doctoral Dissertation Improvement Grant [No. 0849650].

### Note

<sup>1</sup>In 2014, Whole Foods Market was sued by the parents of an 8-year-old boy alleged to have died from exposure to *E. coli* in beef purchased at one of the chain’s Massachusetts stores (Sonfist, 2014).

### References

- American Gut Project (AGP) (2015) What Is American Gut? Available at [http://americangut.org/?page\\_id=7](http://americangut.org/?page_id=7) (accessed 15 May 2015).
- Babb, F. (2001) *After Revolution: Mapping Gender and Cultural Politics in Neoliberal Nicaragua* (Austin: University of Texas Press).
- Benezra, A., de Stefano, J. and Gordon, J. I. (2012) Anthropology of microbes, *Proceedings of the National Academy of Sciences*, 109(17), pp. 6378–6381.

- Bingham, N. and Lavau, S. (2012) The object of regulation: Tending the tensions of food safety, *Environment and Planning A*, 44(7), pp. 1589–1606.
- Blaser, M. (2014) *Missing Microbes: How the Overuse of Antibiotics Is Fueling Our Modern Plagues* (New York: Henry Holt and Company).
- Blue, G. and Medlock, J. (2014) Public engagement with climate change as scientific citizenship: A case study of world wide views on global warming, *Science as Culture*, 23(4), pp. 560–579.
- Boyer, D. (2008) Thinking through the anthropology of experts, *Anthropology in Action*, 15(2), pp. 38–46.
- Candea, M. (2013) The fieldsite as device, *Journal of Cultural Economy*, 6(3), pp. 241–258.
- Cox, L., Yamanishi, S., Sohn, J., Alekseyenko, A. V., Leung, J. M., Cho, I., Kim, S. G., Li, H., Gao, Z., Mahana, D., Zárata Rodriguez, J. G., Rogers, A. B., Robine, N., Loke, P. and Blaser, M. J. (2014) Altering the intestinal microbiota during a critical developmental window has lasting metabolic consequences, *Cell*, 158(4), pp. 705–721.
- De Wolfe, T. (2015) Review: Martin Blaser's *Missing Microbes*, *Edge Effects* blog, January 22. Available at <http://edgeeffects.net/blaser-missing-microbes/> (accessed 15 May 2015).
- Dunn, E. C. (2008) Postsocialist spores: Disease, bodies, and the state in the Republic of Georgia, *American Ethnologist*, 35(2), pp. 243–258.
- Federation of American Societies for Experimental Biology [FASEB] (2013) After the human genome project: The human microbiome project, *ScienceDaily*, February 28, 2013. Available at <http://www.sciencedaily.com/releases/2013/02/130228093831.htm> (accessed 21 March 2013).
- Ferguson, R. B. (2001) Materialist, cultural and biological theories on why Yanomami make war, *Anthropological Theory*, 1(1), pp. 99–116.
- Field, L. (1999) *The Grimace of Macho Raton: Artisans, Identity, and Nation in Late-Twentieth-Century Western Nicaragua* (Durham, NC: Duke University Press).
- Fortun, K. (2011) Afterword: Working “faultlines”, in: G. Ottinger and B. Cohen (Eds) *Technoscience and Environmental Justice: Expert Cultures in a Grassroots Movement*, pp. 249–261 (Cambridge, MA: MIT Press).
- Fortun, K. (2012) Ethnography in late industrialism, *Cultural Anthropology*, 27(3), pp. 446–464.
- Friedberg, S. (2004) *French Beans and Food Scares: Culture and Commerce in an Anxious Age* (Oxford: Oxford University Press).
- Gomez, O., Sirias, T. and Lara, R. (2008) Bacteria en Pollo, la causa más probable. *El Nuevo Diario*. 2/22/08. Sec Nacionales, online ed. Available at <http://www.elnuevodiario.com.ni/nacionales/9100> (accessed 7 July 2010).
- Gordon, J. I. (2012) Honor thy gut symbionts redux, *Science*, 336, pp. 1251–1253.
- Guthman, J., Broad, G., Klein, K. and Landecker, H. (2014) Beyond the sovereign body, *Gastronomica: The Journal of Food and Culture*, 14(3), pp. 46–55.
- Helmreich, S. (2009) *Alien Ocean: Anthropological Voyages in Microbial Seas* (Berkeley: University of California Press).
- Hird, M. (2009) *The Origins of Sociable Life: Human Evolution After Science Studies* (Houndsmills, Basingstoke: Palgrave).
- Holmes, D. and Marcus, G. (2005) Cultures of expertise and the management of globalization: Towards a re-functioning of ethnography, in: A. Ong and S. Collier (Eds) *Global Assemblages: Technology, Politics, and Ethics as Social Problems*, pp. 235–252 (Malden, MA: Wiley-Blackwell).
- Holmes, D. and Marcus, G. (2008) Para-ethnography, in: L. Given (Ed) *The SAGE Encyclopedia of Qualitative Research Methods*, pp. 596–598 (London: SAGE).
- Howe, J. (2012) Chocolate and cardiovascular health: The Kuna case reconsidered, *Gastronomica: The Journal of Food and Culture*, 12(1), pp. 43–52.

- Izadi, E. (2015) Dr. Oz responds after prominent physicians call for his firing from Columbia University. *Washington Post*, April 16. Available at <http://www.washingtonpost.com/news/to-your-health/wp/2015/04/16/a-bunch-of-doctors-ask-columbia-university-to-cut-its-ties-with-dr-oz/> (accessed 15 May 2015).
- Kelly, A. H. (2012) The experimental hut: Hosting vectors, *Journal of the Royal Anthropological Institute*, 18(S1), pp. S145–S160.
- Kirksey, S. E. and Helmreich, S. (2010) The emergence of multispecies ethnography, *Cultural Anthropology*, 25, pp. 545–576.
- Koch, E. (2011) Local microbiologies of tuberculosis: Insights from the Republic of Georgia, *Medical Anthropology*, 30(1), pp. 81–101.
- Landecker, H. (2015) Antibiotic resistance and the biology of history, *Body and Society*. Online early edition. doi:10.1177/1357034X14561341.
- Landecker, H. (2011) Food as exposure: Nutritional epigenetics and the new metabolism, *BioSocieties*, 6, pp. 167–194.
- Langwick, S. (2011) *Bodies, Politics and African Healing: The Matter of Maladies in Tanzania* (Bloomington: Indiana University Press).
- Latour, B. (1988) *The Pasteurization of France*. Trans. Alan Sheridan and John Law (Cambridge, MA: Harvard University Press).
- Leach, J. (2012) Ghosts of Our African Gut, *Paleo Magazine*, Dec/Jan, 40–42.
- Leach, J. (2013) Gut microbiota: Please pass the microbes, *Nature*, 504(7478), p. 33. doi:10.1038/504033c.
- Leach, J. (2014) Available at <http://humanfoodproject.com/rebecoming-human-happened-day-replaced-99-genes-body-hunter-gatherer/>.
- Lezaun, J. (2011) Bees, beekeepers, and bureaucrats: Parasitism and the politics of transgenic life, *Environment and Planning D: Society and Space*, 29, pp. 738–756.
- Lin, A., Bik, E. M., Costello, E. K., Dethlefsen, L., Haque, R., Relman, D. A. and Singh, U. (2013) Distinct distal gut microbiome diversity in healthy children from Bangladesh and the United States, *PLOS One*, 8(1), p. e53838.
- Lock, M. (2013) The epigenome and nature/nurture reunification: A challenge for anthropology, *Medical Anthropology*, 32(4), pp. 291–308.
- Mansfield, B. (2008) Health as a nature-society question, *Environment and Planning A*, 40, pp. 1015–1019.
- Marcus, G. (2000) Introduction, in: G. Marcus (Ed) *Para-sites: A Casebook Against Cynical Reason*, pp. 1–14 (Chicago, IL: University of Chicago Press).
- Marcus, G. (2013) Experimental forms for the expression of norms in the ethnography of the contemporary, *HAU: Journal of Ethnographic Theory*, 3(2), pp. 197–217.
- McFall-Ngai, M. (2008) Are biologists in ‘future shock’? Symbiosis integrates biology across domains, *Nature Reviews Microbiology*, 6, pp. 789–792.
- McFall-Ngai, M., Hadfield, M. G., Bosch, T. C. G., Carey, H. V., Domazet-Lošo, T., Douglas, A. E., Dübilier, N., Eberl, G., Fukami, T., Gilbert, S. F., Hentschel, U., King, N., Kjelleberg, S., Knoll, A. H., Kremer, N., Mazmanian, S. K., Metcalf, J. L., Neelson, K., Pierce, N. E., Rawls, J. F., Reid, A., Ruby, E. G., Rumpho, M., Sanders, J. G., Tautz, D. and Wernegreen, J. J. (2013) Animals in a bacterial world, a new imperative for the life sciences, *Proceedings of the National Academy of Sciences*, 110(9), pp. 3229–3236.
- Murphy, M. (2006) *Sick Building Syndrome and the Problem of Uncertainty: Environmental Politics, Technoscience, Women Workers* (Cambridge, MA: Harvard University Press).
- Nadasdy, P. (2007) The gift in the animal: The ontology of hunting and human-animal sociality, *American Ethnologist*, 34(1), pp. 25–43.
- Obregon-Tito, A. J., Tito, R. Y., Metcalf, J., Sankaranarayanan, K., Clemente, J. C., Ursell, L. K., Zech Xu, Z., Van Treuren, W., Knight, R., Gaffney, P. M., Spicer, P., Lawson, P., Marin-

- Reyes, L., Trujillo-Villarreal, O., Foster, M., Guija-Poma, E., Troncoso-Corzo, L., Warinner, C., Ozga, A. T. and Lewis, C. M. (2015) Subsistence strategies in traditional societies distinguish gut microbiomes, *Nature Communications*, 6, p. 6505. <http://www.nature.com/ncomms/2015/150325/ncomms7505/full/ncomms7505.html>
- Ogden, L., Heynen, N., Oslender, U., West, P., Kassam, K.-A. and Robbins P. (2013) Global assemblages, resilience, and earth stewardship in the Anthropocene, *Frontiers in Ecology and the Environment*, 11, pp. 341–347.
- Orzech, K. M. and Nichter, M. (2008) From resilience to resistance: Political ecological lessons from antibiotic and pesticide resistance, *Annual Review of Anthropology*, 37, pp. 267–282.
- Paxson, H. (2008) Post-pasteurian cultures: The microbiopolitics of raw milk cheese in the United States, *Cultural Anthropology*, 23(1), pp. 15–47.
- Paxson, H. and Helmreich, S. (2014) The perils and promises of microbial abundance: Novel natures and model ecosystems, from artisanal cheese to alien seas, *Social Studies of Science*, 44(2), pp. 165–193.
- Serres, M. (2007 [1982]) *The Parasite*. Trans. Lawrence R. Schehr (Minneapolis: University of Minnesota Press).
- Shapiro, N. (2015) Attuning to the chemosphere: Domestic formaldehyde, bodily reasoning, and the chemical sublime, *Cultural Anthropology*, 30(3), pp. 368–393.
- Solomon, H. (2015) Unreliable eating: Patterns of food adulteration in urban India, *BioSocieties*, 10, pp. 177–193.
- Sonfist, A. (2014) Available at <http://www.necn.com/news/new-england/Whole-Foods-Sued-In-Boys-Death-286088641.html>.
- Strathern, M. (1988) *The Gender of the Gift* (Berkeley: University of California Press).
- Strathern, M. (1992) *Reproducing the Future: Essays on Anthropology, Kinship, and the New Reproductive Technologies* (Manchester: Manchester University Press).
- Thompson, L. (2014) What does a three-day dietary cleanse do to your gut microbiome? *American Gut Project* blog, October 6. Available at [http://americangut.org/?page\\_id=258](http://americangut.org/?page_id=258) (accessed 15 May 2015).
- Van Dooren, T. (2014) *Flight Ways: Life and Loss at the Edge of Extinction* (New York: Columbia University Press).
- West, P. (2006) *Conservation Is Our Government Now: The Politics of Ecology in Papua New Guinea* (Durham, NC: Duke University Press).
- Yates-Doerr, E. (2012) The opacity of reduction: Nutritional black-boxing and the meanings of nourishment, *Food, Culture, and Society*, 15(2), pp. 293–313.
- Yong, E. (2015) Surprises emerge as more hunter-gatherer microbiomes come in, *Not Exactly Rocket Science* blog, March 26. Available at <http://phenomena.nationalgeographic.com/2015/03/26/surprises-emerge-as-more-hunter-gatherer-microbiomes-come-in/> (accessed 15 May 2015).