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political emergences and entanglements of the human microbiome

The microbial human: political emergences and entanglements of the human microbiome

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Author’s Declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Research Degree Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

Signed: Alice Beck Date: 17/10/2022

Abstract

The microbiome has been the cause of much excitement in the biomedical world and beyond, holding promise in medical interventions for a seemingly never-ending list of conditions and diseases. While only recently brought into the mainstream, the processes through which the microbiome is emerging in dominant natural and medical sciences require critical attention. This thesis explores the microbiome via the medical procedure of Faecal Microbiota Transplantation (FMT). Diffracting thinkers from Science and Technology Studies with theorisations about the governance of life, the thesis unpicks the emergence of the microbiome via networks and assemblages, while also paying attention to the power structures that determine and influence such emergence through a focus on the gendered and raced human. Analysis chapters demonstrate the fruits of diffracting critical approaches 'in motion' first through an exploration of the hierarchies of science as they are animated in the microbiome and FMT knowledge production. I then lay out a political ecology of the microbiome to question how the entangled microbiome is currently stabilising in governance regimes. Moving on from systemic structural observations the thesis lastly unpicks corporeal subjectivities via FMT users and microbiome testing kits, noting the ability of bodies to influence and exceed governance regimes. Throughout, using the case study of the microbiome, I argue for a generative politics that takes seriously both the systems/structures and emergent (more-than) human forces that dictate human-microbe entanglement and relationality.

A**cknowledgements**

When I first began writing up this thesis, as a pastime I would read over the acknowledgements of other theses', looking at whom they had to thank for their completed PhD. Initially, and rather naively, I thought that the acknowledgements might be a formality, or in my more cynical moods, that they were an expression of self-indulgence. However, as time went on, I realised that it really takes a village to produce a PhD, especially in these unsettling and dystopian times.

First and foremost, I want to thank my attentive and encouraging supervisors Mark Jackson and Maria Fannin. Your feedback, guidance and reassurance in my academic abilities have been formative in the development of my ideas, my ability to persevere and finally reach the end. You have been so generous with your time right up until the end. Thank you for everything.

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Contents

Table of figures

An autoethnographic preamble

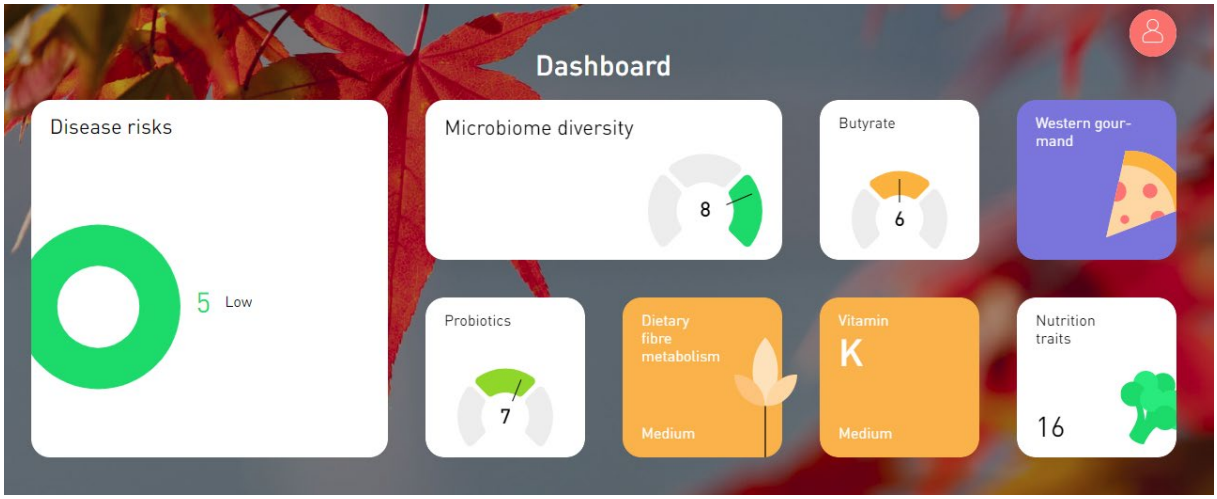

Figure 1 Atlas Biomed test results, 'Dashboard' page, 2022

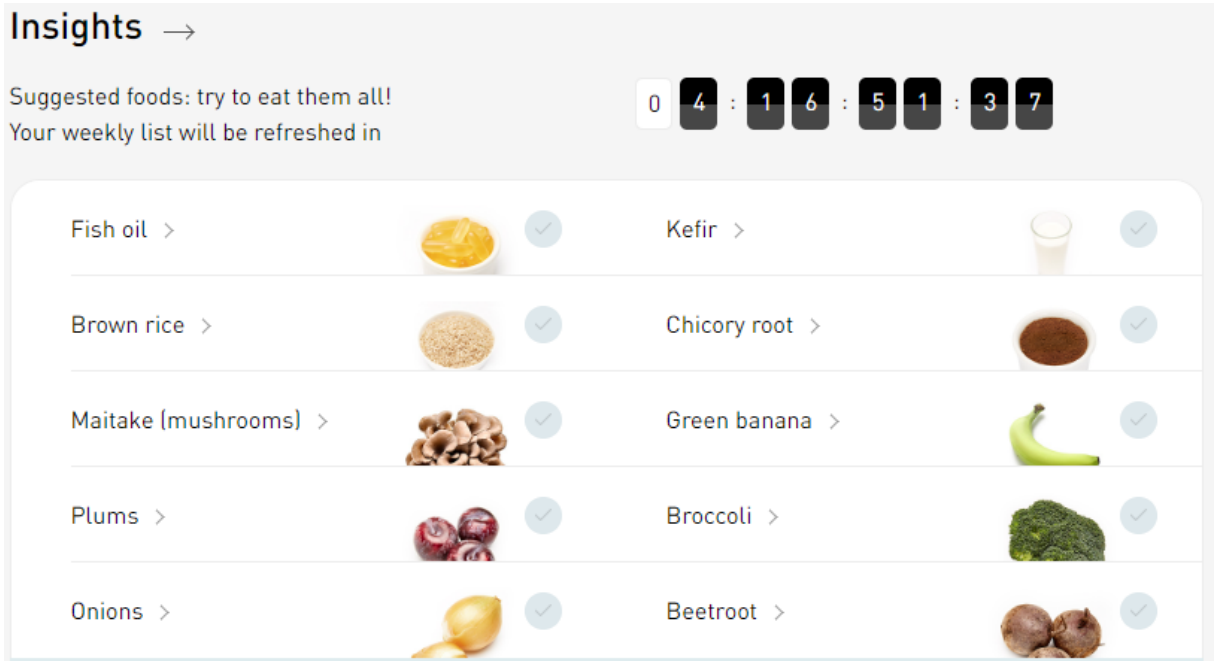

Figure 2 Atlas Biomed test results, 'Insights', 2022

It is the 17th of December 2020. I open my emails to find that my results have arrived from 'Atlas Biomed', a DNA and gut microbiome testing biotech company, they are the

second microbiome testing company that I have sent samples to.[1] The images above are what welcome me as I log into my online account. Figure 1 represents a visualisation of my microbiome according to Atlas Biomed. They use Illumina technology (whole-genome sequencing technology) to analyse the DNA in the bacteria sourced from my faecal matter, which I provided to them as part of the test.

The results envision my microbiome via extrapolating my disease risk, microbiome diversity, number of key microbes and their by-products, including butyrates and probiotics, the geographical location of my diet, my fibre and vitamin intake, my nutritional traits, and a list of food recommendations. I later find out these details are updated every few weeks.

After having waited six weeks for the results, I am intrigued to see what they have to say about my microbiome. I already have a sceptical view of what the test results will show me. Prior to sending off my material, I filled out a questionnaire, which asked about my bodily characteristics, lifestyle, diet, health, and auto-immune disease status. I was surprised they did not ask about specific gut conditions such as Irritable Bowel Syndrome (IBS), a very common gut condition, or other areas of digestive health, like stomach acidity, a digestive problem that enduring this doctoral research has pleasantly bestowed upon me. Similarly, although asking me what my sex is, no other questions to do with hormones or the menstrual cycle were asked. I was surprised such questions did not come up. While it is recognised in the literature that sex and menstruation affect microbiome ecologies, I am also personally aware of their effect on my microbiome. In particular, I notice that my IBS symptoms, bloating, diarrhoea, indigestion, and general digestive discomfort, all worsen during my period. Without such, the test results appeared to provide me, at least at first glance, with a decontextualised understanding of my microbiome outside of the broader ecology of my body.

Though sceptical towards the testing kits, learning about the microbial life that inhabits my body is somewhat novel. I am excited to see the long and, to someone who has

[1] The first was uBiome. I am not able to provide the results from this uBiome test as the company has since shut down. This is expanded upon throughout the thesis, and Chapters Three and Seven detail my interactions with uBiome specifically.

no prior knowledge of the microbiome, seemingly arbitrary list of names; I'm eager to show my friends this visual representation of my microbiome.

At first sight, my results seem to match up with my expectations: I am British and have lived in the United Kingdom for most of my life. It makes sense that I have a western diet. I am also relatively fit and healthy, so it makes sense that I have a low disease risk.

As I continue to look through the recommendations, however, I start to question some of their suggestions; they do not align with my own bodily experiences. For example, one week they recommend white onions and another week, chickpeas, and Quinoa, all of which I avoid due to the unwanted effects they have on my digestion. Further, some of their food suggestions, such as citrus fruit and tomatoes, I also avoid due to stomach acidity issues. The other general recommendations that I eat more vegetables and fibre both appear to be rather standard unspecific insights for a testing method that was supposed to offer me unique and specific bodily information.

I start to doubt the information presented to me as the results inform me of things that I am already aware of, while the specific recommendations, based on my microbiome data, appear incorrect and do not match with my own bodily knowledge. I find myself asking, how do I make sense of this information? If I eat these recommended foods will my microbiome improve and how would it affect the other areas of my digestion? Does this accurately represent my microbiome? What kind of picture of my microbiome do these results paint? How has it changed how I feel about my microbiome and body? What am I supposed to trust more, my personal experience or information processed using the most up-to-date technology and testing methods?

After such reflections I also consider my ability to implement Atlas Biomed's recommendations. While I have access to food shops, my ability to engage in the dietary recommendations is not always possible due to external restrictions such as my time availability and income. These external factors also contribute to my wellbeing and digestive health, which leads me to question the broader politics through which the microbiome emerges as an ecology. As Atlas Biomed does not consider broader situational factors, I ponder the social and political decontextualisation of the

microbiome that my test results produce. I dissect Atlas Biomed's recommendations and consider what the most practical changes are, what are the cheapest and least time costly alterations that I can adopt?

This ethnographic moment crystalises well some of the core themes that this thesis seeks to address. These include the processes and practices by which the microbiome becomes known, both personally, through microbiome testing kits for example, but also more broadly, via structural modes of governance and regulation. I seek to explore the politics of how the microbiome becomes known, how such understandings are interpreted as valid or more accurate representations, and how these different understandings inform how we recognise and relate to the microbiome in various ways.

Chapter One: Introduction

> …It is not enough to decide to include nonhumans in collectives or to acknowledge that societies live in a physical and biological world as useful as these steps may be. The crucial point is to learn how new types of encounter (and conviviality) with nonhumans, which

> emerge in the practice of the sciences over the course of their history, can give rise to new modes of relation with humans, i.e. to new political practices (Paulson 2001, 112).

The human microbiome, understood as the immense array of microbial life that inhabits the interior and exterior of the human body, exposes both the nonhumanness of the human as well as its dependency on nonhuman life (Beck 2019, Haraway 2008, Hird 2009, Hird 2010, Lorimer 2020). Research exploring the microbiome has begun to uncover its integral role in many areas of human health (Cho and Blaser 2012, Clemente et al. 2012, Looi 2020, Madupu et al. 2013, Nie et al. 2019, Rajagopala et al. 2017, Sommer et al. 2010, Yatsunenko et al. 2012) as well as the dynamic and complex relationalities humans have, and have had, with microbial life (Hird 2010, Greenhough 2012, Greenhough et al. 2020, Greenhough 2022, Lorimer 2017b, Lorimer 2020). As a field, however, microbiome studies are still in their relative infancy; understandings of the microbiome are still developing and are not yet fixed (Helmreich 2013, Marcus 2021). While the human microbiome encompasses various microbiomes across the human body, such as the skin, mouth, and scalp microbiomes, that are all important and interact with each other, this thesis specifically explores the gut microbiome.[2] Specifically, the gut microbiome has only recently[3] started to be adopted in spaces of dominant medicine[4] (Velasquez-Manoff 2012b, Clemente et al. 2012, Falony et al. 2016, Valdes et al. 2018, Carlson et al. 2018).

A key moment of the microbiome's emergence into dominant medicine is through the integration and adoption of the procedure of Faecal Microbiota Transplantation (FMT). FMT is a procedure that transplants a sample of faecal matter, with a diverse microbial ecology, into an 'un-diverse' gut (Borody et al. 2014, Houf 2021, Taymount Clinic 2022b).[5] Though FMT has a long and rich history, it has only

[2] From hereon, I refer to the gut microbiome as the microbiome.
[3] Engagements with the microbe and microbiome have existed long before their adoption in dominant medicine. For example, methods of fermentation have been practiced throughout history (Raghuvanshi et al 2019, McNeil 2008).
[4] Similar to geographer Max Liboiron (2021), I refer to dominant medicine and science as opposed to Western medicine or science. This is due to wanting to "keep power relations at the front and centre" (2021, 20). As Liboiron goes on to explain, "Western science is a cultural tradition where ways of knowing start with the Ancient Greeks, get influenced by various forms of Christianity and Judaism, and move through the Enlightenment. Generally, I have no problem with that culture. The problem is when it becomes dominant to the point that other ways of knowing, doing, and being are deemed illegitimate or are erased" (ibid, 20-21). Moreover, "not all Western science is dominant. Midwifery, alchemy, and preventative medicine are part of Western science that suffer at the hands of dominant science" (ibid, 21).
[5] More detail on FMT is provided later in the chapter.

recently been adopted in dominant medicine (De Groot et al. 2017, Joseph et al. 2019, Zhang et al. 2012) and is a key focus throughout this thesis.

How the microbiome, and FMT, emerge as knowable processes and subjects within dominant medicine is crucial as it represents a key spatialisation of bodily authority (Lupton 2012, Mol 2002). The microbiome exemplifies an influential materiality in informing how understanding the human and its relationship with the nonhuman is constituted, and by whom. For this process of emergence is not neutral. Instead, it is informed by, and determines, a specific politics of the microbiome, which incorporates, quite literally, what is known to exist, how that known and its knowability is ethically and politically constituted, and what those ethics and politics mean for bodies and their interactions.

This thesis aims to identify, therefore, the varying 'onto-ethico-epistemologies' of the microbiome as they develop at different sites of knowledge production, both in more traditional sites via microbiome-related academics and industry members, as well as via individuals who personally practice the novel medical intervention, Faecal Microbiota Transplantation (FMT). In a break with the conventional separation of ontology, or *what* is known, epistemology, or *how* things are known, and ethics, or visions of how things *should* be, I use the term 'onto-ethico-epistemologies' in line with feminist philosopher of science Karen Barad's (2007) work, which argues for the impossibility of separating ethics, ontology, and epistemology. As Barad states,

> The point is not merely that knowledge practices have material consequences but that practices of knowing are specific material engagements that participate in (re)configuring the world. Which practices we enact matter—in both senses of the word. Making knowledge is not simply about making facts but about making worlds, or rather, it is about making specific worldly configurations—not in the sense of making them up… but in the sense of materially engaging as part of the world in giving it specific material form (Barad 2007, 91).

Debolena Roy (2018, 208), a neuroscientist and social theorist explains further that onto-ethico-epistemology "describes the simultaneous events of learning how to see the world, learning how we come to know the world, and thinking about how we learn to approach that world". Ontology, epistemology, and ethics cannot be observed as singular events, rather they emerge with and through each other. I argue that the

microbiome is a fascinating and important lens through which to read how a politics and ecology of medical and geographical embodiment is in the process of contemporaneous emergence.

This thesis draws from Barad's (2007) working of onto-ethico-epistemologies to explore the differing engagements with the microbiome that produce it together with the ethical and political implications of these engagements. I argue that the microbiome complicates traditional conceptions of scientific knowledge production because both high-capital, investment-driven, institutionalising knowledge production apparatuses, including industry and academia, as well as personal, embodied, everyday lay productions of the microbiome are in play in the microbiome's emergence for dominant health and embodiment discourses. Further, as I will show, at times these institutional and personal forms of knowledge production come into conflict. Unlike quantum physics (the focus of Barad's exploration of onto-ethico-epistemology) everyday processes of digestion render knowledge about the microbiome accessible to everyone. Microbial, corporeal knowledge is increasingly a collective and everyday process, and produces knowledge of the microbiome outside of extreme disease settings. Microbiome-related industry members and academics, as well as FMT users, all have their own interests in the microbiome, yet they engage with it differently, and, as such, produce the microbiome in their own ways. Consequently, differing onto-ethico-epistemologies of the microbiome enact a variety of ethical relations and political as well as epistemic consequences as they inform different kinds of care, relationality, and interventions with the microbiome and the assemblages it enacts.

Exploring different engagements with, and productions of, the microbiome together with the ethical consequences of these is important. As a novel discovery in dominant medicine, there is not yet a fixed or stable understanding of the microbiome. How understandings of the microbiome stabilise and who gets to contribute to them is important for bringing accountability to how the microbiome enters into, and is engaged by, in dominant medicine. As Barad explains, "…knowing requires differential accountability to what matters and is excluded from mattering" (2007, 380). This is especially important as dominant medicine and human health are highly political arenas where inequalities have been, and continue to be, reproduced (Herrick and Reubi 2017, Lupton 2012). Critically examining how the microbiome emerges in dominant medicine is important in attempting to understand both how knowledge making is always already political, and, importantly, how we might prevent the

reproduction of inequalities, exclusions, and silences in medical and health knowledges more generally.

Further, unpicking a politics of the microbiome speaks to how we understand and go about medically treating the human as a more-than-human ecology. As this thesis goes on to explore, the microbiome reveals the ecological nonhuman diversity within the human, and upon which the human, traditionally understood fundamentally depends. The microbiome, problematizing as it does the boundaries and borders of what constitutes the human, offers the potential to produce a generative politics that moves away from hierarchical and humanistic understandings of the human, where nonhuman life is seen as *less than* the human (Haraway 2008, Smart and Smart 2017, Tsing 2012). Enacting a non-hierarchical view of the human, one that appreciates the human as part of a more-than-human ecology is important both for reflecting a more accurate depiction of the significant role that the nonhuman plays in human health, as well as for building a more convivial relationality with the microbiome.

Science and Technology Studies (STS) scholars, who have long examined the power that scientific authority has in determining politics, and who have become increasingly influential in human geography, have been key in informing this thesis (Daston 2000, Jasanoff 2004, Latour 1988, Latour 2012). Within the umbrella term STS, there are a variety of scholars thinking in overlapping, yet distinct, ways, including material-semiotic theorists (Barad, 2007, Haraway 1988), actor-network theorists (Latour 1990) and historians of science (Daston 2000). However, what is common across this heterogeneous field is a questioning of the role of science and critical sensitivity towards the more-than-human networks and entanglements that constitute scientific knowledge, enabling a deeper inquiry into the politics of science. However, where this thesis departs from many STS scholars is by drawing upon theorisations of biopolitics that arguably place greater emphasis on the productivity of structural and institutional power in producing both scientific knowledge and human bodies (Foucault 2008). In combining STS and biopolitics, this thesis is able to critically observe the emergence of the microbiome via more-than-human networks, while also paying attention to the power structures[6] that determine and influence such networks through a focus on the gendered and raced human. By doing so, I explore how power

[6] I use ‘structures and/or ‘systems’ as shorthand to refer to the ways formal apparatuses of power reproduce themselves through, for example, institutional governing and regulatory bodies or via capitalist and industrial systems of reproduction.

dictates certain kinds of microbiome conceptions, as well as how differing understandings of the microbiome themselves invoke politics of their own.

Although there is a growing body of work by critical social scientists that examines the human microbiome (Beck 2019, Benezra 2020, Bradshaw 2021, Bradshaw 2022, Greenhough et al. 2020, Greenhough 2022, Greenhough 2012, Ishaq et al. 2021, Lorimer 2020), the processes by which the microbiome emerges in dominant medicine and the politics that both shapes its emergence and stems from its conception are largely unexplored. Exploring these emergent processes and complex politics is thus one of the original contributions of this thesis. The following thesis seeks to address, then, how different figures of microbiome knowledge production and the knowledge that they produce are ascribed legitimacy and authority, and how these incite various kinds of *relationality with the microbiome.* Or, in alignment with the Paulson (2001) epigraph at the start of this chapter, I explore how different forms of understanding the nonhuman microbiome produce a *politics of* the microbiome.

The main intention of this introductory chapter is to set the scene of the thesis for the reader. I do so by providing detailed context and background to the main areas that the thesis focuses on. I start by providing a brief genealogy of the microbe and microbiome and background to FMT. I then situate my research focus by specifying the nuances of western industrialised microbiomes. I give an overview of the onto-ethico-epistemic tensions in *who* and *what* gets to contribute to the development of the microbiome's understanding. The last contextual area details how the thesis engages with politics. I then set out the research questions that shape the analysis of the research and how the thesis significantly contributes to the field of human geography microbiome studies. I end the chapter by offering a detailed account of the thesis's structure.

The microbiome's emergence: From microbe to microbiome

Prior to the microbiome's emergence into dominant medicine, the microbe had been a part of contemporary medicine for some time.[7] Pasteurisation was notable in forming understandings of the microbe. As philosopher Bruno Latour (1993) expands in his book *The Pasteurisation of France*, pasteurisation introduced an understanding of the

[7] Notably, the microbe was first discovered between 1665-1683 by Robert Hook and Antoni van Leeuwenhoek (Sachs 2007).

microbe as disease causing and killable through human intervention. The process of pasteurisation along with the many actors in the hygienist movement (Latour 1993) were essential for the development of sanitarian theory (that argued that disease was caused by miasmas) to germ theory (that identified microbial life as the cause for disease) (Sachs 2007). Hence, the discovery of pasteurisation alongside germ theory both cemented an understanding of microbial life as both killable *and* controllable (Hinchliffe et al. 2016, Latour 1993). As geographer Steve Hinchliffe suggests,

> Germ theory rekindles a sovereign and legalistic notion of disease… [where] some infectious diseases and their microbial agents became notifiable and matters of legal jurisdiction once their presence has been confirmed. They were matters to become extinct (Hinchliffe et al. 2016, 32).

Some have suggested this understanding and relationality with microbes has continued into the current day. For instance, anthropologists Heather Paxson and Stefan Helmreich argue,

> For much of the 20th century, the particularity of harmful germs has overdetermined popular views of the microorganism world as a whole; under the modernist, Pasteurian regime of the FDA, microbes have been figured as perilous, requiring human control (Paxson and Helmreich 2014, 172).

However, this perception of microbes as perilous is starting to be resisted (Paxson and Helmreich 2014). Combining their respective work on microbial life in artisanal cheese and in astrobiology, Paxson and Helmreich point to the promise rather than peril of microbes (Paxson and Helmreich 2014). By highlighting the intimate relationship that microbes have with humans via food, and the speculative potentials that astrobiology holds, they pose that, “microbial abundance is assayed for its diversity as well as with respect to its generality – its widespread and suffusing presence, in both daily and distant domains” (Paxson and Helmreich 2014, 167). They emphasise the productive opportunities that microbes can offer when we revise the Pasteurian ideology that holds the absence of microbial life as the objective.

In this vein, geographer Jamie Lorimer offers a ‘probiotic approach’, which "describe[s] human interventions that use life to manage life, working with biological and geomorphic processes to generate forms of human, environmental and even planetary health" (Lorimer 2020, 2). This approach is counter to what Lorimer refers to as the overwhelming predominance of antibiotics and the ideology in which they proliferate. He explains

> Being antibiotic describes systematic efforts to secure the Human through the control of unruly ecologies. It involves efforts to eradicate, control, rationalise, and simplify life that are common across landscapes, cities, homes, and bodies. It describes the scientific and political developments in the nineteenth and twentieth centuries that led to economic growth, food surpluses, and disease eradication (Lorimer 2020, 2–3).

Such a probiotic approach has broadened onto-ethico-epistemic workings of the microbe and situates microbial life in broader ecological contexts (Lorimer 2017c, Lorimer 2020). FMT well represents this onto-ethico-epistemic shift and is discussed later in this chapter.

The microbiome more generally has received a lot of attention for the potential promises it poses for intervention in human health (Cho and Blaser 2012, Clemente et al. 2012, Madupu et al. 2013, Nie et al. 2019). Research is revealing the incredibly important role that the microbiome has in many aspects of human health, however, what makes it particularly interesting is that, unlike other important determinants of health i.e., the human genome, the microbiome is mutable. Factors affecting the microbiome and its development, as well as the prime spaces of intervention and prevention, occur first and foremost in early childhood. The immune system develops primarily after birth, and, as Nie et al note, “appropriate stimulation in early life has an irreplaceable effect on the maturation of the immune system” (2019, 2290). Key spaces of microbial exposure occur from the moment of birth, which includes the birthing method (vaginal or c-section) and the feeding method and length (breast milk or formula) (Mueller et al. 2015). Although no microbiome is the same, the microbiome is informed through members in the family and specifically the maternal microbiome (Schloss et al. 2014), which Knoop (2018, 1295) suggests “raises the possibility of a parental contribution to the development of the gut microbiota and by extension a nongenetic inherited contribution to our long-term health”.

Consumption practices throughout a person's life are also extremely important and long-term dietary changes appear to be significant in reducing inflammation, infection and improving metabolism (Xu et al. 2015). Alongside this, time spent in microbially diverse natural spaces (such as jungles or forests) can be beneficial for diversifying the microbiome compared to microbially sparse environments (such as air-conditioned spaces) or heavily polluted environments (Gilbert and Stephens 2018, Liddicoat et al. 2019).

A significant contributor to microbiome development is the intake of antibiotics over time. Although pivotal in championing the decline of life-threatening diseases, because antibiotics are non-discriminatory, they wipe out many of the microbial ecologies within the microbiome (Stecher et al. 2013, Tompson et al. 2021, Velasquez-Manoff 2012a). The potential for the microbiome to 'bounce back' depends on the host, however, consistent, and long-term antibiotic consumption can have a detrimental impact on the human host through repeatedly depleting microbial diversity (Tabashsum et al. 2020, Velasquez-Manoff 2012b).

The microbiome composition is also impacted by lifestyle habits such as exercise, smoking, and stress. Prominently, exposure to stress can substantially modify the homeostasis and hence composition of the microbiome (Foster et al. 2017). The gut-brain axis enables the gut and brain to be in constant communication through "the vagus nerve, the immune system, tryptophan metabolism, the enteric nervous system and microbial metabolites such as short-chain fatty acids (SCFAs)" (Lebeer and Spacova 2019, 1). This connection represents a material bidirectional connection between the brain, the gut microbiome and the "gastrointestinal mucosal immune system" (Maltz et al. 2019, 534). Broadly, it is understood that when exposed to stress, host-microbe interactions can be disturbed, consequently effecting immune system activity and inflammation (Foster et al. 2017, Maltz et al. 2019, Murison 2016, Rea et al. 2016).

This dynamic and integrated relationship that the human microbiome has both internally and externally, has prompted a reimagining of the human body and its relationship to microbial life (Höll and Bossert 2022, Morar and Bohannan 2019). Two interrelated concepts illustrate this re-imagining: symbiosis and the holobiont. The concept of symbiosis is broadly understood as "a mutually beneficial relationship between two or more organisms living in association in the same space" (Andrade et

al. 2021, np see also Hird 2009, Margulis 1971, Margulis 1981). [8] Symbiosis emphasises cooperation rather than conflict, which has disrupted common understandings of how life on earth started and opposes the very notion of the human individual (O'Malley 2017, van Loon 2000). The 'holobiont', a term formulated by biologist Lynn Margulis, has been argued by some (Haraway 2008, Gilbert 2017, Gilbert 2019, Guerrero et al. 2013, Margulis 1971) as a more useful concept to understand the organism as. This is because the holobiont more accurately represents the relationality of organisms, that multitudes of life are interconnected and enable each others health and flourishing (Guerrero et al. 2013). The holobiont can be understood "as the anatomical term that describes the integrated organism comprised of both host elements and persistent populations of symbiosis" (Gilbert et al. 2012, 327-328). Entrenched within "symbiotic assemblages" (Tsing et al. 2017, m26), some have argued for the human to be revised as a holobiont (Gilbert 2017, Gilbert 2019).

The human as a holobiont first complicates traditional understandings of the human as an autonomous individual that is superior to nonhuman life (Haraway 2008, Gilbert 2019, Gilbert et al. 2012, Smart and Smart 2017).[9] First, understood as a holobiont, the human requires and is dependent on nonhuman life for human flourishing and wellness (Haraway 2008, Gilbert et al. 2012, Gilbert 2017, Gilbert 2019). Second, it allows for a different set of relations with microbial life (Haraway 2016). Multispecies feminist theorist Donna Haraway's work has been formative in considering how these revised relationalities with nonhuman life inform new politics and relationalities with nonhuman life. She uses the term 'sympoiesis' to situate organisms in the wider ecological enmeshment that enables life to exist as it has done. As she explains, sympoiesis is,

> …Making-with. Nothing makes itself; nothing is really autopoietic or self-organizing … Sympoiesis is a word proper to complex, dynamic, responsive, situated, historical

[8] While the exact definition of symbiosis has been debated, three dominant types of symbiosis are often cited. These include mutualism (where both organisms benefit), commensal (where only one organism benefits) and parasitism (where "one organism benefits to the detriment of the other") (Aganetti et al. 2021, np, Leung and Poulin 2008). All these definitions rest heavily, however, on a 'cost and benefit' model, which defines the symbiotic relationship depending on a dichotomous and short-sighted separation of the 'pros and cons' that the relationship brings (Roughgarden 1975). The host and symbiont relationship is not always clearly defined nor immediately apparent (Foster et al 2008). Instead, they may be multifaceted and vary over time (Leung and Poulin 2008).

[9] Discussed later in this chapter, in the section 'Posthuman politics'.

> systems. It is a word for worlding-with, in company. Sympoiesis enfolds autopoiesis and generatively unfurls and extends it (Haraway 2016, 58)

Haraway makes clear that thinking with symbiosis is productive as it depicts a more accurate representation of human-nonhuman coevolution, and, furthermore, it can inform better ways of being together (ibid). Haraway also points out, however, that sympoiesis and mutuality are repeatedly misunderstood as autopoiesis and singularity.

> This point is important for thinking about rehabilitation (making liveable again) and sustainability amid the porous tissues and open edges of damaged but still ongoing living worlds, like the planet earth and its denizens in current times being called the Anthropocene (Haraway 2016, 33).

If organisms are open systems rather than close singularities, interaction can be made in "the porous tissues and open edges" (ibid, 33). Similarly, by expanding our understanding of organisms, or, in this case, revising the human as an open system that inhabits and is part of a diverse microbial ecology, new forms of relating can emerge. Put differently, "what we perceive may be transformed if the way we pay attention changes" (Stengers 2008, 95). Hence, how the microbiome is understood determines how we relate to and engage with it, and as Haraway points out, this offers opportune moments of change.

In the next section, I will explore how the microbiome has emerged and been engaged with via the procedure of Faecal Microbiota Transplantation, a key focus within this thesis.

Faecal Microbiota Transplantation

Before we explore FMT's integration into dominant medicine let us first go through the mechanics of the procedure. FMT "is applied for many…conditions where the microbiome ecology" lacks significant strains of microbial life or has been damaged or weakened (Beck 2019, 359, Crum-Cianflone et al. 2015, Seekatz et al. 2014, Terveer et al. 2016). The medical procedure of "FMT involves taking a sample

of ['healthy'[10]] faecal matter from a healthy donor and transplanting it into [a host] where the microbiome ecology is in a state of 'dysbiosis'" (Beck 2019, 359, Carding et al. 2015). Dysbiosis can be understood as a shift in ecological equilibrium, where something has caused the ecology to become 'unbalanced', a state often understood and observed as 'unhealthy' (ibid).

FMT is most frequently used for the condition recurrent *Clostridium difficile* (*C. diff*) infection (Khanna et al. 2016). The infection usually occurs after taking antibiotics: antibiotics aforementioned non-discriminatory nature means that much of the microbiome ecology is wiped out, allowing for *C. diff,* a spore forming bacteria, to overpopulate (Blaser 2016, Leffer and Lamont 2015). Colonisation resistance theory (CRT) is often cited to explain how FMT works for *C. diff* (Pamer 2016). CRT states that a diverse microbiome ecology prevents one microbe from overpopulating and causing harm (ibid). Despite being critiqued for producing a 'passive' representation of the body (Wolf-Meyer 2017), CRT well demonstrates the ecological dynamics and nuances of the microbiome (Pamer 2016, Xiao et al. 2020). Further, it is useful in explaining why, if treated repetitively with antibiotics, *C. diff* can become a recurrent[11] and chronically debilitating, sometimes life-threatening, infection. However, for others, the repetitive consumption of antibiotics inhibits microbial diversity and hence can prevent recovery. If the microbiome ecology remains un-diverse, without other microbial strains to outcompete it, *C. diff* may continue to proliferate.

Outside of *C. diff,* FMT is currently being actively trialled in clinical trial settings and experimentally by patients for other gut conditions, such as Irritable Bowel Syndrome (El-Salhy et al. 2020, El-Salhy et al. 2019), ulcerative colitis (Angelberger et al. 2013, Cammarota and Ianiro 2019, Mańkowska-Wierzbicka et al. 2020, Narula et al. 2017), and Crohn's disease (Suskind et al. 2015, Vaughn et al. 2016), conditions also associated with gut microbiome dysbiosis. However, the dysbiosis associated with these latter conditions is much more complicated than one microbe overpopulating; instead, there are a number of microbiome and host factors, such as genetic predisposition, at play (Agnello et al. 2020, Chong et al. 2019, Carding et al. 2015). FMT is also being trialled for several 'non-gut' conditions and disorders,

[10] I use scare quotes around the term 'healthy' as the concept of a healthy microbiome is not easily defined. A microbiome that is too varied, or where one strain has overpopulated the microbiome, is associated with certain disease states and conditions. Further, certain microbes may be safe in some people but dangerous in others; there is no one microbiome that is universally healthy.
[11] Also known as recurrent *Clostridium difficile* Infection (rCDI).

including depression and anxiety (Cai et al. 2019, Evrensel and Ceylan 2015, Foster and Neufeld 2013, Li et al. 2019, Meyyappan et al. 2020), autism (Kang et al. 2019, Zhao et al. 2019), neurologically degenerative conditions such as multiple sclerosis (Borody et al. 2011, Li et al. 2020), and others (Smits et al. 2013). However, how these conditions and disorders interact with the microbiome are not very well understood (Smits et al. 2013).

The procedure itself entails transplanting faecal matter from the donor into the host. The transplantation of the faecal matter involves adding a saline solution to the faecal sample and either putting it into a centrifuge machine (if the procedure is being administered by a medical professional) or a blender (if self-administered in a 'Do It Yourself' setting, discussed later in this section). Centrifuge or blending enables the solids to be separated from the fluids. Precipitate solids are disposed of, and the remaining solution is kept for the procedure. When administering the sample, the solution needs to be administered past the anal canal and rectum and into the colon (Borody et al. 2014, Joseph et al. 2019, Kim and Gluck 2019). This can be achieved by colonoscopy or enema if done by a professional (Kim and Gluck 2019). When self-administered, the popular protocol is to use a funnel and tube. Less common is the use of a Nasoduodenal Tube (NGT), which orally feeds the material via a tube through the oesophagus, stomach and into the upper intestine (ibid). Other methods include consuming the material orally via freeze-dried encapsulated material (Hecker et al. 2016). These latter options are only available in professional medical settings due to the required technology and equipment.

Thus, the mechanics of FMT are complex and emergent, with the procedure currently a site of speculation and experimentation in dominant medicine. I now go on to lay out how this unusual and promise-laden procedure has come about.

FMT: A short history

FMT's integration into dominant medicine has had a significant impact in how the human microbiome is observed and engaged with. Though only recently emerging in dominant medicine, FMT has a rich and diverse history. "The first records of faecal transplantation date back to 4th century China, where 'yellow soup' (boiled faecal matter) was applied in cases of severe food poisoning and diarrhea" (De Groot et al. 2017, 254, Zhang et al. 2012, 1755). Italian surgeon Acuapendente (1533-1619)

practised the procedure of FMT on animals coining the term “transfusion”, which describes the “transference of gastrointestinal content from a healthy to a sick animal” (Wang et al. 2019, s24). However, the procedure’s first entry into dominant medicine started to emerge in 1957, when “bacteriologist Stanley Flakow…treat[ed] surgery patients with ‘faecal pills’” (De Groot et al. 2017, 254-255). Notably, a year later in 1958, the surgeon Dr Eiseman led a procedure that “cured four pseudomembranous colitis patients with faecal enemas” (ibid, 255). The first record of FMT being used to treat *C. diff* was in 1983, by clinical bacteriologists Schwan et al (1984). Later, in 1989, Australian gastrologist, T.J Borody successfully used FMT as a medical therapy for refractory ulcerative colitis (UC) (Borody et al. 1989, Borody et al. 2014). Despite this, FMT only started to gain real traction in dominant medicine in 2013 when the first randomised control trials were performed to treat *C. diff* via FMT (Joseph et al. 2019). Van Nood et al. (2013, 407) found that “the infusion of donor faeces was significantly more effective for the treatment of recurrent *C. difficile* infection than the use of vancomycin [an antibiotic]”.

FMT’s integration into dominant medicine, in the United States (US) specifically, has not been smooth. In 2013, the US Food and Drug Administration (FDA) labelled FMT as an Investigational New Drug (IND) as FMT’s effectiveness “ha[d] not yet been demonstrated in the controlled clinical trial setting” (FDA 2013, 401, Sachs and Edelstein 2015). Therefore, patients would only be treated with FMT for conditions of recurrent *C. diff* in clinical trials (Sachs and Edelstein 2015). After much outcry from doctors, medical professionals, advocacy groups, and patients, “the FDA revised its decision and announced that it would exercise enforcement discretion when FMT was used to treat patients ‘with *C. difficile* infection not responding to standard therapies’” (Sachs and Edelstein 2015, 401).[12] This allowed patients to access the procedure where “*C. difficile* infection [is] not responding to standard therapies” (Food and Administration 2013, np). As “long as the physician obtained adequate information”, the patient could access FMT instead of engaging in a clinical trial (Sachs and Edelstein 2015, 401).

The complexities that the microbiome poses to regulatory and legislative parameters have been explored at length by critical social scientists. Importantly, some have pointed out that how the microbiome is regulated is extremely important

[12] The FDA’s regulation of FMT is discussed in detail in Chapter Five.

for its conceptual emergence and for how the microbiome and FMT are understood and interacted with (Wolf-Meyer 2017). In his paper 'Normal, Regular, and Standard: Scaling the Body through Faecal Microbial Transplants', Wolf-Meyer points to the limitations of governing microbial life. By observing how

> Medical professionals conceptualise bodies, disorders, and treatments – the 'normal', the 'regular', and the 'standard'—, some of the limits of contemporary medical governance can be elucidated, namely that individuals are much easier to control than microbial colonies are (Wolf-Meyer 2017, 299).

Hence, it is microbial lifes nonhumanness, autonomy, and its ability to exceed human attempts at coercion via governance regimes that makes it difficult to control. Similarly, Cohen (2020) highlights the challenges that the microbiome poses to legislative modes of governance. As she explains,

> In the eyes of the law, one of the problems with such practices [FMT] is that they destabilise conventional forms of governance, calling for the mediation of state-sanctioned organisations into people's decisions about what to take in and out of their bodies (2020, 9).

Both Wolf-Meyer (2017), Cohen (2020), and others (Rhodes et al. 2013, Scheeler 2019) have pointed to the pressures that the microbiome poses to both how the human is understood and how regulation for medical intervention is formulated, something this thesis expands on in Chapter Five.

Both faecal banks and private health companies have been pivotal in producing research on the procedure and the microbiome, as well as enabling the procurement of FMT material for patients. Open Biome, the US's only Faecal Bank, has been the predominant figure in both catalysing research on FMT and providing faecal material throughout the US (Open Biome nd). As an independent nonprofit organisation, they represent an interesting figure in the microbiome's emergence as they both enable the delivery of FMT while also catalysing research on FMT and the microbiome (ibid). Their "operation costs are funded primarily through user fees collected from hostpitals" and their "research efforts and … pro bono treatments for patients" are "support[ed] through private donations" (Open Biome nd, np). Because of the novel space in which

they operate, representing members from both industry and academics, Open Biome are a key research participant that this thesis drew from.[13] However, on the 23rd of Februrary 2021, Open Biome stated that, due to financial pressures and with an FDA approved drug for *C. diff* close to production, they are starting to "phase out production of new treatments" (Open Biome 2021 np). However, they have confirmed that they will continue to provide donation material until an FDA drug is approved (ibid). Restricted access to official faecal banks and the significant cost of private health companies have prompted those suffering from such conditions to undertake the procedure themselves.

Coined 'Do It Yourself'ers' (DIYers), those performing FMT on themselves through unofficial sources self-experiment in an attempt to ease or cure their ailments. DIYers acquire donated faecal material through unofficial sources, either through family and friends, or by advertising on online communities such as Facebook and blogs. Many DIYers screen the donation material for harmful or dangerous parasites, antibodies, or bacteria. Of course, although there is no mandatory screening process for DIYers, if screening of the donation is not done, unoffical background checks of the person who has provided the donation will usually be performed to understand their antibiotic consumption, recent or chronic personal or family illness, lifestyle and diet history. Using equipment such as food blenders and funnels (often purchased through recommendations via online communities), DIYers blend the donated faecal matter up and (most commonly) perform an at-home enema, attempt to retain the material over night, and then excrete the matter the next day.

While to an outsider, especially if done DIY, FMT may appear as disgusting or 'yucky' (Chuong et al. 2015, Houf 2021), the materiality of faecal matter implicates a novel kind of relationality with the microbiome. To exchange faeces from one person to another, for many, operates in a space of taboo (Cohen 2020). Some have explored this via media representation, finding that while earlier representations of the procedure employ messaging of disgust and reproduce FMT using the 'yuck factor' (Chuong et al. 2015), more contemporary representations work to disrupt FMT's association with disgust and instead "reframe bacteria from being bad to being good, from enemies to friends, from others to neighbours, from weeds to gardens" (McLeod et al. 2019, 347). Others have explored what disgust can offer for how we think about

[13] Details of Open Biome's involvement in the research are detailed in Chapter Three.

human-nonhuman relationality. As medical humanities scholar Jessica Houf recommends,

> If we counter our impulses to avoid the disgusting, this might allow us to focus on the ambiguity of disgust in order to interrogate its source -where a personal difficulty or crisis become a means to face our shared insecurity (2021, 414).

She advocates "for a sceptical approach to the assumed disgust of FMT" highlighting its role as "an emotion that functions to displace our shared vulnerability" with nonhumans and the humans animality (Houf 2021, 414). Similarly exploring a human nonhuman relationality, in his later work, Wolf-Meyer (2020) suggests kinship emerges via the procedure of FMT. He argues that the technologies of FMT work to enable care to manifest within themselves and others while also appreciating the multispecies interdependencies (Wolf-Meyer 2020). Observing "kinship as a necessarily political category" (ibid, 232) he argues for a "more expansive, inclusive politics that" opposes the ideological move to individualism that arises through structures of neoliberalism (ibid, 43). This thesis similarly explores the role of politics in human-nonhuman entanglement via FMT. However, building on Wolf-Meyer's work, I specifically explore how differing actants, beyond FMT users and at varying scales, produce a politics of the microbiome and critically consider how these actants are engaged with and reproduce power structures that facilitate and/or restrict how a human microbiome relationality emerges.

FMT users specifically represent an important onto-ethico-epistemological contribution because of the conditions that have led them to FMT. Many FMT users' conditions sit outside of the remit of dominant medicine's capabilities. As so little is known about the microbiome (Carlson et al. 2018, Clemente et al. 2012, Falony et al. 2016, Helmreich 2013, Marcus 2021, Valdes et al. 2018) intervention for microbiome-related conditions are limited. Further, many FMT users' conditions are commonly caused or worsened by dominant medical intervention such as antibiotics. In other cases, FMT users were told that there was nothing else that their medical provider could do for them. Because of this, FMT users have had to craft their own bodily knowledge using material found online and through self-experimenting with FMT. FMT users, then, represent a novel group that have had to develop a deeply intimate

relationship with, and understanding of, their microbiome – yet they remain absent in much of the academic literature.[14]

Because of the lack of assistance from dominant medicine alongside the severity of FMT users' conditions, many operate in a space of particular precarity. While most people seeking medical attention face some form of precarity, there is a specific nuance to FMT users having chronic conditions that are not well understood by dominant medicine. This precarity becomes apparent microbially, socially, and financially. Further, and as I go on to explore later, the specific hierarchical power dynamics of dominant medicine, underwritten by the onto-ethico-epistemologies that this thesis seeks to critique, contributes to this precarity. This dynamic illustrates the importance of exploring the production of the microbiome by both 'lay' FMT users, who personally interact with their microbiomes through the procedure of FMT as well as afterwards in an everyday context, and by 'expert' microbiome-related academics and industry members who produce the microbiome through classical and traditional modernist modes of knowledge production. While others have explored the forms of biosociality that emerge in spaces where dominant medicine has lacked answers for conditions (Rabinow 1992, Rabinow 2005), this thesis seeks to question how FMT users produce their own understandings of, and relationality with, their microbiomes and the onto-ethico-epistemic dynamics at play between different sites of microbiome knowledge production. To be able to do so, it is first essential to understand the broader geographies of the microbiome.

Geographically specifying the microbiome

As I discuss later on, FMT regulation varies from country to country, and the microbiome field more generally, is an international field (Scheeler 2019). This thesis focuses, however, on the US regulatory landscape as the administration responsible for ensuring safety standards on drug development, the Food and Drug Administration (FDA), is incredibly powerful and important in setting the standard for regulation globally, in part because FDA approval enables market access to US consumers. This market is highly lucrative. In 2021 "Americans spent $576.9 billion on medicine" (Kolmar 2022, np) and "prescription drug use reached a record 194Bn daily doses"

[14] Wolf-Meyer (2020) incorporates FMT users' stories, however, this is the only work I found thus far that does so.

(IQVIA 2022, np). The powerful influence of the FDA was indicated to me by TJ, an Open Biome employee, as he explained

> It turns out that most countries are willing to follow the FDA's lead especially when they are at the forefront of this. The way they are doing that is to go through the normal drug development which involves tons of investment.

The US then represents an interesting setting to explore the microbiome's geographical emergence as it is home to world-leading microbiome research by life science and biotechnological industries[15] (Breznitz and Anderson 2005, Green 2021, Ledford 2015). The huge success of such industries has, in part, been enabled by the neoliberal resistance to regulation (Cooper 2011). How the microbiome is engaged in this highly capitalised neoliberal setting is important in remaining attentive to the processes of enclosure and exploitation that are deeply entrenched in the structures of capitalism and neoliberalism (Cooper 2011, Lebowitz 2003).

However, more broadly, there is particular importance in observing the human microbiome relationality in a western industrialised context because of the developmental transition that the microbiome has undergone due to processes of industrialisation. Processes of industrialisation have considerably changed human environments and habits that impact the human microbiome (Blaser 2014, Sanders et al. 2021, Velasquez-Manoff 2012a, Velasquez-Manoff 2012b). A reduction in time spent outdoors, in consumption of high fiber foods, and an increase in pollution and social stress are all heavily indicative of a western, industrialised capitalist environment. All contribute to decreasing microbiome diversity in western populations (Velasquez-Manoff 2012a). Changes to the human microbiome have occurred throughout human evolution and are not inherently bad (Yong 2016). To romanticise a pre-industrial or former microbiome falls into what anthropologist Alexis Shotwell (2016) would refer to as a discourse of purity. "This ethos is the idea that we can access or recover a time and state before without pollution, without impurity, before the call from innocence, when the world at large is truly beautiful" (Shotwell 2016, 3). However, both the disruption that industrialisation has to the environment and to changes in human behavior are cause for concern as they negatively implicate the

[15] Further details on the research sites are detailed in Chapter Three that discusses my methodology and methods.

development and maturation of the human immune system (Lerner et al. 2015, Murdaca et al. 2021, Sanders et al. 2021, Velasquez-Manoff 2012a).

As mentioned, a key space of microbial influence in human health is the immune system. Because the human immune system evolved *with* microbial life, microbial presence is required to enable the appropriate development and programming of the immune system (Daşbaşı and Öztürk 2016, Klenerman 2017, Knoop et al. 2018, Lee and Mazmanian 2010, Nie et al. 2019). Many argue that the rise in autoimmune conditions is due to overactive immune systems caused by decreasing microbial interaction (Lerner et al. 2015, Murdaca et al. 2021, Velasquez-Manoff 2012a). Or, as some have suggested, the human's 'missing microbes' (Blaser 2016) have led to an 'epidemic of absences' (Velasquez-Manoff 2012a, Velasquez-Manoff 2012b). Dysbiosis in the microbiome can increase "aggressive immune cells" that are symptomatic of autoimmune conditions (Nie et al. 2019, 2291). Autoimmunity occurs when the immune system is inflamed, causing it to attack human cells instead of invading organisms (ibid). A consensus has not been reached to confirm the exact mechanics as to why, however the two hypotheses often cited to explain the relationship between industrialisation and increasing autoimmune conditions are 'the hygiene hypothesis' and 'the old friends theory' (Lorimer 2017a, Murdaca et al. 2021). Both claim that increases in autoimmune conditions and allergies occur because there has not been enough exposure to microbial life, either through overly hygienic conditions or dramatic changes in the environment and living conditions that are associated with industrialisation (Bloomfield et al. 2016, Lorimer 2020, Murdaca et al. 2021, Parker 2014). These changes have altered the development of the immune system through the lack of exposure to certain forms of microbial life (Blaser 2014, Segata 2015, Velasquez-Manoff 2012a, Velasquez-Manoff 2012b).

The erosive qualities of industrialisation unto the microbiome mirrors the slow violence that literary scholar Rob Nixon (2011) refers to where ecological collapse, toxic pollutants, and deforestation slowly emerge because of climate change. Instead of the macro environment of the global climate system it is the micro bodily ecology of western populations. This harmful relationship between industrialisation and microbiome diversity speaks to anthropologist Anna Tsing's (2012) work that explores how a relationality between mushrooms and humans emerges in "capitalist ruins" (2012, 151). She posits that, "yet most everywhere a negative correlation exists

between diversity and the intensity of capital investment and state control" (ibid, 151). This negative correlation may also be witnessed in the western human body as processes of increased environmental pollution, lifestyle changes like reduced fiber consumption, time spent outdoors, and increases in social stress associated with industrialisation have contributed to the erosion of microbial diversity (Segata 2015, Velasquez-Manoff 2012b, Velasquez-Manoff 2012a). This thesis seeks to explore how a relationality forms with the microbiome in a context where industrialisation exposes humans to processes of microbial erosion and where FMT is used as a way of re-introducing microbial diversity into bodies that are microbially estranged.

Processes of industrialisation and their effects unto the microbiome are not universal. Instead, they materialise through broader systems and structures of oppression. As Isha et al (2021) clearly summarise,

> Microorganisms form genetically flexible, taxonomically diverse, and biochemically rich communities, i.e., microbiomes that are integral to the health and development of macroorganisms, societies, and ecosystems. Yet engagement with beneficial microbiomes is dictated by access to public resources, such as nutritious food, clean water and air, safe shelter, social interactions, and effective medicine. In this way, microbiomes have sociopolitical contexts that must be considered (Ishaq et al. 2021, 2).

The microbiome, then, materialises political forces; it reveals wider determining structures of health (Greenhough et al. 2020, Ishaq et al. 2021, Mansfield and Guthman 2015, Stallins et al. 2018). It becomes a tool through which to critique the processes by which the microbiome emerges as it exposes broader manifestations of inequality, the intricacies of which this thesis explores throughout.

Who gets to contribute to understandings of the microbiome?

The thesis explores the onto-ethico-epistemological politics of the microbiome via multiple sites of emergence. How the microbiome is produced via microbiome-related academic and industry members, and by FMT users, and the ethical implications that each of these productions have, is a key focus. I explore the politics of microbiome knowledge production by critically questioning the processes of legitimation within which each of these figures is entangled. The politics of knowledge production has

formatively been explored by members from Science and Technology Studies (STS) and Feminist Science Studies (FSS) (Collins 1997, Daston 2000, Harding 1991, Harding 2004, Harding 2019, Haraway 1988, Hartsock 1983, Hartsock 2019, Jasanoff 2004, Latour 1988, Latour 2004, Latour 2012, Latour 2013)[16], who have largely explored how knowledge practices "have the power of objectifying, of totalizing" (Haraway, 1991b: 79). Here I focus on how legitimacy is ascribed to certain figures and forms of knowledge production, a substantial focus of the thesis.

Of particular interest is the differentiation between the labelling of producers of knowledge as either 'lay' or 'expert'. While dominant biomedical discourse is often understood as upholding 'expert' status, 'lay' forms of knowledge regarding medical issues are usually disregarded as it is assumed "that experience on its own is rarely sufficient to understand the technical complexities of disease causation, its consequences or management" (Prior 2003, 53). Distinguishing between these two groups is, however, not so clear cut. Many have resisted the distinction between the 'lay' and 'expert' labels (Jasanoff 2004, Kangas 2001, Kangas 2002, Wynne 1996). For example, Kangas's (2001) work on exploring the experiences of depression highlights that 'lay' patient groups formulate their understanding of their depression through 'expert' discourse. In a paper responding to Kangas, sociologist Ian Shaw (2002) refutes her suggestion that 'lay' patient populations enact 'expert' knowledge and questions how precisely 'lay' the patients are. Instead, Shaw suggests that because the patients have formed an opinion on their body through multiple expert accounts, they represent "patient as expert" (2002, 295). He goes on to argue that patients find comfort in medical professionals to take charge rather than the patient and "that there is no 'indigenous cultural development' in western society, which is not informed by an expert …conceptual framework" (ibid, 294).

Although Shaw successfully complicates the distinction between lay and expert perspectives by highlighting the highly technical advanced medical discourse through which lay patients make sense of their conditions, to suggest that expert frames of reference are the only way in which lay patients come to understand their bodily condition disregards other ways of coming to understand the body. For example, Carel (2018) in her work on *Illness: The cry of the flesh*, explores the phenomenological experiences of embodiment and understandings of the body. She uses the term, the

[16] The theoretical debates of such and how I use these theorisations are expanded on in Chapter Two

‘body subject’ which sets out a phenomenological way of understanding embodiment, what she offers as a mode through which to convey the bodily experience. In this sense, insinuating that lay patients cannot make sense of their own body unless moderated through modernist medical technologies can be seen as disregarding patients’ own bodily, phenomenological experience, thus disempowering patients.

Rather than focusing on delineating the labels ‘expert’ and ‘lay’ as they pertain to legitimating the microbiome, this thesis seeks to address the power dynamics that work to ascribe legitimacy to some forms of knowledge and reject others. This is particularly important within FMT, and microbiome research as ‘lay’ FMT users represent a novel space within which microbiome research is occurring via self-experimentation, yet which remains unrecognised in spaces of ‘expert’ microbiome knowledge production (academic and industry-related spaces). These themes are similarly discussed by STS scholar Brian Wynne (1996) in his work that explores the role that local sheep farmers had in informing geologists about the impacts that the Chernobyl incident would have on the soil and, hence, local livestock and the surrounding environment. He summarises that the mobilisation of labels like ‘expert’ and ‘lay’ in the construction of scientific knowledge “becomes critical to the stabilisation of forms of authority” (Wynne 1996, 75). He explores the complicated personal reactions of trust, mistrust, and ambivalence by ‘lay’ members towards scientific ‘experts’ when experiencing the hazardous treatment of Chernobyl nuclear fallout. He explains

> The reality of social dependency should not be equated with positive trust, when it could be better characterised as ‘virtual’ trust or ‘as-if’ trust... [This sociological work] shows how people informally but incessantly problematise their own relationship with expertise of all kinds, as part of their negotiation of their own identities. They are aware of their dependency, and of their own lack of agency even if the boundaries of this are uncertain; and awareness of this causes anxiety, a sense of risk, and an active interest in evidence, for example about the basis of their unavoidable as-if ‘trust’ in those experts (Wynne 1996, 50)

Hence, as Wynne convincingly expresses, the practice of legitimation of certain knowledge over others implicates how ‘lay’ people interpret and trust ‘expert’ discourses. Foremostly, the treatment of ‘lay’ members and “systematic patronisation

of the public as intellectually vacuous" contributes to a lack of trust expressed by 'lay' members towards 'experts' as the latter are positioned as superior given their impenetrable forms of knowledge production (Wynne 2001, 447). As Wynne states, "scientific institutions" are protected "from the necessary process of critical self-reflexivity about the implicit limitations and contingencies of their own knowledge which is being given unqualified sovereignty" (Wynne 2001, 447).

This thesis explores how the microbiome emerges via those traditionally observed as experts, such as microbiome-related industry and academic members, as well as 'lay' FMT users. In doing so, this thesis aims to contribute to literature that unpicks the power dynamics by which some knowledge is legitimated and other knowledge dismissed. Further, it critically assesses how legitimacy is ascribed to FMT users' conceptualisations of the microbiome and the implications that such practices of legitimation have for 'lay' populations' trust in 'expert' discourse.[17]

Thus far, this introduction has situated three different sites and scales of microbiome knowledge production and interaction: industry, FMT (personal/lay), and academic. Exploring the dynamics, and politics of space is something that geographic thought has long been concerned with (Massey 1994, Thrift 1983). As Herbert (2000, 555) explains, "geographers have long argued that spatial analysis draws attention to the concrete moments when large-scale and small-scale intermingle, and that spatial contexts shape how this intermingling transpires". In this thesis, I explore the micro scale of microbiome politics in FMT user's self-experimentation alongside the international macro scales of governance and regulation. Although geographical studies of the microbiome are emergent, it is important to note that I am not the first to stress the importance of geographic thought in microbial studies. For example, Stallins et al (2018) speculate that "microbial agency is part of the larger postgenomic goal of spatialising DNA [and is] a practice that invokes themes central to geographic thought about the relationship between humans and their relationships with [the] environment" (2018, 153). They continue "that although geography's theorisation of space is rich and prolific, it has not yet bridged back to the new and evolving ideas about the relations among DNA, organisms and environment" (2018 154-155). Where I seek to contribute to this emergent geographic literature is through a close, empirically-driven analysis of the dynamic conceptual spatialisation of the microbiome, and through my

[17] This is specifically addressed in Chapter Four and the development of the periphery patient.

analysis of these differing productions of the microbiome as hierarchically situated. This process of ordering and prioritising certain forms of microbiome knowledge over others, as I will go on to explore, has a powerful role in determining a human microbiome relationality.

Posthuman politics

In order to fully understand how humans understand and relate to nonhuman microbial life, I argue that we must also dissect how the human has positioned itself onto-ethico-epistemologically and how this has shaped human/nonhuman relationality. The microbiome has been the focus of excitement largely because it problematises traditional understandings of the human and human functioning (Beck 2019, Lorimer 2020). Dominant understandings of the human have largely been informed via humanism (Haraway 2008, Whatmore 2004). While humanism has a diverse range of interpretations, this thesis broadly refers to humanism as the anthropogenic belief "that everything revolves around us humans", and idea that formatively emerged around the fourteenth century during the Italian Renaissance period of enlightenment (Smart and Smart 2017, 4). What distinguished this time was a move away from spiritualism and towards rationalism: "by rejecting medieval superstitions and constraints on free thought, humans could apply reason to understand the universe" (Smart and Smart 2017, 4). This period cemented an ill-formed understanding of the human as exceptional, superior, and separate from the nonhuman and inhuman worlds (Haraway 2003, Haraway 2008, Haraway 2015, Haraway 2016, Povinelli 2016, Tsing 2012, Tsing 2015, Yusoff 2018). As anthropologist Anna Tsing summarises,

> Human exceptionalism blinds us. Science has inherited stories about human mastery from the great monotheistic religions. These stories fuel assumptions about human autonomy, and they direct questions to the human control of nature, on the one hand, or human impact on nature, on the other, rather than to species interdependence (2012, 144)

The microbiome confronts humanism by exposing how "the 'human' that we know now, is not now, and never was, itself" (Wolfe 2003, xiii). Furthermore, it reveals a highly reliant dynamic between humans and nonhumans for human existence, health, and flourishing. The microbiome's discovery and interaction with human health has

encouraged some to suggest it invites a paradigm shift in how we understand the human (Gilbert et al. 2012, Madupu et al. 2013).

While the microbiome challenges humanistic conceptions of human autonomy and individuality, understandings of what the microbiome is and how it operates are still developing. A lot has been written on the potential possibilities of the microbiome, in all fields of dominant medicine, including but not limited to oncology (Helmink et al. 2019, McQuade et al. 2019, Rajagopala et al. 2017), obesity and type 2 diabetes (Devaraj et al. 2013, Hartstra et al. 2015, Komaroff 2017, Vallianou et al. 2018), the gut-brain axis (Bercik et al. 2012, Cryan and O'Mahony 2011b, Dinan and Cryan 2017), cognitive development (Carlson et al. 2018, Sarkar et al. 2018), autism (Srikantha and Mohajeri 2019, Yu and Zhao 2021), and mental health (Evrensel and Ceylan 2015, Foster and Neufeld 2013).[18] As a field in its relevant infancy, a lot remains unknown (Carlson et al. 2018, Clemente et al. 2012, Falony et al. 2016, Helmreich 2013, Marcus 2021, Valdes et al. 2018). Anthropologist Stefan Helmreich explains, "the [microbiome] biology, as astonishing as it is, does not tell us what it will mean" (Helmreich 2013, 59). Instead of a unified and universally agreed upon definition, understandings of the microbiome are *emergent*. Its identity has not stabilised (Daston 2000, Jasanoff 2004, Latour 1988, Latour 2012). As others have noted, the processes through which new novel scientific information becomes solidified into ground truth is both implicated by and powerful in reproducing politics (ibid). As historian of science Lorrane Daston argues, scientific objects and knowledge are not fixed or immovable, rather they have "biographies" (Daston 2000, 10). These biographies, Daston argues, reveal both how scientific discovery solidifies their authority and meaning as well as exposing broader social and cultural characteristics (ibid). Science and politics can be observed "as strands of a single, tightly woven cultural enterprise through which human beings seek to make sense of their condition" (Jasanoff 2004, 21). This thesis employs a similar 'biographical' approach to the microbiome, scrutinizing the politics through which it emerges, as well as the politics that this emergence in turn produces.

But what does politics mean in the context of this thesis? While traditional liberal humanist politics has focused solely on the human individual, I take influence from

[18] The seemingly unending list of potential promises that the microbiome offers and overselling of the microbiome's capabilities exposes what microbiome researcher Jonathan Eisen refers to as microbemania (Eisen n.d).

post-human and more-than-human work that reflects on *who* is involved in theorisations and conceptualisations of politics. Specifically, work by Latour (1990, 2004, 2012, 2013) provokes an adoption of politics that seeks to de-center the human in two considerable ways. First, his critiques on the modernist production of a nature-culture binary[19], where modern science upholds 'nature' as a space where objective natural truth can be made, have been formative in exposing false assumptions of western scientific human authority (Latour 2012). By doing so, the illusion of human rationality imposed by modernism falls flat; consequently, 'we have never been modern' (ibid). Second, by revising agency as the ability to cause action, Latour exposes how various actants, both human and nonhuman, express agency (Latour 1990, Latour 2012). His work has been seminal in both complicating the false pretenses of scientific truth and objectivity, while also expanding understandings of the agencies of nonhuman life (Latour 1988, Latour 1990, Latour 2012, Latour 2013).

Similar to Latour, philosopher of science Isabelle Stengers (1997, 2005, 2018) seeks to decenter the human from politics. Specifically, she raises the question of politics in spaces of modern sciences, positing that, "the so-called modern sciences appeared to be a way of answering the political question par excellence: who can talk of what, be the spokesperson of what, represent what?" (Stengers 2005, 995). She argues that science is not devoid from, or separate to, the world. Rather it emerges and is affected by broader societal contexts and settings. She offers a theorisation of 'cosmopolitics' as a way of exploring the interconnectivity of the world and its continual reformation. As she explains, "cosmos refers to the unknown constituted by these multiple, divergent worlds, and to the articulations of which they could eventually be capable" (Stengers 2005, 995).

While Latour and Stengers' work seeks to deconstruct how we understand and make knowledge of the world, Donna Haraway's (2003, 2008, 2015, 2016) work has similarly decentered the human from politics by engaging with nonhuman life. Haraway encourages more lively and impassioned engagement with the nonhuman, by revising our relationality with such creatures (ibid). She offers the term 'staying with the trouble' as a means of taking moral responsibility for engaging in topics or with research participants, both physically and conceptually and both human and nonhuman, that

[19] Discussed in Chapter Four of the thesis.

may bring up complications or difficulties to current ways of thinking (Haraway 2016). She explains that,

> Staying with the trouble requires making oddkin; that is, we require each other in unexpected collaborations and combinations, in hot compost piles. We become-with each other or not at all. That kind of material semiotics is always situated, someplace and not no place, entangled and worldly. Alone, in our separate kinds of expertise and experience, we know both too much and too little, and so we succumb to despair or to hope, and neither is a sensible attitude. Neither despair nor hope is tuned to the senses, to mindful matter, to material semiotics, to mortal earthlings in thick copresence (Haraway 2016, 4).

By taking seriously the role that nonhuman life has in the world, being sensitive to how we form relations with nonhumans, and, perhaps, most importantly not positioning humans as the central focus, Haraway enacts a multispecies politics that attempts to think of new possible futures (2016).

Arguing for a generative politics that takes seriously both the systems, structures and emergent more-than-human forces that dictate a human microbial entanglement, in the following thesis I seek to explore how the microbiome becomes known by unpicking the politics of its emergence and the politics that different materialisations insight. To do so, and in taking inspiration from a multispecies politics that decenters the human and concepts of scientific rationality and objectivity, this thesis understands politics as the modes, processes and practices that inform different ways of being together between and within both humans and nonhumans.

Research questions:

As established in this introduction, this thesis aims to analyse and understand the dynamic and emergent onto-ethico-epistemologies of the microbiome. I explore the politics of the microbiome's emergence by focusing largely on the procedure of FMT to examine a human-microbe relationality. My research is situated in a western industrialised context, where increasing levels of autoimmunity represent a fraught human-microbe relationality. While work by post human and more-than-human scholars have explored the microbiome's role in human health (Beck 2019, Lorimer 2016, Lorimer 2017a, Lorimer 2017b), and the varying relationalities that emerge with

microbial life and the microbiome (Beck 2019, Greenhough 2012, Greenhough 2022, Wolf-Meyer 2020), there remains a lack of critical work that addresses the politics of the microbiome, a key area to which this thesis seeks to contribute. To do so, the thesis employs the following research questions,

- How does the microbiome become known through various modes of knowledge production?
- How is legitimacy ascribed to different actants making knowledge about the microbiome?
- How do these distinct forms of microbiome knowledge inform different modes of relationality?

Thesis outline

This chapter, Chapter One, has introduced and contextualised the microbiome and set out the problem this thesis is focused on, which centres on unpicking the spaces where microbiome knowledge is produced, how it becomes legitimated, and how such knowledge informs certain kinds of relationality.

The next chapter, Chapter Two, introduces the key concepts and approaches that the thesis mobilises and contributes to. It provides a commentary of the approaches to science, knowledge and the human body in the social sciences and geography. I first introduce the ideas of the body, knowledge, politics, science in geography, distinguishing between the two predominant paradigms that seemingly oppose each other, Science and Technology Studies, of which Latour's actor-network theory is a key touch point for this thesis, and then biopolitical literatures informed by Foucault and theories of governance. While STS and ANT often observe the flat ontologies and nonhuman-human networks of emergence, biopolitics and analysis of governance unpicks the power hierarchies that shape and dictate such relations. Though there are tensions between the two concepts, I use both by implementing my own feminist decolonial approach to the microbiome to diffract these two fields through a focus on the gendered raced human body.

Chapter Three provides an overview of my methods and methodology, detailing the research sites, the groups chosen to research, and the practical details of what I did while researching in the field. I reflect on my position in making knowledge about

the microbiome, a key concern throughout the thesis, and discuss the complexities involved in critiquing science, while also acknowledging its importance and not contributing to anti-science movements. It concludes by considering the risks and ethical considerations required for the research project.

The thesis then moves into the analytic chapters. I first explore the systemic and structural forms of microbiome emergence, via knowledge production and regulation, before then exploring the more intimate and personal engagements with the microbiome via FMT and microbiome testing kits. The first analysis chapter, 'Chapter Four: The making of 'real' and 'legitimate' microbiome science', sets out to observe and critique the dominant modes by which knowledge is produced about the microbiome. Drawing on ethnographic material, I discuss how microbiome knowledge production follows often very traditional and strict modernist ways of knowing the world that intend to create objective truth. This occurs despite how radical and ground-breaking microbiome research claims to be. The concept of 'real' science emerged during my time in the field as a practice of science and research that removed any sociality or other unquantifiable variables, denoting the production and reinforcing of an artificial binary between 'nature' and 'culture'. This, as I go on to show, contributes to the reinforcement of a hierarchy between knowledge that excludes the 'social' and 'cultural' and the knowledge that is created that recognises its role in creating the world, despite its frequent inability to be quantified. I observe two related implications of enacting such strict knowledge hierarchies. First, by absolving the role that 'culture' plays in producing knowledge, I explore how the violences of oppressive structures and systems (racism and colonialism) are reproduced within microbiome research. Second, I highlight how this hierarchy also works to exclude important forms of knowledge regarding the microbiome, both from the social sciences as well as by patient groups, into scientific understandings of the microbiome. I argue that such exclusions work to dissociate vulnerable patient populations by invalidating and dismissing their onto-ethico-epistemologies. Throughout I argue that while the dominant modes of knowledge production have been incredibly important and valuable, they also enact a politics of exclusion and violence.

The second analysis chapter, 'Chapter Five: Drug, tissue, or organ? How do you solve a problem like the microbiome?' explores a political ecology of the emergent governing practices of the microbiome via FMT regulation and standardisation. While all forms of standardisation and regulation inherently require the enclosing practices

of reduction, how the microbiome is reduced and standardised is political and has political implications. The chapter draws attention to the important role that defining the microbiome via regulation has in determining a relationality via the material limits of patient access to donation material for FMT. Foremost, I argue that the US FDA's decision to regulate the microbiome as a drug employs a humanistic and liberal economic approach to the microbiome. This decision ensnares the microbiome into the deeply neoliberal realms of privatised pharmaceutical, life science, and biotechnological industries. Manufacturing the microbiome into an FMT drug first operationalises the microbiome via privatised actants and within circuits vulnerable to free-market capitalism. Second, this regulation informs a relationality that is constituted by a humanistic onto-ethico-epistemology that observes the microbiome as a controllable, discrete object separate from the human. The political motivations to regulate the microbiome as a drug stem from humanist/capitalist onto-ethico-epistemologies that distort the ecological multiplicity of the microbiome's entanglement to and with the human. This, I argue, enforces an estranged and human/capital orientated/centric politics in human-microbe relationality.

While Chapters Four and Five explore how the politics of the microbiome emerges via macroscale systemic modes of knowledge production and governance, Chapter Six, 'Bodily Identity: Exploring an FMT-induced hospitality', explores the personal means by which FMT users' experiences engage with their microbiomes via the process of FMT. By applying Derrida's theorisations of hospitality to the body via FMT, the chapter contributes to posthuman and more-than-human literature that complicates how we understand human-nonhuman relationality in everyday, corporeal, and sensuous settings. The chapter draws from material gained during interviews with FMT users, many of which can be described as 'periphery patients'.[20] It explores the processes and practices by whom FMT users revised their understanding of their bodies as hosts to the nonhuman ecologies of the microbiome and engaged in practices of bodily hospitality via the procedure of FMT. I develop the concept of 'corporeal communication' to expose the politics of care enacted by some FMT users to their microbiomes via a bodily hospitality. I demonstrate how some FMT users come to revise their understanding of what it means to be a 'healthy human' and come to understand their place as *dependant on* and *entwined with* nonhuman lives

[20] A term I develop in Chapter Four.

through a politics of care to their nonhuman selves. Throughout, I demonstrate how FMT users are also faced with immense precarity. I explore how this occurs via their microbiomes, where some are more vulnerable to microbiome disruptions (via exposure to stress, lack of diet etc), and others are at risk from further dissociation to biomedical discourse and false information. Hence, I argue that while a politics of care emerges in bodily hospitality and corporeal communication these too are subject to broader societal political forces.

The last analysis chapter of the thesis, 'Chapter Seven: Coming to know a microbial self via microbiome testing kits', explores how the microbiome becomes known through microbiome testing kits. Microbiome testing offers thoughtful conceptual interminglings between attempts to govern and secure microbial life through recording the taxonomic presence of one's own microbiome. While the testing kits provide a visual mode through which to observe the nonhuman and ecological diversity of the human, I go on to make the case against using and engaging with the kits. I first critique the methods by which the tests obtain information about the microbiome and the lack of important information they require about the participant doing the test. I argue that these factors combined expose how the kits reproduce a false sense of embodied control while also individualising the microbiome. Furthermore, as I make clear, due to the high price point, the kits are inaccessible to many people, exposing the influence of wider societal determining factors. Drawing from ethnographic experiences of uBiome's[21] closure, I draw attention to the risks that engaging with privatised companies offer, most prominently that they produce a privatised politics of the microbiome and expose users and their biological data to the vulnerabilities of free-market capitalism. I end the chapter by speculating on an onto-ethico-epistemological shift that could offer an alternative mode of coming to know and relate to the microbiome that animates techniques of corporeal communication and avoids such privatising forces.

The thesis concludes by bringing together the analysis discussed in the preceding chapters. It critically reflects on the trajectory of the microbiome and FMT in natural and medical sciences as well as the critical social sciences. I argue that while the microbiome offers many interesting and exciting opportunities for bodily

[21] uBiome was the first microbiome testing company I engaged with in the research field. uBiome have now ceased operations. More detail on uBiome and the closure of the company is detailed in Chapters Three and Seven.

intervention and philosophical interest about the body, the role that power structures have in dictating both the microbiome's emergence in knowledge production, governance, and human-nonhuman entanglement requires considered attention to understand the politics of how the microbiome is emerging and the potential political implications that its emergence may have.

Chapter Two: Theoretical foregrounding

This thesis is concerned with the ways of knowing the microbiome and the implications that these ways of knowing have for how a human-microbiome relationality emerges. While the introduction laid out some of the puzzle pieces involved in the politics of knowledge production that the microbiome emerges through, I will now go on to expand on these debates and how I use such theorisations of knowledge politics. The purpose of this chapter is to introduce the key concepts and approaches that the thesis mobilises. I do so by providing a critical commentary on the approaches to science, knowledge and the human body in the social sciences and geography that have been formative in developing my understandings of the microbiome.

I first introduce the ideas of the body, knowledge, politics, and science in geography, distinguishing between the two predominant paradigms that seemingly oppose each other, STS scholar Bruno Latour's Actor-Network-Theory (ANT) and continental philosopher Michael Foucault's theorisation of biopower. Whilst ANT enacts a flat ontology to observe and analyse nonhuman human networks of emergence, biopower and analyses of governance seek to examine "how power is constituted through accepted forms of knowledge" (Zaidi et al. 2021, 454), insodoing providing tools to unpick the power hierarchies that shape human-nonhuman

networks. I use both ANT and biopower by implementing my own feminist decolonial approach to the microbiome that diffracts (Barad 2003, Barad 2007, Haraway 1997) these two fields through a focus on the gendered, raced human body. I also employ both feminist and decolonial thinkers to provide accountability to, and highlight where and how, oppressive and exploitative power is reproduced and reenforced. This approach enables me to emphasise how discourses and global structures emerge from and reproduce histories of oppression and hierarchy, such as coloniality. I argue that such an approach is both useful and important as understanding the politics of the microbiome requires attention to the intersectional power dynamics that determine, and in some cases limit, human-microbial networks. While I do not seek to propose that certain modes of knowing are superior to others, I do wish to explore the workings of power that produce dominant and subversive modes of knowing the microbiome, and the implications that such ways of knowing have for how we understand and engage with the microbiome as it emerges in dominant medicine.

Onto-ethico-epistemic politics of the microbiome

When thinking about the onto-ethico-epistemological landscape of practices and processes that attempt to make sense of the microbe, first we must start with modernity as a movement largely responsible for legitimising certain forms of knowledge over others via the construction of objectivity and truth (Escobar 2020, Latour 2004, Latour 2012, Latour 2013). Modernity, as a historically significant period informed "a particular ontology…[and] mode of being in the world" (Escobar 2020, xii) that was responsible for "building an allegedly ordered, rational, and predictable world" (Escobar 2007, 183). When I refer to modernity, I am referring to the onto-ethico-epistemology "that finds in logical truth the foundation for a rational theory of the world as made up of knowable (and hence controllable) things and beings" (ibid, 182).

In order to make the world ordered and abide by rules of rationality, 'nature' was distinguished from 'culture' (Escobar 2007, Escobar 2020). Dominant representations of nature in western sciences were presented as a predefined and fixed space, whereas culture was susceptible to changes and ambiguity (Escobar 2007, Escobar 2020). This has meant that nature is often assumed to be a static backdrop that can be studied and observed 'objectively' to expose a 'true reality' or knowledge, distinguished, and separate from culture (ibid). Because this knowledge of nature is understood to be separate from culture and removed from humans, it is

also assumed that it can be applied universally (ibid). Latour and Woolgar (2013, 243) point to the role science has in claiming ownership over the representation of nature, as they explain,

> Scientific activity is not 'about nature,' it is a fierce fight to construct nature. The laboratory is the workplace and the set of productive forces, which makes construction possible. Every time a statement stabilises, it is reintroduced into the laboratory (in the guise of a machine, inscription device, skill, routine, prejudice, deduction, program, and so on), and it is used to increase the difference between statements. The cost of challenging the reified statement is impossibly high. Reality is secreted.

As Latour and Woolgar denote, in modernity, science, and only science, has been able to validate reality, through repeatable experiments that revealed the same results independently of who was performing them. This view, as geographer Steve Hinchliffe drawing on the work of Donna Haraway suggests, is an "all-seeing, god-like view, divorced from all of the messiness of worldly matters". He continues that such a view "is a trick, a god trick" (2007, 16).[22]

How nature is reproduced and presented has a powerful role in rationalizing other forms of power and oppression (Haraway 1988, Hinchliffe 2007, Sharp 2011). This is well exposed by philosopher Hasana Sharp as she explains that dominant discourses of nature are powerful in reproducing a "naturalist ideology" that justifies oppressive expressions such as "capitalism, bourgeois sexuality, European superiority, [and]… patriarchy" by arguing that they are "unalterable expressions of human nature" and are hence to be expected in human behaviours (Sharp 2011, 6). As Sharp (2011) and others (Haraway 1984, Haraway 1989, Hinchliffe 2007) have clearly demonstrated, how nature is understood and reproduced, has a powerful role in normalising certain kinds of human behaviours and relations to the nonhuman.

Distinguishing nature from culture manifests in a naturalist view of the body and is animated within dominant medicine. Naturalism, as biologist and medical anthropologist Deborah Gordon (2012, 24) suggests, establishes a view of the body

[22] Although Hinchliffe uses this language in reference to "the famous view from nowhere" which is "a device rendered in landscape painting in the seventeenth century" (Hinchliffe 2007,16), Haraway also popularised this notion, citing objectivity as a 'god trick' (1988, 581).

and its ailments as a solely “natural phenomenon” that requires “using a naturalist method (scientific rationality) “ and the objectifying tools of science. She writes,

> The approach to the body in biomedicine is an exemplar of naturalism in medicine. The body is regarded as nature's representative in human beings: it is an ‘it,’ a physical object (and as such passive), with a stable… separate from the self (‘I have a body, not I am a body’)… and bounded from others by skin (‘my body’). Neither the body nor symptoms belong to a social field. As representative of nature, the body is distinct from and lower than the mind and opposed to reason. It is a resource to cultivate, manipulate, train, that is ahistorical, acultural, asocial, amoral, non-emotional. As a ‘thing,’ the body is neither a person nor something sacred (‘a thou’), but run by mechanisms and best approached objectively through the purest and most objective of languages – numbers (Gordon 2012, 29-30).

As Gordon suggests, understanding the body in naturalist terms, meaning as separate from ‘cultural’ realms, reduces the human to quantitative terms and misses out on the nuance and power of that which is not quantifiable. A naturalist approach remains the dominant approach in the production of microbiome knowledge and understanding, which, as I go on to argue, means that the unquantifiable complexities of the microbiome are overlooked.

Science and Technology Studies (STS) and Feminist Science Studies (FSS), two interwoven fields that this thesis works from, both emerged in resistance to the dominant science’s assumed omnipotent powers. Both fields have worked towards dismantling modernity’s division of nature and culture and have called into question science’s supremacy over ‘nature’ (see Shapin and Schaffer (1985) for a detailed account). As prominent feminist and decolonial philosopher Sandra Harding (2019, 187) points out, attempting to separate science from society is limited as, “any science was always fully inside its society, and any society inside its sciences”. Scholars in FSS and STS, as well as feminist theorists in political philosophy and, as Harding reminds us, anti-racists and class theorists, formed their critiques of neutrality, and objectivity, by highlighting the sciences’ association with the white male scientist in a lab coat (Haraway 1988, Harding 1991, Harding 2004, Harding 2019, Jasanoff 2004). ‘Standpoint theory’ was developed in order to question such concepts of objectivity and neutrality by exploring the “relation[ship] between the production of knowledge

and practices of power" (Harding 2004, 1). Predominantly, it questions positions that deem methods of quantification as the only way of producing knowledge about the world (Collins 1997, Harding 2019, Hartsock 2019). For multispecies feminist theorist and critical theorist Donna Haraway, standpoint theory, as feminist theorists Christina Hughes and Celia Lury (2013, 790) summarise, "is not about coming from a particular place" but instead about "the being in and of relations of situatedness" and importantly, the positioning which occurs through processes that are unfixed and instead "always dynamic".

Drawing from STS's critiques of dominant science, Actor Network Theory largely refined by French philosopher and social scientist Bruno Latour (2012), ascribes agency to actors by observing how they enable action to happen in the world through networks. ANT is highly successful in highlighting the interconnections and dependencies between and within human and nonhuman networks and actors (actants).[23] Specifically, Latour points to the role that the nonhuman has in the emergence of life and the world. Networks, of human and nonhuman actants enable action to happen in the world, hence "agency is distributed" (Gregory et al. 2011, 7). Such work has been formative in reconsidering the emergence of the human body via networks. Within the ANT literature, Dutch ethnographer and philosopher Annemarie Mol, for example, has been seminal in considering how varying practices and their associated actor networks generate differing material realities (Mol 1999, Mol 2002). Mol specifically focuses on the differences in how lower limb atherosclerosis[24] emerge in different countries (Mol, 2002). She demonstrates how, although the body appears as a singular unit, in practice, it is made multiple through the wide range of shifting processes and practices that create it (ibid). Due to the wealth in the body's ontological production, Mol makes clear that there may be many contradictory active understandings of, and interactions with, the body operating at the same time (ibid). Rather than distinguishing what productions of the body are more or less correct, Mol encourages recognising that there is no one singular or definitive way of producing the body; rather the body is always multiple.

[23] When referring to actor/actants, I am referring to "something that acts or to which activity is granted by others" these include both human and nonhuman figures (Latour 1990, 7).
[24] Lower limb atherosclerosis is a condition where the arteries in the body narrow, reducing blood flow. Mol (1999, 2002) explores how the condition is treated and diagnosed in a multitude of ways, she argues that rather than exposing a fragmented understanding of the condition, the condition exists as, and is interacted within, a multitude of realities. The ontologies of the condition are made through practices and these practices cannot be reduced to one thing.

Beyond work that has a distinctly human focus, ANT has also been fundamental in complicating understandings of the human as networks encompass “agents of various kinds: there is no privileging of the human subject” (Clegg and Haugaard 2009, 8). Building on ANT’s exploration of nonhuman agency in networks, posthumanism and work regarding the more-than-human have been crucial in conjuring new imaginations of the human that resists humanistic depictions of the human as superior to, and distinct from, all other life (Haraway 2008, Ginn 2016, Greenhough 2014, Tsing 2015, Tsing et al. 2017). As prominent anthropologist Anna Tsing succinctly lays out, humanism blinds us to the need for other species, ecologies, and assemblages that are essential for life to go on (2015). Where humanism presents the human as a rational, conscious, intuitive figure that possesses language, who “stand[s] at the centre of social action and can transcend the natural realm”, posthumanism pushes against such beliefs (Gregory et al. 2011, 564).

Instead, posthumanism questions the possibility of an unadulterated or fundamental human subject. Haraway has been formative in broadening attention to the more-than-human worlds beyond and outside of the human (Haraway 2003, Haraway 2006b, Haraway 2009, Haraway 2008, Haraway 2016). She playfully questions, “why should our bodies end at the skin?” to challenge traditional conservative understandings of human boundaries and their reliance on and susceptibility to nonhuman actants and life (Haraway 2006a, 31). By exploring the essential and myriad roles that nonhuman life have in the world, both independent of and in relation to the human, posthumanism and the more-than-human turn have developed rich accounts of complex nonhuman worlds, highlighting that “humans are always in composition with nonhumanity and never outside of a sticky web of connection or an ecology (of matter)” (Bennett 2004, 365 , Whatmore 2006, 603).

Within Geography, both posthumanism and the shift to the more-than-human have been constructive in encouraging explorations of human-microbe relationality. Notable examples of such work include geographer Jamie Lorimer’s work on helminth worms[25] and their therapeutic effects on the microbiome and autoimmune conditions (Lorimer 2016). Lorimer observes that “health and disease [are] multispecies conditions configured by specific socio-ecological ‘situations’” (Lorimer 2017b, 545). With this argument he presents hookworms as a useful companion to those with

[25] A type of hookworm usually understood as parasitic.

autoimmune conditions as opposed to the dominant understanding of them as a parasitic threat to life (ibid). Similarly, geographer Beth Greenhough's work on virus-human relations in common cold studies animates "a post-humanist approach to understand[ing] human" virus relations in the clinical space of a Common Cold Unit between 1946-90 (2012, 285). By providing alternative modes of being with the common cold virus, she revises the common understanding of a relationality between humans and viruses as one of conflict to one of understanding. Wolf-Meyers (2020) work similarly explores the complexities of human-microbe relationality that emerge via the procedure of FMT[26]. However, as a novel procedure that has only recently emerged and been integrated into dominant medicine, more work is needed to explore the nuanced intricacies and politics of human-microbe relationality that emerges via FMT, something that this thesis specifically contributes to.

Despite its influence, ANTs enactment of a 'flat ontology' (Law, 2019) has been critiqued as being insensitive to the structural forms of power that dictate how differing networks form. As Hinchliffe suggests, for instance, that although Latour offers ANT as a way to "flatten things out" so that we may see "how dimensions are generated," it is this flatness or "homogeneity" that warps the importance of "the rich variety of partial connections, loose affiliations, deferrals, allegiances and differences that also inhabit and make the world" (Hinchliffe 2007, 56). Specifically,

> According to ANT traditionalists, analytical concepts such as power, gender, race, class, inequity, and oppression are effects of the network to be revealed by tracing associations but are not seen as *a priori* elements of the concatenations of action that give rise to and stabilise networks" (Brady 2018;130).

Although ANT work has been highly influential in taking seriously the expansive networks of human and nonhuman actants, by enacting a flat ontology, ANT does not offer sufficiently critical tools for exploring structural or systemic forms of power, such as those of systemic racism. Similar critiques have been made regarding posthumanism and the more-than-human turn, where broader systemic forces that dictate certain human-nonhuman relationalities have not always been a central focus[27] (Giraud 2019). Consequently, the role of power structures and systems in determining

[26] As discussed in Chapter One on pages 41-42.
[27] Something I address and expand on in greater detail at the end of this chapter.

such networks requires more attention and is something that this thesis seeks to address by exploring the politics of the human microbiome via FMT.

Governing life

Where ANT, posthumanism, and the more-than-human turn have sometimes been critiqued for not being consistently attentive to the politics of systemic and structural power dynamics, theoretical considerations regarding the governance of life begin by considering how power is *productive* in the world by constituting how people live in it. Most prominent here is critical historian of modernity and philosopher Michel Foucault. He argued that while power "excludes and oppresses, it [also] produces reality" (Lane 1993, 82). Everyone is exposed to and susceptible to power. As he explains,

> Power is produced from one moment to the next, at every point, or rather in every relation from one point to another. Power is everywhere, not because it embraces everywhere, but because it comes from everywhere (Foucault, 1978, 92).

A key focus of Foucault's work that attends to the systems of power is the genealogic[28] exploration of institutions. Fundamental to understanding an institution, as philosopher of history Mark Bevir (1999, 352) explains, "is not its formal legal character, its class composition, or the patterns of behaviour associated with it; rather, all of these things, like the institution itself are understood in terms of the ideas or concepts that give them their character". Foucault pointed to the normalising effects of institutions that manifest in self-regulation of behaviour, a mode of governance he described as 'disciplinary' (Caputo and Yount 2010). "Normalisation keeps watch over the excessive and the exceptional, delimiting the outcasts who threaten the order of normalcy" (Caputo and Yount 2010, 6). This normalisation speaks to the productive role that power has in shaping and determining behaviour, what Foucault refers to as the conduct of the self (Foucault 1980). While institutions work to set normal standards and acceptability, these are also internalised and shape how "individuals construct themselves in accord with the ruling configuration of power/knowledge" (Bevir 1999, 349).

[28] A mode of inquiry that Foucault used to observe "the moment of emergence of a problematic and to trace its descent through all the circuitous paths it may have taken" (Gregory et al 2009, 270).

Institutions also exist, however, outside of material confines (for example, prisons or mental institutions) to include broader conceptual structures and systems, such as the family unit and, more relevantly here, the discipline of science. The science of bodily and mental illness, and their role in producing a medicalised 'self', for example, acts as a powerful figure in determining 'normalcy' (Bevir 1999, Caputo and Yount 2010, Taylor 2011). Crucially, because power is *a priori* and productive in normalising and shaping behaviours, Foucauldian theorisations of power offer conceptual modes to unpick "the distribution and interaction of power relations…and resist existing power structures" (Zaidi et al. 2021, 458). Hence, I use Foucault's theorisation of institutions in the thesis to unpick the power structures and systems at work that shape the varying conceptualisations and understandings *of*, and relationality *with*, the microbiome.

In his later work Foucault referred to the concepts of biopower and biopolitics, which, although defined in multiple ways, broadly denote the political technologies of governance that define the population as a unit (Foucault 2008). Foucault locates the emergence of biopower in the shift from regimes of sovereign power and disciplinary power, which he argued operated at the site of the individual, to a more omnipresent mode of governance that aimed to "influence, limit, correct, and determine' the behaviours of populations 'whether in terms of the state, the economy, the family, or the soul" (Bevir 1999, 350). He suggests that before 'Western Man's' awakening and realisation that he was alive, the sovereign right[29] took form through the monarch's "power of life and death" which materialised through "the right to take life or let live" (Foucault 1978, 136). As Foucault suggested, the effect of transitioning from sovereign/disciplinary governance to biopolitical governance was "not individualising but...massifying...directed not at man-as-body but man-as-species" (Foucault 2003, 234), and through this, the population transitioned into "an object of knowledge and power" as it could be mobilised to secure prosperous outcomes (Campbell and Sitze 2013, 10). Hence, practices regarding the management of the population adjusted in order to "administer, secure, develop and foster life" and maximise control and maintenance of the social body (Campbell and Sitze 2013, 35).

[29] The sovereign right can be understood as the power from which a state is governed and from which political powers and legitimacies emerge.

Sociologist Nikolas Rose (2007) explores the normalising powers of self-governance that emerge in what he refers to as 'vital politics'. Rose suggests that increased genetic and general bodily knowledge all have implications for how we understand what health means and have informed an increased individualised medical politicisation, what he refers to as molecular biopolitics.[30] Through technoscientific advances and medical innovation, understandings of the human body and health have been unsettled, "the old lines between treatment, correction, and enhancement can no longer be sustained. The ways in which they are to be redrawn shapes the new territory of molecular biopolitics" (Rose 2007, 17). In recognising the 'genetic inheritance' that individuals conceptualise themselves through, Rose refers to 'ethopolitics' as an alternative biopolitical register (2007). He differentiates ethopolitics from previous vital politics that operate at a macroscale, concerned with observing and administering the health and well-being of a population, by suggesting that,

> The vital politics of our own century looks rather different…it is concerned with our growing capacities to control, manage, engineer, reshape, and modulate the very vital capacities of human beings as living creatures. It [ethopolitics] is, I suggest, a politics of "life itself" (Rose 2007, 3).

Rose's ethopolitics exemplifies the personal practices of biopolitics through the everyday politicisation of life and the increasing prominence of the individual's responsibility in managing such vital capacities. He argues that this has taken shape through a personal impetus (instead of other sovereign interventions) to maintain or aim to achieve a status of health and prevent that status from slipping.

Examples of the growing individualisation of health can be seen in "patients [who] are increasingly urged to become active and responsible consumers of medical services and products ranging from pharmaceuticals to reproductive technologies and genetic tests" (Rose 2007, 4). Such products are a part of what Rose and Novas (2005) refer to as 'biological citizenship', which describes the broader modes of living that aim to enhance vitality. While Rose and Novas suggest "that not all have equal citizenship in this new biological age" (2005, 3), some have pointed out

[30] Molecular biopolitics refers to the biopolitical registers that operate at the molecular level, including genetic and biological information, as opposed to molar politics which observes the relationality of and *between* bodies.

the degree to which the systemic and structural regulatory forces that shape biological citizenship have not been accounted for (Sparke 2017). Geographer Mathew Sparke, for example, refers to the 'biological sub-citizen' to integrate the determining role that systemic inequality plays in individuals' abilities to employ biological citizenship (2017). Sparke explains that neoliberal forces exclude certain groups from obtaining biological citizenship through austerity and health service cutbacks that prevent patients from accessing medical services (ibid). He goes on to expose the role that neoliberalism, as a structural form of power, has in reproducing individualised responsibility for one's health. As he suggests, "neoliberal societies…focus only on individual behaviours for explanation" rather than the broader societal, structural, or systemic forces at play that similarly determine health outcomes (ibid, 290). FMT users sit in an uncomfortable position: while demonstrating traits of biological citizenship, of self-experimenting, and investing in their microbiomes for their health, they are also faced with immense financial, social, and microbial precarity.[31]

Formative in unpicking the integrated relationship between governing life and broader systems of neoliberalism, sociologist Melinda Cooper (2011) argues that the seemingly unending expansion of the biological sciences has enabled its merging seamlessly into the tools and technologies of the political economy and hence biopolitics. Cooper's work exposes how the biotechnology industry, born from Reagan's restructuring of the American economic and social landscape, is inextricably linked to the ideology and institution of neoliberalism and hence plays an informative role in how life takes shape (2011). As she suggests,

> Neoliberalism and the biotech industry share a common ambition to overcome the ecological and economic limits to growth associated with the end of industrial production, through a speculative reinvention of the future (ibid, 11).

Increasing power, then, lies with the commercial industry of the life sciences as it has become integral to shaping the governance of populations through its power in determining the limits of life via technologies of observation, analysis, and management of biological processes (Rose 2007). Such biological processes act as "a new source of surplus value generation" and similarly reproduce the exploitative

[31] Something discussed in detail in Chapters Four and Six.

practices of capitalism (Cooper 2011, 24). Taking Cooper's critiques of the life sciences industry into consideration, this thesis seeks to explore how the microbiome, presented as a novel "source of surplus value generation" (ibid, 24) by biotech companies, poses parallel potentialities for inequalities to be reproduced.

The structural exploitation of the life science and biotech industries is specifically explored by medical anthropologists who have explored how inequality and injustices are reproduced because of biocapitalism (Gibbon and Novas 2007, Helmreich 2008, Rajan 2006). Biocapital and biocapitalism can be understood "as the surplus value generated by the commodification and circulation of forms of biological life within economic systems" (Breithoff and Harrison 2008, 12). Specifically, anthropologist Kaushik Sunder Rajan, using the example of ex-mill workers in Mumbai, shows how vulnerable people bear the costs of outsourcing medical trials to the Global South, with experimental subjects experiencing dangerous clinical trials at a much lower pay-out rate than would be expected in the Global North (Rajan 2006). Rajan suggests that this creates new 'experimental subjectivities' who bear injustices that are worsened by the capitalisation of medicine and profit-driven aspects of pharmaceutical companies (ibid). Observing FMT users as 'experimental subjects' whose health and finance are both precarious, this thesis similarly explores the intricate enmeshment between structural forces of capitalism and neoliberalism in the medical industry and FMT patient experience and precarity.

Theorisations of governmentality and biopolitics, however, including Rose's work of ethopolitics, have been critiqued for the assumption of a molecularly fixed body. Geographer Bruce Braun (2007) specifically highlights how Rose (2005), although recognising the body as molecular, assumes this body is stable. As the microbiome exemplifies, the body is dynamic and changeable. Braun offers biosecurity as the medium through which increasing molecularization occurs and highlights the "chaotic and unpredictable world filled with emergent yet unspecified risks" that the body is exposed to (2007, 7). He defines biosecurity as

> Much more than a set of political technologies whose purpose is to govern the disorder of biological life; it increasingly names a global project that seeks to achieve certain biomolecular futures by pre-empting others and does so in part by reconfiguring in

> other places relations between people, and between people and… animals. (Braun 2007, 23)

Braun argues that Rose assumes biopolitics operates through governmentality, which is increasingly concerned with “genetic conditions and the mobilising of resources in their name” (2007, 24). However, he highlights that “genetic inheritance” and “molecularization of life” are also mobilised through biosecurity discourse and “the government of the ‘global biological’” as fears over biosecurity play a role in biopolitics (ibid, 24). Hence, Braun makes the case for observing the enmeshment between biopolitics and biosecurity; he argues biosecurity “takes hold of life so as to make life live” (2013, 47). By referencing the disruption of the molecular body that occurred in the Severe Acute Respiratory Syndrome (SARS) outbreak in 2005, Braun shows how disease events disrupt the notion of the secure and stable molecular body as the virus was able to infect international populations by exceeding countries borders (2007). Although Braun’s exploration of SARS complicates the concept of the bounded human body used elsewhere in biopolitics, it does not show how the individual “govern[s] itself” (Braun 2013, 6) on a subjective or everyday scale, which is a central point within ethopolitics. Despite Rose detailing the personal practices that form ethopolitics, Braun uses extreme disease events rather than the everyday experiences of health maintenance to unpick the practices of biopolitics and biosecurity. What interests me here is how current literature on biopolitics and biosecurity might be revised through the less dramatic incidences of global pandemic events and the more mundane everyday maintenance of the microbiome that occurs after the procedure of FMT.

Broader critiques of biosecurity literature have brought attention to how microbial life is not seen as a research subject, but instead observed through the disease infections they cause and the networks that they benefit from (Greenhough 2012). Although much of the literature on biosecurity refers to microbial life, it does so through relations and networks of epidemic disease events. Usually this is done in reference to viruses such as SARS (Braun 2007) and bird flu (Hinchliffe et al. 2016) that are a threat to human life, instead of referring to the microbial subjects themselves. Greenhough notes that both Lorimer and Haraway's work feature accounts of human-microbe relationality, however, they do so by focusing on the connections and contexts that arise because of such embodied

communication rather than on the subjects that stem from and are inherently involved in such events (Greenhough 2012). Considering these critiques, this thesis explores the politics of the microbiome, the networks of its emergence and the variations in how it is understood as opposed to approaching the microbiome through the lens of disease.

Similar critiques have been made regarding theorisations of biopolitics. While such work has been formative in conceptualising the governance of life, it has also been guilty of overlooking the entangled nonhuman networks and fails to observe nonhumans as active agents. Within the social sciences, a nuanced critique of biopolitics has focused on the limited emphasis on governing humans and/or nonhumans that resemble what Lynn Margulis suggests are “big like us” (Margulis in Hird 2009, 21). By exploring a range of biopolitical intricacies “that easily bear human ocular scrutiny - creatures we can see unaided by the technology of microscopes”, a version of biopolitics is produced that assumes “creatures ‘big like us’ resemble the majority of life” (Hird 2009, 21). In contrast, anthropologist Heather Paxson’s work incorporates microbial life into theorisations on the governance of life in her research on artisan cheese (Paxson 2008, Paxson 2012). She coins the term ‘microbiopolitics’ to describe,

> The creation of categories of microscopic biological agents; the anthropocentric evaluation of such agents; and the elaboration of appropriate human behaviours vis-à-vis microorganisms engaged in infection, inoculation and digestion (Paxson 2008, 16)

Paxson highlights that microbial life is commonly viewed as either Pasteurian (which views microbial life as problematic for human health and hence promotes its removal) or post-Pasteurian (which sees the potential benefits in microbial life beyond disease-causing bacteria) (2008). Paxson illustrates the turbulent relationship between humans and microbial life within the United States of America through the FDA’s stance on food regulation. Observing the requirements for food sterility within the US, she highlights the problematic implications this has for the production of artisan cheese, as the depth of flavour, texture, and smell of cheese are all dependent upon the microbial communities present in unpasteurised cheese (2008). Beyond cheese, and food in general, this framing of microbial life by governing bodies impacts how the

population relates to microbial life in a more general, day-to-day setting. As she makes clear, the majority of the western world "blames colds on germs, demands antibiotics from doctors, and drink[s] ultra-pasteurised milk and juice" (2008, 15). In taking inspiration from Paxon's work, this thesis seeks to explore the political decisions of the FDA and their role in establishing microbial relationalities in the context of FMT. However, where I expand on Paxson's work is by also remaining attentive to broader societal political and power structures that similarly determine a relationality with the microbiome.

Alternative approaches to the microbiome

This thesis observes networks but importantly situates them within broader hierarchies of power that dictate and alter configurations of networks differently for different groups. Here, I introduce my feminist decolonial approach to the microbiome, that diffracts ANT and theorisations of biopolitics through a focus on the gendered, raced human body.

To draw on thinkers from ANT, posthumanism and more-than-human fields alongside Foucauldian theorisations of power, I take inspiration from feminist theorist Karen Barad and her work on diffractive analysis. As a method, diffraction seeks to bring together differing disciplines and theorisations to explore the novel conceptual fruits of difference that emerge from such unusual meetings (Barad 2007, Haraway 1997, Lupton 2019). As Barad explains, "diffraction involves reading insights through one another in ways that help illuminate differences as they emerge, how different differences get made, what gets excluded, and how those exclusions matter" (2007, 30). Using such an approach, the intention is not to offer explanatory justification, or provide defined meaning, but rather to question what is produced in the meetings of contrasting research or theory (Taguchi 2012). Hence, by diffracting ANT with biopower, I seek to explore the more-than-human networks involved in engagements and interactions with the microbiome, while remaining attentive to the productive politics and power dynamics that work to shape and dictate the emergence of such networks.

Broadening the horizons of work that explore more-than-human networks and relationality is motivated by the need for more grounded understandings of the political and ethical capabilities of such networks. Philosopher Alexis Shotwell (2016) has

sympathetically pointed out the limitations of more-than-human and posthumanist work's provision of alternative ways of acting and being. As she explains,

> The specifics of how we would understand and act on the specifically ethical call… are somewhat thin. In these texts, theorists do not tell us how to parse the specifics of the ethical call, or the relational economy toward which we might aim to behave more adequately (Shotwell 2016, 117).

Instead, Shotwell "champions the usefulness of thinking about complicity and compromise as a starting point for action" (ibid, 5). She does so through complicating notions of purity, pointing out, first, the impossibility of purity, and then by laying out how purity has come to prevent realistic and possible action for change. Throughout her book, *Against Purity*, she draws attention to the role that power and politics have had and continue to have in determining narratives on purity as well as in exposing certain groups to more toxicity than others (2016). She summarises,

> We are not all equally implicated in and responsible for the reprehensible state of the world…to say that we live in an unjust world is to hold a clear recognition that there are people who gain immense power and profit from this situation- and in real ways the people who benefit from the lie of purism are the ones who reiterate it (ibid, 19).

Building on Shotwell, Eva Giraud's (2019) work has been valuable in curtailing the (at times) rose-tinted view of more-than-human relationality and entanglement that has arisen from posthumanist and more-than-human work. While such work has been important in emphasising the dependence on and inseparability of humans and nonhumans in everyday life (and their associated political and ethical forces and implications) focusing on entanglement alone can make meeting ethical responsibilities unclear and muddy the waters of "culpability for particular situations" (Giraud 2019, 2). Hence, she argues that work thus far on the more-than-human has at times, "undermine[d] scope for political action" (ibid, 2).

Giraud's work exposes what more-than-human theory can learn from social movement activism as she explores how inequalities may emerge in practices of exclusion (2019). Drawing on Jo Freeman's definitive feminist text *The Tyranny of Structurelessness* (1972), which examines how oppressive forces still operate despite

attempts by political activist groups to dissolve hierarchies by making groups 'structureless', Freeman suggests that any organisation of people requires "that the group of people in positions of authority will be diffuse, flexible, open and temporary" (Giraud 2019, 12). This ensures that members that hold power "will not be in such an easy position to institutionalise their power" (ibid, 12). Giraud maintains that Freeman's ideas are both relevant to and important for more-than-human theoretical endeavours. Attempting to completely flatten relations between human and nonhuman actants can cause damage by not recognising the power of human politics that dictates much of the nonhuman and inhuman worlds around us. Hence, "in order to create alternative ways of being [together], it is necessary to make decisions not only about which relations prefigure and enact but about which to exclude" (ibid).

This, however, is where I depart from Giraud's work that explores an ethics of exclusion. Giraud recognises that,

> Purposive decisions to exclude certain relations do[es] not have to be negative and are indeed inevitable…. nonetheless [it is] critically important to find clearer ways of fostering responsibility for these exclusions" (ibid, 13).

The question of who gets to decide the limits and extents that are absolved by the exclusion is dependent on the empirical setting. While this is an important and timely critique of the limits and potential hazards of relational and more-than-human work, I focus on the specific *powers that work to exclude* rather than distinguishing the conducive ethical implications *that stem from* the practice of excluding. My interests are concerned with how exclusion occurs instead of considering where exclusions are necessary for pragmatic ethical work, as is the focus of Giraud's work. The thesis focuses on the powers and politics that produce and normalise certain forms of exclusion. To do so, I embrace feminist and decolonial approaches to science and the body that observe gendered and raced bodies as sites of and actants in political emergence.

Feminist decolonial approaches to the body and bodily science

The critical social sciences, including human geography, have often shied away from engaging biological materialism, in large part because of long-standing critiques of the

totalising naturalist tendencies of the biomedical gaze (Roy 2018, Wilson 2015). However, sociologist Elizabeth Wilson introduces biology into feminist theory through focusing specifically on the gendered and minded gut (2015). As she explains,

> If we start with the presumption that mind and gut are keenly alive to each other rather than disengaged, perhaps our political intuitions (for cuisine; against the belly) can be rescripted. In particular, perhaps we can move away from a politics primarily informed by the rhetoric of domination (biology!) and rebellion (culture!) and look for theories that exploit the logic of imbrication (Wilson 2015, 38)

Wilson rejects attempts to make distinctions between the 'reality' of biology and 'phantastical' modes through which senses of the body are interpreted. Working from a psychoanalytic perspective, Wilson offers "a phantastic theory of biology" which takes seriously mind-body relations rather than dismissing them as mere bodily sensations (2015, 43). Differentiating between a child's need of "sucking-sensing-feeling-phantasying" as a way of understanding and operating in the world, compared to adults' abilities to represent, vocalise and "to stand at an affective distance from the body" (2015, 42), Wilson argues that although adults become able to understand the difference between the biological need for food and the sensations of hunger, this "sucking-sensing-feeling-phantasysing" continues through a human's life (ibid, 42). As she explains, "knowing is also moving; sensing is also imagining" (ibid, 40). She reflects that such a framing

> Of biology strikes me as critical to feminists as they struggle to get themselves unstuck in relation to biological determinism, and as they seek ways to politically engage that are not always caught in juridical positions of for/against (2015, 43).

Where the scope of Wilson's argument is limited is in its human-centric focus; despite focusing on the feminist politics of the gut, the role of the nonhuman microbiome in such politics is not considered. I concur with Wilson that biology should be reincorporated into feminist and geographic theory; however, I argue that such a move requires onto-ethico-epistemological diversity that recognises the human as more-than-human and is considerate to the relationality that emerges within the context of the body. In particular, and because of the inaccessibility in making one's

microbiome known, the thesis later explores[32] the fruitful imbrications and potentialities that phantastical modes of corporeal sensing can offer for understanding FMT users' relationality with their microbiomes.

Similarly to Wilson, biologist and social theorist Deboleena Roy argues that "biological processes need not be essentializing or deterministic" when approached via a feminist *and* decolonial lens (Roy 2018, 5). She approaches the medical sciences critically while also appreciating the fruitfulness they may offer with a critical approach informed by critical social theory. She suggests that by taking consideration to and being reflexive of the lessons learnt in feminist social science, science and technology studies, actor-network theory, and posthumanist thought, we can produce creative and alternative approaches to the normative categorisations of science. She summarises that:

> My goal is to contribute to theory-making by creating conceptual frameworks that can be used to approach the lab bench, bring scientific research and data out of the lab, and revitalise how we think about bodies, biologies, and matter (2018, 11).

Roy grounds the importance of decolonial perspectives in her own research and specifically to understandings and engagements with feminist thought and science. She emphasises the importance of drawing from feminist post colonialist and decolonial writers, such as Sushumia Chatterjee and Gayatri Chakravorty Spivak "to ensure some level of contextual accountability" (2018, 45). As Roy advocates, decolonial thinkers have been fundamental in "reframing dominant relations and practices found in both feminism and in science and" for her has involved, "givi[ing a] voice to a diverse range of knowledge bases in order to produce new ontological accounts" (ibid). Similarly, I use decolonial literature to provide "contextual accountability" when analysing scientific knowledge that is often assumed as neutral, or devoid of politics (Roy 2018, 45). Inspired by such work, this thesis explores the structures and discourses that materialise from and reproduce the histories of coloniality. I explore expressions of colonialism in the reproduction of the racialized

[32] In Chapter Six 'Bodily identity: Exploring an FMT induced hospitality'.

body in microbiome research[33], and in the capitalist markets that seek to employ therapeutic strategies.[34]

Using decolonial thinkers as a way of holding new ideas accountable, speaks to the politics of knowledge and what knowledge is seen as legitimate. As Haraway, in an influential extended exchange with the anthropologist Marilyn Strathern, reminds us:

> It matters what matters we use to think other matters with; it matters what stories we tell to tell other stories with; it matters what knots knot knots, what thoughts think thoughts, what descriptions describe descriptions, what ties tie ties. It matters what stories make worlds, what worlds make stories (Haraway 2016, 12).

Haraway's work has been formative in bringing to the fore the politics of thought and responsibility of ideas in creating new approaches to and ways of being (ibid). Ideas do not sit in a vacuum outside and unaffected by of the world, they emerge through and are active in complex and messy world making (Haraway 2016, Stengers 1997, Stengers 2005, Smith and Stengers 2000). STS scholar Maria Puig de la Bellacasa (2017) accentuates this as she uses 'thinking with care' as a way of productively reimagining how we make knowledge that seeks to configure a productive and responsible politics of care personally as well as within academic discourse. The microbiome introduces new novel understandings of the human and body more generally as ideas of symbiosis encourage new and diverse understandings of the human as a holobiont.[35] While such ideas offer exciting new potentialities as they resist old dominant medical paradigms, as a field, microbiome studies are dominated by and largely contextualised within a white, male, and western setting. Feminist and decolonial viewpoints then are critical in contributing to alternative onto-ethico-epistemological accounts of the microbiome that are held accountable by positions that have worked to encourage productive and just critiques of the sciences and understandings of the body.

[33] In Chapter Four "The making of 'real' and 'legitimate' microbiome science".
[34] In Chapters Five "Drug, tissue, or organ? how do you solve a regulatory problem like the microbiome?" and Six "Coming to know a microbial self via microbiome testing kits".
[35] As discussed in Chapter One.

Conclusion

This chapter has introduced key concepts and approaches that this thesis uses throughout. I have explained how I use ANT, STS, and biopolitics together to critically explore the networks of actants and hierarchies of power that contribute to the microbiome's emergence. The chapter started by exploring onto-ethico-epistemic politics that produce dominant knowledge and the formative role that ANT has had in complicating such knowledge (Latour 1990, Latour 2013). I have suggested that ANT has been critical in expanding ideas of nonhuman agency by bringing attention to the important role of the nonhuman (ibid). ANT, however, has been limited by enacting a flat ontology (Brady 2018, Hinchliffe 2007). I then went on to detail how I use theorisations of the governance of life, which are more attentive to structural forms of power (Brady 2018, Clegg and Haugaard 2009). By observing how power is productive in normalising and shaping behaviours, through, for example, institutions, such theorisations of power offer crucial tools of analysis to unpick the structures of power and power relations (Zaidi et al. 2021). Work on biopower and biopolitics is crucial in progressing understandings of the role that the life sciences have in shaping the limits and understandings of life, and importantly, their relationship to neoliberalism, something this thesis explores in relation to the emergence of the microbiome in dominant medicine (Rose 2007, Cooper 2011).

I have introduced the approach that will be employed throughout the thesis that diffracts work from ANT, biopolitics, and more-than-human, with a feminist decolonial approach as I explore the politics of the human microbiome. Importantly, such an approach seeks to observe the myriad of nonhuman actants involved in the politics of the microbiome while also remaining attentive to how power operates to dictate such networks. Using this approach, this thesis aims to hold different ways of knowing the microbiome accountable by critically exploring the spaces where oppressive powers emerge. This feminist decolonial approach will be used to make sense of the different modes of knowing the microbiome that emerge via everyday contexts of FMT users and by members in academic and industry-related fields to consider how the microbiome becomes known, what knowledge gets to contribute to dominant understandings of the microbiome and how these understandings shape certain forms of relationality with the microbiome.

Chapter Three: Methodology and methods

This thesis questions and unpicks modes of coming to know the microbiome, the relationality that these inform, and the kinds of politics enacted in these different spaces. I trace the relationships that people build via coming to know the microbiome, which require thinking about spaces where microbiome knowledge is produced and talking to actors in such spaces. Therefore, I researched the microbiome in the relational interactions of FMT users, microbiome-related researchers, industry members, and academics. I also investigated spaces where microbiome knowledge is shared and produced: at talks, networking events, in labs and at academic conferences.

This chapter outlines the research I performed over the course of my doctoral programme. I first provide a summary of the research that I completed. I then detail the different groups that I researched and provide justifications for focusing on these groups. I introduce the microbiome testing companies that I engaged with and explain why I chose these companies. Towards the end of the chapter, I examine the methods I used and observe the limits of using them. I reflect on my own research positionality that has dictated both the direction of research and the analysis and interpretation to come. Throughout, I argue for onto-ethico-epistemological reflection within microbiome studies to decentre the supposed 'objectivity' and 'neutrality' of the natural and medical sciences. I end the chapter by detailing the ethical considerations taken with a particular focus on consent.

Research summary: Summary of my research

A central area of research throughout my PhD has involved FMT and FMT users. I sourced FMT interview participants by posting on various Facebook advocacy groups. These included both general FMT groups based in different countries and specific FMT groups that addressed certain aspects of FMT such as the procurement of donation material and what to do after the procedure. However, all groups were linked by their intention to act as spaces where advice, information, and support regarding the procedure of FMT could be shared. Many members were part of multiple groups and most groups had international memberships; thus, the FMT users that I interviewed represented varied nationalities. Coincidently, most interviewees were from America, although I also interviewed FMT users from Canada, Sweden, the

United Kingdom, Australia, and Poland. They represented a mix of DIYers and those that had used professional services including Taymount[36] and OpenBiome. Due to the international base of FMT users that had accepted my invitation, all interviews took place using an online video programme, except for one conducted via email. In total, I conducted nine new interviews with FMT users during my PhD.

I have also drawn on two interviews with FMT users completed during my Geography Master of Research (MRes) in 2017. I chose to do this as they both represented rich and detailed accounts of FMT users' experiences, yet the analysis of these interviews was limited by the restricted focus of the MRes thesis. By applying novel analytical frames and research questions, I was able to draw out new themes and analysis from the interviews. Rather than focusing primarily on the *representation* of the microbiome, which was the focus of the MRes thesis, I was able to draw out important insight regarding how a politics of the microbiome emerges through FMT users' experiences with the procedure.

While, during my MRes, I used in-depth semi-structured interviews with FMT users, for the duration of the doctoral research, I updated my interview method to use oral histories to gain a better understanding on FMT users' changing relationships with their microbiomes over time and from their own perspectives.[37] I wrote a post on the Facebook advocacy pages to invite FMT users to be interviewed. The post detailed my project, why I was seeking out FMT users and what I intended to ask them.

My research data also consisted of interviews with a range of academic and industry members. I approached academics who were leading research in microbiome and FMT-related areas, organising interviews via email. Much harder to organise were interviews with industry members. As my emails were often not replied to, I decided to seek out industry research participants at conferences, talks, and networking events. Apart from one virtual interview with academic member Margret[38], which took place using online video software, all my interviews with academic and industry members were in person during my fieldwork.

OpenBiome were another key site of research. They remain the only faecal bank in the United States and are very well regarded internationally. My relationship with them was first formed during my MRes, when I interviewed an OpenBiome

[36] Taymount is a private health company and represents the leading FMT clinic in the UK.
[37] Further details on my interviewing methods are given in 'Methods and their limits'.
[38] All research participants and sites have been anonymised using pseudonyms.

employee. I decided to continue to research them as firstly, they were very accommodating and willing to contribute to my research in FMT and the human microbiome, and secondly, they represent a key figure in FMT's emergence in the United States. Further, they operate in a unique space in microbiome research because – unlike members in industry and some academic figures – OpenBiome are not profit driven, and they are relatively 'neutral' in terms of the microbiome research they catalyse. In total, I completed eight interviews with OpenBiome employees.

The majority of the field research was performed in Boston and Cambridge, Massachusetts over two trips. The first took place between October 31st and 10th November 2018; and the second trip between 25th March and 3rd June 2019. The first visit acted as an academic reconnaissance trip to network with members in appropriate fields and form relationships for future research. I did this by attending conferences, talks and networking events where I employed an ethnographic approach using participant observation. I stayed in Longwood, home to the Longwood Medical and Academic Area, an extensive medical campus. Here, I arranged to meet specific academic researchers and relevant members in industry, and I visited OpenBiome and interviewed TJ (an employee). I also visited and interviewed at the Alz lab (a laboratory group investigating the microbiome at a prestigious university within the Boston area) and attended the three-day International Microbiome Engineering Conference. At the conference, I met industry members such as Rhianna and Sam, who I interviewed on my second trip. Attendance at this conference was especially important as industry members were difficult to gain access to, as many were restricted by the strict Intellectual Property (IP) laws and restrictions of their employers. Some interviews had to be cancelled due to fears of breaching privacy laws.

During my second trip to Boston, I stayed in Allston, Massachusetts, where I attended the four-day Translational Microbiome Conference. I re-visited OpenBiome and re-interviewed TJ along with seven new OpenBiome employees. I also attended lab visits and tours at DC Lab and Ernk Laboratory and interviewed several industry members and academics. In total, I completed twelve interviews with microbiome academics and researchers at Betz and Cargo University, and five industry members. I also went to fifteen talks, tours, events, and workshops around the city intended for

both professional and lay audiences.[39] The second trip strongly benefitted from the local biotech "buzz" (Bathelt et al. 2004), as many of the events were aimed at providing a space for networking and innovation. Hence, although I was not able to attend some of the other important microbiome conferences that took place across the United States, I was able to benefit from being based in the 'medical biotech capital of the world'.[40]

In March 2019, the first week of the trip, I got my microbiome tested by uBiome. I decided to do this as I thought it would offer me insight into what FMT users experience when they try to come to know their microbiomes. Further, it also provided me the opportunity to engage with the biotech companies capitalising on the 'microbial moment'. I intentionally waited until a week into my trip so that my microbiome had time to fully acclimatise to its American environment, and may potentially reflect an American microbiome. I chose uBiome as they were one of the leading microbiome testing companies at the time (Arthur 2013). Later, in November 2020, I re-tested my microbiome in the UK. Initially the two tests were planned to allow comparison of the results and see if there was a difference between an American and British microbiome; however, as I discuss in Chapter Seven, this comparison did not come to fruition. The second test took place a year after I returned to the UK. I waited until my microbiome had presumably acclimatised to its UK setting to take the other test. I chose the company Atlas Biomed after they were recommended to me by an industry interviewee participant and saw that their tests were within my research budget.[41]

After both research trips to Boston, I attended a summer school 'Microbiota, Symbiosis, and Individuality: Conceptual and Philosophical Issues' in Biarritz July 2019 hosted by the European Research Council (ERC) Immunity, DEvelopment, and the Microbiota (IDEM) team. The week consisted of talks about the microbiome and its impact on individuality and symbiosis, and the philosophical implications of the microbiome from members of a range of disciplines including STEM (microbiology and immunology), philosophy of biology and the social sciences. Here, I was exposed to different perspectives and approaches to the microbiome and their philosophical and

[39] Details of the talks and events that I attended are listed in the appendix.
[40] An expression that was often articulated in interviews, at microbiome talks and at networking events.
[41] A more detailed account of the microbiome testing companies is provided later in this chapter.

social implications. From here, I was put in touch with interviewees Callum Karn and George Felg,[42] both of whom are leading experts in microbiome research.

Groups and areas researched

I chose to research the FMT community as they complicate the dominant model of knowledge production that sees objectivity and truth as the only valuable modes of producing knowledge. As such, they shed light on the different modes of coming to know the microbiome and the politics within which they are entangled and reproduced, which is a key area that this thesis aims to explore. While I use FMT as an entry point to explore how the microbiome is becoming known, I also chose to research other areas and figures that are not so directly linked to FMT. These areas of research included attending talks and events about the microbiome and interviewing microbiome-related industry members that do not directly research FMT. Through such, I cultivated an in-depth understanding of the field of microbiome studies and what microbiome researchers are broadly interested in. This enabled me to understand how other areas of microbiome research are emerging in spaces of dominant knowledge production and medicine and how FMT fits into the broader ecology of microbiome research. While academic and industry-related spaces of microbiome knowledge production are producing cutting-edge research, FMT users are engaging with their microbiomes in a highly intimate and self-experimental way. Thus, each group is creating differing forms of microbiome knowledge and *producing* the microbiome differently. How these differing understandings come together in moments of sympathy or tension, and which of these understandings is recognised as legitimate, are key areas that this thesis explores.

Natural and medical scientists and researchers were chosen as they represent classic figures that produce ‘expert knowledge’ or ‘truth claims’. To reiterate, I use the term ‘natural sciences’ here to refer to disciplines that use the scientific method and use the term ‘medical sciences’ to refer to natural sciences that specialise specifically on the human body, such as microbiology, physiology, molecular biology, and molecular genetics. Research on the microbiome requires interdisciplinary forms of knowledge production. Fields such as engineering, systems biology, and medicine, for

[42] Both participants have been anonymised with pseudonyms.

example, all represent dominant disciplines that are producing novel knowledge about the mechanics and behaviour of the microbiome (Berg et al. 2020).

Though the natural and medical scientists and industry members in this thesis all represent knowledge and 'truth claim-makers', industry members also engage more closely with the practices and processes of the biocapitalist economy that is synonymous with the life sciences and biotech industries. As actants in the biotech economy, their attention focuses on how biological knowledge can be mobilised into medical technologies or products. Hence, while the microbiome-related biotech industry does create microbiome knowledge, there is a significant focus on constructing such knowledge into something that can be profited from. The motivation of profiting from biological knowledge exposes the entangled relationship that the pharmaceutical and biotech industries have between wellness and profit, which have direct impacts in medical and health spaces (Cooper 2011, Franklin and Lock 2003).

A key figure in my research is FMT users as they represent a group with a considerable wealth of knowledge through self-experimentation yet are largely overlooked as producers of bodily knowledge in favour of the natural and medical sciences in industry and academia. In line with Pitt (2015), I chose to view FMT users as experts in order "to disrupt conventional power dynamics of academic research" (Pitt 2015, see also Pain 2004). In recognising the importance of developing rapport and trust with interview participants (Sword 1999), I emphasised their role in providing expert insights into this novel medical therapy. However, that is not to say that what FMT users said was taken uncritically. Pitt (2015) also notes the importance of recognising the limits of viewing research participants as experts. As she explains in her work on gardeners and their relationships with the more-than-human, her research participants did not always provide insights that aligned with her research focus (Pitt 2015). Hence, I was careful with setting expectations from my interviews, making sure I was open to however FMT users responded to my questions.

In being cautious to not enact "methodological individualism" through focusing solely on the narratives provided by participants interviewed (Lamont and Swidler 2014, 19), I do not intend for the researchers, industry members and FMT users to represent or speak for all of the communities I have ascribed to them. What I comment on are the themes and discourses that appeared multiple times, or that were in contrast, opposition, or in favour of positions I found in other areas of my research. This thesis intends to paint a picture of microbiome research through what I deem are

key figures in the curation of microbiome understandings based on conversations with these figures and attendance at relevant events during my time in the field.

Microbiome testing companies

Direct to Consumer (DTC) microbiome testing (MT) kits represent a form of knowledge production that is accessible to the public and can seemingly contribute to an improved understanding of the body. Direct-to-consumer (DTC) products first became popularised with the launch of DTC genetic testing (GT) products after the seminal work done by the Human Genome Project in 2003 and its promise revolutionise treating and diagnosing a whole range of conditions (Almeling 2019). While this promise never manifested, DTC products have nevertheless become incredibly popular (Helgason and Stefánsson 2022). Common DTC GT products include those that directly address the health of the consumer, such as those that test for genetic conditions and "diseases, including diabetes, Parkinson's disease, and certain cancers" (Hauskeller 2011, 1). Other products, using genomic testing, enable the user to learn about their "ancestry, ethnicity … paternity, extended relationships and individual uniqueness" (Nordgren and Juengst 2009, 158). DTC GT products have been critiqued for the questionable testing methods and validity of their results (Hauskeller 2011, Helgason and Stefánsson 2022, Horton et al. 2019) as well as the precarious positions they can put some consumers in (Helgason and Stefánsson 2022). As some have pointed out, consumers may not be able to "cope with disease risk estimates from tests" and there is no support offered from the companies (Helgason and Stefánsson 2022, 65). Many companies that had previously operated genetic testing have now extended their operations to the microbiome, applying a similar business model and marketing strategy, and by selling the idea of increased bodily knowledge (Knoppers et al. 2021). For example, Atlas Biomed started out as a DTC GT company and only recently started a microbiome testing arm; uBiome, similarly, was often cited as "the microbiome equivalent of 23 and me" (Marcus 2021, np).

DTC microbiome testing (MT) products work within the disciplinarity regimes of genetics and microbiology, where the embodied self is commonly communicated

through the medium of 16s rRNA sequencing, often referred to as 16s.[43] The effects of such a process follow what Foucault (2014) would refer to as subjectivising the self within regimes of truth. The knowledge created by these tests affects both the subjects offering up such information and the information that is created. Similarly to genetic testing, the results offered are presented as truth "supported by the status of science as rational, objective, disinterested and authoritative" (Nash 2004, 3).

The first company that tested my microbiome was USA-based company uBiome. Founded in 2012 by Jessica Richman and Zachary Apte, uBiome originally offered an at-home microbiome test kit to the public. There was a lot of excitement and hope for uBiome as a company as they were one of the first to introduce 16s testing to the human microbiome (Arthur 2013, Buhr 2016). The company started out using a citizen science model and transitioned "into a key player on the life science venture scene" (Brodwin 2019, np). uBiome was first crowdfunded and later secured funding from Venture Capital groups such as Y Combinator and Andreesen Horowitz (Menegus 2020). The company initially raised $15.1 million in funding in 2016 "with the launch of its testing" (Arthur 2013, np) and then later raised $83 million "to expand into microbiome drug research" (Vinluan 2018, np). When I used their product in 2018, they were a well-known and highly regarded microbiome company in the industry. As of 2019, uBiome offered three levels of microbiome testing: (1) 'Smart gut,' a test that required the authorisation of a medical professional and was billed via medical insurance; (2) 'the Explorer kit,' aimed at curious members of the public to sequence their own gut microbiomes, and (3) 'Smart Jane,' a vaginal microbiome tester.

However, the company made the news when the uBiome buildings were raided by the Federal Bureau of Investigation (FBI) in April 2019. By October 2019, uBiome had gone into liquidation (Menegus 2020) due to the fraudulent billing practices they employed (Farr 2019b). These included overcharging patients' insurance for tests without consent and putting pressure on doctors to approve their medical tests for insurance without adequate oversight or monitoring. In some cases, physicians were pressured to approve tests for patients that did not have appropriate symptoms (Farr 2019b). The dramatic ending to such a well-regarded microbiome company came to

[43] 16s is a sequencing method "for studying bacterial phylogeny and taxonomy" (Eurofin 2022, np). It offers a "way to profile the bacterial make-up of a microbiome" by revealing "which genus is present and in what relative quantity;" however, it does not "tell you which species are present, what their function is, and will likely miss low abundance bacteria and viruses/fungi" (Maurer 2022, np).

a shock for many in the industry. Sam, an industry member and interview participant, said "I think this will set the microbiome field back by 5 years … for such a well-regarded company to pull the wool over everyone's eyes will lead to serious mistrust in the field".[44]

UK-based Atlas Biomed was founded in November 2016 by Sergey Musienko and currently has total funding amounting to $21 million (Crunchbase 2021). They represent an exemplar of a biotechnology company profiting from the 'microbial moment.' Atlas Biomed first offered DTC GT products in 2013 and have only recently added microbiome testing as a product. They claim that both testing products enable users to learn more information about their bodies, "which allows you to take control of your health through actionable, personalised recommendations!" (Biomed 2021, np).

Both microbiome tests arrived in the post and required a survey to be filled out, which included questions regarding one's bodily characteristics, lifestyle, diet, health, and auto-immune disease status. They then required a sample of faecal matter to be collected and sent in the post to a laboratory where it would be tested using the latest genomic testing. uBiome used 'Illumina' technology, which uses 16s rRNA gene sequencing to identify microbes through analysis of DNA fragments from stool samples (Biomed 2022a), "and a custom bioinformatics pipeline" [45] to identify the microbial life present in the donated sample (Idrus 2016, np). uBiome's former Director of Research and Community, Alexandra Carmichael, explains that "basically the samples come into our lab, we break the cells open and extract the DNA, amplify the bacterial DNA using PCR (polymerase chain reaction), then run it through a sequencer to discover which kinds of bacteria are in each sample" (Carmichael in Scoles 2015, np). Atlas Biomed uses the same Illumina technology and 16s rRNA methods. Both companies formulate(d) lifestyle recommendations using "algorithms based on published scientific research" (Biomed 2022a, np). Both companies also analyse the microbiome samples in aggregate, which means comparing samples to other samples of consumers using the same testing products.

Once sent off, the results from both companies came back within 4-6 weeks with the results available on an online platform. Both tests provided an overview of the

[44] The implications of uBiome's dramatic collapse are discussed in detail in Chapter Seven.
[45] A bioinformatics pipeline is made up of algorithms that process and annotate data (Roy et al 2018).

taxonomic presence of microbial life, a microbiome diversity rating, and an overview of the presence of probiotics. Additionally, they also both provided information on how to improve your microbiome based on your results, offering specific and personalised recommendations based on your data. I still have access to my Atlas Biomed results; however, I unfortunately lost all my microbiome data from uBiome due to the sudden closure of the company.

Methods and their limits

This thesis takes a multi-sited ethnographic approach, consisting of a mixture of participant observation, interviews, and auto-ethnography. While traditional ethnography is concerned with learning about research subjects' "lives from their own perspective and from within the context of their own lived experience" through interactions, observation, and participation over a *prolonged period of time* (O'Reilly 2012, 86), my multi-sited ethnography was conducted during the relatively short periods of time when I was in the field. I mobilised my sensory and emotive sensitivities at conferences and events, as well as virtually in FMT Facebook advocacy pages.

I initially joined the FMT advocacy Facebook pages in 2017[46] to source interview participants. However, they also provided me with learning resources and were a source for recent research and papers. Being part of these social media communities gave me insight into the debates and discussions that FMT users are having and enabled me to keep up to date with global news and events surrounding FMT. These included the uBiome investigation and closure by the FBI and the reaction from the FMT community, the news of two FMT patients who tragically died from unscreened donation material, and the implications that Covid-19 has for FMT and people with gut conditions.

Face-to-face participant observation was carried out at the conferences, talks, lab tours and events I attended. These spaces are sites where leading research is presented (for varying audiences from lay public to experts), networking occurs, and where sponsors and other industry members try to sell products and scout people and ideas to invest in. By looking at the networks involved in knowledge production, I aimed

[46] The names of the Facebook groups will remain anonymous as the groups were member-only communities. Further, some participants specifically asked for me to not mention the names of the groups to maintain confidentiality.

to situate and question the concepts of ‘neutrality’ and ‘objectivity’ and observe what research is presented and how it is ‘sold’ to the audience members.

I used interviews to reveal “multiple aspects of life” by “allowing participants to share their stories in several ways” (Pitt 2015, 53). All of my interviews were in-depth, semi-structured and one-to-one, combining “depth of understanding with purposeful, systematic, analytic research design to answer theoretically motivated questions” (Lamont and Swidler 2014, 7). I interviewed industry members, academics, staff, and researchers at OpenBiome to understand how they observe microbiome research developing, how this research changes the way the body is understood in dominant natural and medical sciences, and if it has changed the way that they perceive their own bodies.

I interviewed FMT users using both official faecal banks and DIYers using oral histories. The oral history format is well suited to understanding processes. As I was asking the FMT users about processual topics (such as their experiences with FMT and their health more generally), it made sense that the interviews took an oral history format to allow interviewees to narrate how they order and draw out what is important to them. By asking FMT users “to structure their own life story narrative, sometimes according to specified principles (for example via family, work, or educational biographies) and to follow their own cues,” I intended for “the significance of [their] social experiences [to] be revealed through contextual data” (Mason 2002, 232). Online video interviews were performed to ensure flexibility and accessibility as interview participants were internationally located and, because of the severe conditions that led participants to engage with FMT, many were in precarious employment and had irregular schedules.

In agreement with sociologist Jennifer Mason, I observe that the worlds within which social science research exists are fluid (2002). Interviews in particular are conversational events that are variable rather than pre-determined (ibid). Hence, my interviewing approach worked to disrupt the “interviewer as miner” method (Kvale 1994, 3). Instead, and in honouring the impossibility of reflecting a ‘true’ or ‘predetermined’ reality from interviewees (Lamont and Swidler 2014), I treated “the interview as a site of knowledge construction, and the interviewee and interviewer as co-participants in the process” (Mason 2002, 227).

Interviews were transcribed from interview recordings verbatim and coded using analytic and in vivo codes. Analytic coding involves coding research material

through themes that arise while analysing the research data (Cope 2005). As Cope notes, “analytic codes typically dig deeper into the processes and context of phrases or actions” (Cope 2005, 361). Analytic coding offered a flexible approach to analyse the data and the ability to use prior research to generate codes (Braun and Clarke 2013). I updated the codes as I analysed the research material with in vivo codes, which come from observing phrases or themes that reoccur within the research (Cope 2005, Strauss and Corbin 1990). I used a combination of the two coding methods to ensure that less apparent themes were not overlooked and to avoid only focusing on the themes that are most frequently repeated (MacKain 2010). As I was using some research material from my MRes research, the in vivo codes were updated as I went back to old interviews and when I re-interviewed TJ, an OpenBiome employee. Being able to ruminate over interviews for four years has led to a deeper reflection on my approach to the research findings and project. While some ideas have fallen away, others have developed, shifted, and connected with each other.

The limits of interviewing within my own project manifest most prominently through the problem of what escapes language. Although Lamont and Swindler suggest “that interviews can reveal emotional dimensions of social experience that are not often evident in behaviour” (Lamont and Swidler 2014, 7), some concepts and emotions evade easy verbal communication and escape normative narrative formats (Mason 2002). Experiences of the body are complex and multidimensional and can neither be accessed nor observed in a complete, objective or direct way (Scarry 1985). As is well established, there are significant complexities in the communication of pain (Scarry 1985, Phipps 2013). I asked FMT users how they viewed their mental and physical health before and after FMT, and more broadly about their experiences with FMT and their relationships with their microbiomes. Although the impasse between bodily sensation and verbalisation is significant (Scarry 1985), considering the themes of the thesis, attempts were made to move beyond using the interview at ‘face-value’ to observe the emotional tone and register, and, where possible, body language, meditating on parts of the interview that did, either directly or indirectly, frame their health. The nuances of verbalising bodily corporeal sensations, including pain, was a considerable theme that arose in the discussions with FMT users and contributed to the development of corporeal communication, discussed in Chapter Six.

Beyond interviewing, I got my microbiome tested by two companies: uBiome and Atlas Biomed. Getting my microbiome tested was motivated by the desire to

employ a multispecies autoethnography that would engage insights from posthumanism and the more-than-human turn, as well as by the desire to facilitate a shared understanding between myself and FMT users of coming to know one's microbiome. Adapting an understanding of autoethnography as "a method that calls upon the body as a site of scholarly awareness and corporeal literacy" (Spry 2001), I proceeded with microbiome testing with the intention to enact a method that made my microbiome knowable while also attempting to "decentre human-as-authority" (Dowling et al. 2017, 828). Following sociocultural anthropologist Noah Theriault's (2017) work of 'ethnographic participant observation' where the researcher becomes a part of the research process, employing "a range of embodied and performative techniques," the research method was explicitly aimed at "recognising, attending to and representing the M-T-H" within me (2017, 825). I sought to observe how ecologies of the self are "continually shaped and reshaped … through the sharing of 'meanings, interests and affects' as well as flesh minerals, fluids, genetic materials and much more" (Van Dooren 2016, 4). The method worked as an unusual way of performing multispecies autoethnography in that it aimed to provide multiple nonhuman perspectives but only from within me, the researcher (ibid). Although being about the human, the focus was about making the nonhuman part of my human self known, observing the "self and other and self as other" (Spry 2001). As Smart reminds us, "sometimes, of course, human mediation is indeed central in [the] …interactions" of multispecies studies (Smart 2014, 4). I intended to apply the method by first comparing both sets of test results, and second by critically analysing the results through theoretical insights from posthumanism and the more-than-human turn.

To address critiques of autoethnography that point to the risk of "grand theorizing" that acts as a "facade of objective research that decontextualises subjects and searches for a singular truth" (Spry 2001, 710), the multispecies autoethnographic method was grounded in its intention to enable empathy between myself, FMT users and the world of microbial life. As Herbert makes clear, ethnography requires "empathy to enable the researcher to see how the social world is understood and made meaningful by its members" (2000, 552). By doing the microbiome tests, similarly to Kempster, Stewart, and Parry's (2008, 11) work on co-produced ethnography, the practice was "most helpful to illuminate tacit processes of situated learning". Performing the tests required me to experience similar interactions with my microbiome as my research participants. Engaging in the handling of my own faecal

matter did indeed force me to undertake the “full sensuality – the sights, sounds, smells … and tactile sensations that” are central to ethnography (Adler and Adler 1994 in Herbert 2000, 552). I found this an important process in learning to empathise with FMT users’ experiences. Alongside this, I was able to take this understanding and experience with me to conferences where patients’ experiences were often lost.

However, my initial assumption that the method would offer a deep understanding and shared experience of coming to know the microbiome with the FMT users who participated in this project was perhaps naive. I was made aware of the limits to my empathetic intentions early in the research. Paul, an FMT user, made it clear to me in an interview that the knowledge I was gaining of my relationship with my microbiome through the research was partial. When I referred to my increased understanding of the human body and relational practices towards my own microbiome through researching FMT, he responded:

> Yeah, it is very easy, but you don’t have the necessity or motivation to do it [personal practice to improve my microbiome]. I have the reason and motivation because I want to get well, because that’s what guided me to … I don’t know, in the morning, instead of having a Danish … Well, for example, I cut out sugar in my coffee. The first time I cut it out I was like, ‘eww, this is gross,’ but the motivation got me through. Similarly, I don’t have Danishes, I have yoghurt or fruit and, what’s it called … flax seed, and I do that, and I started that because I had the motivation to do it. I now eat seven or eight portions of vegetables a day, and beforehand I would eat, you know, in the UK we have the ‘five a day’ thing, and I tried to eat five a day, but I didn’t always. I would eat what I did and drink quite a lot and all the rest of it, and eat quite a lot of crappy snack food, whereas this has given me the motivation to put that change into action.

This interaction with Paul was an important moment for me that distinguished the emotional space that many FMT users are in. Many have had to engage with an experimental procedure due to severe and life-threatening health problems, rather than out of intellectual interest. Though not enabling a complete shared understanding, the multispecies autoethnography did open my eyes to the complexities and difficulties in coming to know the microbiome and the limits of what microbiome testing can reveal of the microbiome. It was significant in contributing to the development of the concept of ‘corporeal communication’ that I develop later on in the thesis.

While the closure of uBiome[47] shifted my attention to how the microbiome is being integrated into the dynamics of the biocapitalist economy, the multispecies autoethnographic method was still useful in engaging ethnographic sensibilities towards my microbiome and body. The method encouraged me to employ the "arts of noticing" elsewhere in life (Tsing 2015, 17). Beyond the taxonomic recording, which perhaps was me being enticed by the "siren call of the scientists themselves" (Haraway 1989, 7), through the process of getting my microbiome tested, I paid greater attention to what my microbiome is and what it continues to show me. As Pitt explains when researching plants, there is a need "to learn directly from plants by encouraging them to tune our attention towards their agency and characteristics" (2015, 50-52). This approach in research requires "modes of sensitivity not typical for social scientists" (ibid, 50-52).

What emerged in the sites of research – in my body, in interviews and in the ethnographic moments – is neither stable nor fixed. They do not represent moments that could be reproduced or repeated with the exact same results. Rather, they expose a reality made in that space and time where two subjects came to meet and exchange ideas about the microbiome, bodily identity, and subjectivity. Using the methods that I have just discussed, I put to question how these moments of exchange provide modes of understanding the microbiome, how these come to be legitimated, and then become stabilised in governance regimes.

Research positionality

Being constantly in 'the research field' of my body meant there was an inescapable detachment from the autoethnographic experience and prompted me to question my biological positionality. Spry prompts those employing autoethnography to question "as I seek to embody this text, how does my own cultural situatedness (i.e., standpoint theory) motivate my performance choices?" (2001, 716) and, thus, I came to meditate on the microbial impact of being a sickly child and consequent courses of medication that I took from a very young age. However, beyond the usual reflection that is required when operating in research spaces as a white middle-class woman, I was also provoked to consider how these qualities impact my biological positionality. Most notably, I have not experienced systemic racism (Kim et al. 2021), or an impoverished

[47] Expanded on in Chapter Seven.

diet (Prentice 2020), which, among other things, could have negatively impacted my microbiome and immune system.

Another locus of positional introspection in the course of the research involved looking beyond what the research participants were saying to me to be sensitive to "the 'politics of talk' … what counts as language, who uses it, what is its nature, what it can mean and do" and recognising the "power relations and struggles" that occur in an interview (Mason 2002, 237). Power relations became particularly noticeable when speaking with some participants who were particularly vulnerable. Many FMT users I spoke with were very ill or were recovering from illness and in precarious positions. Further, unlike industry and academic members, who tend to hold authority status and move in spaces where they may represent themselves and their ideas about the microbiome to the wider public, FMT users as a group rarely have this opportunity.

In these spaces, my role as a researcher engaging with vulnerable people and communities made me present to the power dynamics at play within research. Unease emerged when I realised that some FMT users who had responded to my advertisement on Facebook groups thought I would be able to help them gain access to FMT or be directly involved in policy and legal changes regarding FMT to enable better access to the treatment. These experiences forced me to take seriously the role of researching potentially vulnerable groups. In response, beyond revising my advertisement, I also clarified that my intentions for the research were not in policy and legal change. Instead, I stressed that my interest in talking with them was based on my desire to involve their voices in a research field that is currently dominated by the natural, medical, and the life science and biotech industries.

Within academic and industry spaces I was aware of and experienced the greater societal power dynamics that run along the lines of race, sex, and gender. It was easy to observe how well-represented white and able-bodied males were in these spaces and that my own presence fitted in well with the middle-class white population. However, over time, I came to realise that while I was attempting to make critiques of rational objective science, the research project was itself embroiled in hierarchical modes of ordering knowledge. For example, within industry and academic spaces, there were instances where I experienced being spoken down to as a social scientist by industry and academic members. On multiple occasions, I found myself defending the legitimacy of my research project and the social sciences more generally to natural

and medical scientists. Time and again it was pointed out that my project lacked a hypothesis and experiments that would provide repeatable results.

Although being aware "that 'objectivity' is itself a social construction" (Herbert 2000, 559) and that "there is no 'view from nowhere' that legitimates the objectivity of epistemic claims" (Jackson and Maracle 2014, 6), I came across ignorance within the field, as well as within myself, to the socially situated nature of the natural and medical sciences; they too exist within a certain social setting or 'milieu' (Herbert 2000, 259). As Herbert explains,

> It [the sciences] fails to recognise that interpretive practices are central to all science, and that various social practice's structure how data and theory are interrogated to create scientific work. The irony here, of course, is that it is ethnographies of science which teach us this (Herbert 2000, 558).

In the process of observing lab spaces, interviewing researchers and learning about the competing ideas around how the microbiome functions, I became more aware that the "the interpretive dilemma is unavoidable and hardly unique to ethnography" (Herbert 2000, 558).

After my first trip to Boston, I had to take into consideration how I would begin to position myself as a social scientist in a field site dominated by the natural and medical sciences. I became aware that my project would have to grapple with the broader discussions of the hierarchies of knowledge production that I aimed to explore in relation to the microbiome. This manifested in my own imposter syndrome of not being a 'real microbiome researcher'. Though uncomfortable, these experiences offered valuable insight into how varying onto-ethico-epistemologies are productive in enacting hierarchies of knowledge production.[48]

As with any research, reflecting on my own onto-ethico-epistemological positionality and situatedness is also required in order to recognise the limits of my research scope (Hinchliffe 2007, Mason 2002). As Mason argues,

> Asking, listening and interpretation are theoretical projects in the sense that how we ask questions, what we assume is possible from asking questions and from listening

[48] This is discussed at length in Chapter Four.

> to answers, and what kind of knowledge we hear answers to be, are all ways in which we express, pursue and satisfy our theoretical orientations in our research (2002, 225).

In committing to viewing worlds in process, the intention of the project is not to provide a neat reductive representation of a specific reality. I do not aim to provide a universally agreed upon narrative of the microbiome. I actively avoid language, such as truth and objectivity, that operate as “elevator words” that intend “to improve the scientific status of whatever is at issue” (Hacking in Harding 2019, 117). Instead, I observe ontologies as “being brought into being, sustained or allowed to wither away in common, day to day, socio-material practices” (Mol 2002, 6). Therefore, my analysis provides observations that stem from my specific research orientation and consider real-world material manifestations and implications that might occur as a consequence. The project starts within the messiness inherent in the world (Haraway 2016). I aim to avoid “tidy(ing) up and sanitiz(ing) what are often messy social processes and experiences” and instead observe, pay attention to and give value to the sites and research participants “in all their messiness" (Mason 2002, 232) and within the “ever-contingent reality of every day” (Herbert 2000, 555).

The project then seeks to complicate the onto-ethico-epistemologies that are animated in dominant microbiome science. This, in part, responds to calls to integrate the social sciences into microbiome knowledge production (Benezra 2020, Delgado and Baedke 2021, Fortenberry 2013, Greenhough et al. 2020) while also incorporating perspectives that would be considered as ‘lay’ (Greenhough et al. 2020). In doing so, I intend to demonstrate the importance in diversifying the voices that get to contribute to understandings of the microbiome. As Mol reminds us, just as within the field of biology, ‘disease’ and ‘illness’ should not be observed as neutral concepts immune from analysis from the social sciences as it would risk that “those who talk in its name will always have the last word” (2002, 22).

Ethics and consent

The research was carried out under the University of Bristol’s ethical guidelines and received approval from the University of Bristol School of Geographical Sciences’ Research Ethics committee. Due to the sensitive and intimate nature of the associated medical conditions and procedure of FMT, special ethical consideration was given to

the research elements and practice concerning the FMT users. To avoid causing harm to research participants, I made extensive efforts to explain my research, its aims and intentions to everyone involved (Stacey 1988). Special attention was paid to how I communicated my research and the expectations of participants in the research to FMT users due to the power imbalance between myself and FMT users mentioned earlier in this chapter. Unlike other researchers or members in industry, FMT users have the least power in representing themselves in other domains. I made sure the FMT users were aware that they did not have to share any intimate details if they did not feel comfortable to do so. However, I was surprised to find that all of the FMT users were so used to talking about their conditions, FMT and faecal matter generally, that everyone was very happy to share (even unprompted) the gory details of the procedure. With all the interview participants, I made it clear that no information should be shared unless they feel comfortable to do so and that they can remove themselves from the research process at any point. All interview participants' identities have been anonymised with the use of pseudonyms.

I decided to use verbal consent over written consent forms. I chose to do this to set a relaxed precedent and more conversational style setting for the interviews. This was especially important for the interviews with FMT users as I wanted to minimise the hierarchies that appear in interactions between researchers and research subjects. Alongside this, verbal consent was useful for me to lay out my research to other people moving in microbial-related spaces that I was researching, receive feedback, answer questions, and sometimes to defend my work.

Conclusion

This chapter has provided an overview of the methods and approaches used throughout the research process that form the basis of the analysis discussed hereafter. It has justified and set out the specific groups and sites of microbiome knowledge production that I engaged with. Finally, I considered my own research positionality and laid out the ethical considerations that were made throughout the research. Overall, the methodology of the project promotes broader onto-ethico-epistemological reflection within microbiome studies in order to decentre the 'objective' and 'neutral' natural and medical sciences.

Thus far, I have provided a contextual background to the social, cultural, and scientific understandings and engagements with the microbe and microbiome,

stipulated the theoretical frameworks that I use, and detailed why and how I did the research. Utilising the feminist decolonial approach that I presented in the previous chapter, the rest of the thesis will provide empirical analysis to unpick how microbiome knowledge is emerging, the processes by which such knowledge is legitimised, and the relationality that such knowledge produces between humans and the microbiome via FMT. I start the analytical part of the thesis by first exploring the troublesome relationship that microbial life has with being coerced into modernist apparatuses of the natural and medical sciences as they attempt to methodically order and categorise organic matter.

Chapter Four: The making of 'real' and 'legitimate' microbiome science

The role of human politics remains important in exploring how microbiome knowledge is made and legitimised, and as I go on to show, has a significant role in dictating how the microbiome is known. While arguments have been made for "stronger integration of social science and humanities scholars into human microbiome research" (Delgado and Baedke 2021, 9 see also Greenhough et al 2020), as a field, microbiome studies continues to be dominated by traditional 'natural' science disciplines (Berg et al. 2020).[49] Little recognition is given to what critical social sciences[50] can offer to understandings of the microbiome. This chapter enacts my feminist decolonial approach - inspired formatively by Karen Barad (2007) - to observe and critique the

[49] Including but not limited to "agriculture, food science, biotechnology, bioeconomy, mathematics (informatics, statistics, modelling), plant pathology, and especially human medicine" (Berg 2020, 2).

[50] I am aware that this term may seem to homogenise or overgeneralise the social sciences as they represent a hugely diverse set of disciplines. However, I refer here to the critical social sciences as those that are attentive to and critical of the dynamics of power that dictate certain forms of relationality. It is also worth noting that this homogenisation is a product of the hierarchical onto-epistemic construction of 'real' science that this chapter seeks to complicate.

dominant modes by which knowledge is produced about the microbiome. Drawing on ethnographic material, I discuss how microbiome knowledge produced via dominant science follows traditional and strict modernist ways of knowing the world that intend to create objective truth and that work to exclude the potential contributions of the critical social sciences. Throughout the chapter, I unpick the tensions, harmonies, contradictions, and power dynamics that intra-act to produce different versions and knowledges of the microbiome.

The concept of 'real' science emerged during my time in the field. Interlocutors would often use the term to refer to a practice of science and research that sought to remove sociality and otherwise unquantifiable variables from microbiome knowledge. The term 'real science' was used quite unselfconsciously and assumed the reproduction of an artificial binary between 'nature' and 'culture'. This, as I go on to show, reinforced a hierarchy between knowledge that excludes the 'social' and 'cultural' and knowledge produced by the critical social sciences.

I observe two related implications of enacting such strict knowledge hierarchies. The first is that by absolving the role that 'culture' plays in the microbiome, the violences of oppressive structures and systems (for instance, racism and colonialism) are reproduced within microbiome research. My focus here is to explore how hierarchical and exclusive modes of knowing the microbiome work to both delegitimise other forms of knowledge the microbiome and so also enact a violent politics of the microbiome by reproducing racist and colonial onto-ethico-epistemologies. The second related implication that I explore is how such strict knowledge hierarchies work to exclude and disenfranchise FMT patient groups by pushing them to the periphery. I point to how the colonial onto-ethico-epistemic construction of microbiome knowledge enforces a periphery to construct and edify itself as the centre. Hence, peripheralisation is an integral function to the colonial reproduction of 'real science'. I highlight how the professionalisation of microbiome knowledge is integral to the discursive construction of 'legitimate' microbiome knowledge (as the centre), that requires the exclusion of all associations with the label alternative in medicine (the periphery). I argue that such exclusions work to exclude vulnerable patient populations from biomedical discourse and the medical institution. Throughout I argue that while the dominant modes of knowledge production have been incredibly valuable in providing insight into the mechanics and functions of the microbiome, they also enact a politics of exclusion and violence. I suggest that what is needed is thoughtful

consideration on how racism and colonialism structure knowledge. Integral to this is reflecting on the onto-ethico-epistemology of dominant microbiome science that requires a nature-culture binary, where culture can and must be removed from nature to create 'objective truth', for knowledge to be seen as legitimate.

What knowledge matters when knowing the microbiome?

Being told I was not a 'real' microbiome researcher.

17th April 2019

It is the second day of the Translational Microbiome Conference at the Westin Copley Place hotel in the commercial part of Back Bay, central Boston. Despite the mild April weather outside I am uncomfortably cold as a strong air conditioning breeze floods the hotel conference room. During the morning networking coffee hour as I wrap myself up in an unseasonably thick woollen jumper, I strike up a conversation about the warm weather outside, but arctic conditions inside, to a PhD student, Russel. The conversation quickly turns to the work that Russel is presenting at the conference. Mentioning that he was hopeful for a postdoc position or a potential job at some of the industry members' companies he excitedly tells me that his poster, about how faecal samples can be stabilised in different settings of collection, was receiving a lot of interest from some important industry members in attendance at the conference. We were then joined by Harry, a member from industry (who I later interviewed for this project). During the introductions, Russel went first, enthusiastic at the prospect of selling his poster's findings to another industry member. I then introduced myself as "Alice, a PhD student from the University of Bristol studying the microbiome..." But before I could move on to explain anything more, I was interrupted by Russel, who decided to clarify that, "oh, but she isn't a real microbiome researcher." Both Harry and I looked at him with slight amazement that he had decided to take this upon himself. Shocked, and feeling like I had to defend my work as worthy of counting as 'real' microbiome research, I hurriedly started to talk about the scientific elements of my work. After several interactions during my time in the field

where other microbiome-related figures had communicated their serious doubts towards critical social sciences, this response was no surprise to me. Harry politely made allowances for the social sciences and asked me more about my work as Russel skulked away.

'Real' science and 'real' scientists

The excerpt above crystalises well the approach to critical social science that I witnessed during my time in the field. Russel's approach to knowledge produced in the sciences echoes what environmental humanities scholar Lesley Green (2020) refers to as 'scientism'. Green, referencing decolonial Argentinian philosopher Enrique Dussel, distinguishes between science and scientism, where scientism creates "dogma about truth because it was generated by scientists" that leads to an "unreasonable faith in the claim that science is independent and neutral", whereas science "is investigative scholarship for which any claim is open to question and reasonable answer" (Green 2020, 38). Scientism, then, is not inherent in science but an ideology that is adopted. Such an ideology reproduces what Belgian philosopher Isabelle Stengers (2018) refers to as the illusion of 'real' science and 'real' scientists. In her manifesto calling for slow science she critically observes that, in order to maintain legitimacy, 'real' science must exclude all 'non-scientific' variables such as opinions and values both theological and metaphysical. She continues that doing so requires a process of dismissing,

> Any questions he [the scientist] considers 'non-scientific' in a manner which is not without parallel to the phobic misogyny of the priesthood, meaning that he endows them with a dangerous, seductive power that is liable to lead him down the one-way road to perdition (Stengers 2018, 36).

Such a belief in 'real' science enforces a hierarchy that distinguishes the natural and medical sciences above critical social sciences. Emily, an industry researcher had experienced how work including unquantifiable elements was not seen as legitimate by the scientific community she was part of. Emily had been working in various industry jobs since finishing her PhD but had to leave the workforce due to an autoimmune condition. After experimenting with a range of alternative medicines (such as acupuncture) and researching the links between psychological wellbeing and

autoimmunity, she focused on her diet and cutting out inflammatory foods, however, as she explained, what really helped her was dealing with her undiagnosed Post Traumatic Stress Disorder (PTSD) and childhood trauma. The results for her were so successful that she started working on researching the relationship between mental health and autoimmunity full time. When I spoke to her, she was working on a website to accumulate research and advocate for alternative medical routes to deal with autoimmune conditions. In using other epistemic routes in her investigation, Emily experienced alienation from the scientific community. She explained,

> But for me, coming out of regular science it's kind of hard for me to tell people what I'm doing because I think they look at it like I'm leaving the community of 'real science' to go do this stuff [gestures around] … I mean I think they get autoimmune conditions are a huge problem in this country and they understand that, but I'm kind of leaving science to do more of an 'intermediate' between psychology and what I used to do and they look at that… like 'oh what's going on here, good luck with that' [rolls eyes], but at the same time I love learning about the brain and like the connections with all of that, I still feel like it's unexplored, like the next frontier, so who knows, in ten to fifteen years from now who will be saying what!

Emily's experience very closely resembles what Stengers refers to in her manifesto. Ostracised scientists who work with un-quantifiable data "are still half-implicitly dismissed through the subtle smile, the ill-disguised warning, or the snickering and gossip about so-and-so 'who doesn't do science anymore" (Stengers 2018, 36). As Emily demonstrates, venturing outside of the so-called hard sciences' delegitimised her work, even if this only meant working in other ostensible sciences such as psychology. This interaction exposes a hierarchy of knowledge production that situates the physical, quantifiable, and therefore, 'hard' natural and medical sciences' as superior, as more legitimate sources of knowledge production than other modes that do not involve producing repeatable experimental results that can be quantified about objective material or processes.

Such a hierarchy assumes a linear, top-down construction of information. For example, in cases where interview participants recognised that critical social science could contribute to microbiome research it would be assumed such work would merely add commentary to, rather than formulating, knowledge on the microbiome. Charles,

a researcher at Betz University, exhibited this approach to knowledge at the end of our interview. As I was leaving and thanking him for his time, he said, “you always know when the scientists have found something interesting because we seem to attract the anthropologists and social scientists”. This speaks to the broader trend of social scientists being included “only at the end of grand multidisciplinary procedures, to inform implementation strategies or communication plans, rather than to help determine policy directions” (Stirling 2014, np). Such a view infers a linear understanding of research, where a phenomenon exists for scientists to discover and make facts about, then once it has been discovered the social scientists come in to investigate, and not vice versa. This understanding of knowledge production echoes a similar linear format to what Latour refers to as the ‘bicameral modern condition’, where it is assumed that the science produces neutral objective facts for politicians to then implement related social policy to address whatever science has revealed (Latour 2004). Such an assumption, Latour emphasises, distorts the influence of politics on and in scientific discovery and misses out the complex networks that operate to influence and produce policy. As he continues to make clear, the direction of action is anything but unilateral (ibid). Charles, however, assumes a unilateral flow of knowledge production and in doing so he also establishes his position that the critical social sciences are there to analyse and not contribute to microbiome knowledge.

Even in spaces where knowledge hierarchies are intended to be disrupted, such as in the DC Lab[51] where Lacy, an artist who works with microbial life, was supposed to complicate the binary between art and science by working with scientist Mark, a linear assumption remained that the art was to learn from the natural and medical sciences as opposed to contributing to the knowledge produced and not vice versa. This was revealed to me very clearly when interviewing Mark and Lacy. During our discussion, Mark was referred to as bacterial artist and scientist, but Lacy was only referred to as a bacterial artist. Mark made his views on critical social science very clear as the following excerpt from our interview, where we were discussing the production of knowledge in the critical social sciences, demonstrates,

> Mark: I will never take things seriously that aren’t repeated.
>
> Me: Just because it isn’t repeatable doesn’t mean it’s not valid

[51] A microbiome research laboratory visited at the end of my second research visit in Boston.

Mark: I agree with that, but I would go beyond, I would say that's an observation; cute. For example, just an example, a psychologist published a paper saying that people commit suicide on the Golden Gate Bridge, most of them face the city and not the ocean so they are giving a message to the city, they are still linked to the city instead of the ocean. This was published, this is an observation, there are actually cameras on the Golden Gate Bridge, so he just recorded it. It's an observation but it was debunked because there is no sidewalk on the other side so they can't jump from the other side. For it to be valid you would have to repeat it at another bridge, an observation like that is valid but completely valid for the wrong reasons.

Me: Isn't that the same in science, where some experiments are not repeatable?

Mark: yeah, but we don't validate those very well, they don't get high impact, that's just a cute observation.

Me: But there are some things [interrupted]

Lacy: That happens in those experiments, and they can be useful [interrupted]

Mark: But if you can't repeat it, you're not using scientific methodology, science is a method not truth.

Though recognising science as a method instead of dogma (Green 2020, Stengers 2018), Mark also enacts a forceful hierarchy between the natural and critical social sciences. Perhaps there was some confusion about what the critical social sciences are, though referred to as a science they do not all follow scientific method, yet they remain a crucial form of producing knowledge about the world. Mark's ungenerous and patronising application of the word 'cute' works to delegitimise critical social sciences by presenting it as inferior. He makes clear that he does not see non-repeatable work as a legitimate way of producing robust knowledge about the world. If it is not repeatable, it is a 'cute observation'. Similar to Charles, for Mark, a linear construction of knowledge is assumed, where science exists to create knowledge and art comes in after its construction.

The hierarchy that I witnessed being employed in the field, is largely underpinned by the reproduction of a nature culture dichotomy, where "nature [exists] out there" (Hinchliffe 2007, 7) in an "imagined pristine state…outside of society" (Green 2020, 176, see also Apffel-Marglin 2011, Cronon 1996, Jackson and Maracle 2014, Haraway 1989, Latour 2004). An assumption that science is able to uncover truth about the natural world, via the exclusion of social factors was demonstrated in the interactions with Emily, Russel, Charles, and Mark. Where Emily's intrigue in the

relationship between unquantifiable variables, such as the role of PTSD in experiences of autoimmunity, encouraged her dismissal from scientific dogma, for Russel, Charles and Mark, science observes the natural world, devoid of any human politics or culture, making the results that stem from such work objective (Escobar 2020).

Critiques of this binary are well trodden. Geographers, social scientists and philosophers have all exposed the sinister and exploitative colonial onto-ethico-epistemologies that underpin and extrapolate nature-culture distinctions (Escobar 2020, Jasanoff 2004, Haraway 1988, Haraway 2003, Haraway 2008, Povinelli 2016, Wynter 2003). As anthropologist Marilyn Strathern (1980, 181) well summarises, "Western nature-culture constructs ...revolve around the notion that the one domain is open to control or colonisation by the other". Similarly, this binary and its violences have been explored at length in relation to the production of scientific information and the production of bodily knowledge (Hilgartner et al. 2015, Jasanoff 2004, Stehr 2015). Scholars from STS and FSS have been vital in exposing how the biological sciences construct and reinforce artificial binaries between "nature and culture, genetics and the environment, and the biological and social"[52] (Rajagopalan et al. 2016, 367 see also Duster 2015, Haraway 1997, Marks 2002, TallBear 2014). However, there is specific importance in observing the development and damage that this binary, and the related hierarchies it employs, has in microbiome research as it emerges and becomes institutionalised as a field. The next part of this chapter goes on to explore the specific violent politics that are reproduced in microbiome science when attention to these systems and structures of power and their histories, something well understood and developed by the critical social sciences, are left out of scientific inquiry.

Consequences of restricting modes of knowing the microbiome: Reproducing racist and colonial onto-ethico-epistemes

Colonial onto-ethico-epistemes in microbiome research

The exclusion of particular people has always been intimately connected to the hegemony of scientific knowledge, made possible through geographies of colonial

[52] To expand on the full depths of STS and FSS work on the nature culture binary is beyond the scope of this thesis.

violence. Escobar's work has been pivotal in unpicking the strict political ontologies and entangled relationship between modernist constructions of knowledge and colonial violence of ontological enclosure and exclusion. As he suggests, "Modernity created the idea that we live in a world that has room for only one world, the One-World World (OWW), now globalised" (Escobar 2020, 26). The One-World world has been fundamental in the west's positioning of itself as the 'real' or true state of being. Through such, all other worlds, including indigenous forms of knowledge, are subordinated as they do not conform to modernist formats of creating knowledge (ibid).

> The Western realist episteme translates non-Western reals into beliefs, so that only the reality validated by science is real. We have science (and thus the true perception of the real); 'they' can only have 'beliefs' (myths, ideologies, legends, superstitions, local but never universal knowledges, and so on) (ibid, 13-14).

By determining what gets to count as real, modernism has been a fundamental crux of colonialism. As decolonial thinker Walter Mignolo (2010, 316) explains, "the outside of modernity is precisely that which has to be conquered, colonised, superseded and converted to the principles of progress and modernity". Colonialism and modernism, as two sides of the same coin, delegitimise non-western and non-modern ways of knowing the world because they exceed and do not conform to modernist onto-ethico-epistemologies (Escobar 2020, Mignolo 2010). Further, by doing so, the One-World world is reified as modernist knowledge is reproduced as the only way of creating real accounts of the world (Dussel 2003, Dussel 1995).

Exclusive and violent politics of the microbiome emerge in the reproduction of colonial methods of domination and dispossession in microbiome research. These are most evident in how indigenous microbiomes have been included into contemporary microbiome research. During my time in the field, I was made aware of the colonial and imperialist ideologies on multiple occasions. This was most apparent in the language used to refer to the microbiomes of indigenous communities. Prominent was the common use of the 'seed bank' analogy when justifying why recording indigenous populations' microbiomes was important. As Charles demonstrated when answering a question on how lifestyle and environmental factors affect microbiome diversity, explaining,

> This is the big frontier… I forgot the name of the initiative, it's an international collaboration to collect microbiomes from all over the globe especially from populations that are shrinking or disappearing, natives of a particular region of small regions or communities, primitive tribes in different countries where they are [their microbiomes are] being sequenced before they go out of existence…it's like a seed bank to preserve seed types so that we don't lose the botanical diversity in the world.

Referring to indigenous people as 'primitives' and their microbiomes as the next 'frontier' exposes the outdated and extractivist viewpoints typical of colonial discourse. Using such language highlights a palpable ignorance to the wider architectures of colonialist powers that justified the exploitation and oppression of indigenous groups by historically positioning them as uncivilised and less-than human (Driver et al. 2005). Further, I also want to draw attention to the perverse undertone of the seed bank analogy considered in the colonial and imperialist roots of mapping. Using predominately taxonomic recording as the main mode through which microbial life becomes known within contemporary microbiome studies requires critical reflection. The wish to record and itemise taxonomic presence of microbial life echoes a colonial empiric, embedded in cartographic impulses of discovery. The practice of mapping enables ownership over space, as Akerman (2009) argues, "the connection between cartography and the exercise of imperial power is an ancient one" (2009, 1).

Beyond the gravely exploitative approach to using indigenous peoples as microbial resources, the common reference to seed banks as a form of recording stands within a broader colonial politics of the archive. Inspired by geographer Kathryn Yusoff's (2010, 95) work that explores the "archival impulse" prompted by the climate crisis, I want to speculate on the future that such an archival approach to indigenous communities' microbiomes imagines. In reference to the archival impulse prompted by the climate crisis, Yusoff explains

> That as we look, we are enfolded into the technology of the archive and its power over the future; we must consider fates – generative or destructive… as anthropogenic climate change commits us to mass extinction events, we might spend a while in the embrace of such violence to hear its dark secret (Yusoff 2010, 95).

The future that the initiatives Charles referred to reveals itself as dark and violent for indigenous communities as there is an assumed inevitable extinction event on the

horizon. Indigenous groups are propelled into a future of extinction, valued primarily for their microbial taxa, and presented as a living artifact. With little critique to the structures that are causing such indigenous groups extinction, microbial seed banks' fit into broader criticisms of seed banks as their "objectives [have] simply been to make genetic resources available for human use, not to conserve agricultural environments and diversity in any fuller sense of these terms" (Van Dooren 2009, 380). Such findings echo work done by the genetic mapping project, the Human Genome Diversity Project (HGDP) which was heavily critiqued for the colonial and imperialist violences that it imposed (Burrows 2006, Khan 1999, Lock 1997, M'charek 2005, Nash 2015). As others have noted, the HGDP's interest in gaining information on indigenous people was, in part, motivated by the presumption that they will soon no longer exist (Nash 2015).

Observing indigenous communities as resources was also exemplified by Margret, a researcher looking at South American indigenous microbiomes. Margret made specific reference to the research groups concerted efforts to not enact the same harm done in the HGDP. She explained that the group worked with a community who had received government-sanctioned protection, which dictated what researchers would be allowed to do and gave the community legal protection. Despite this, some of the language Margret used to refer to the communities was worrisome. While explaining that including indigenous groups in microbiome research was of the upmost importance so that clinical interventions can be inclusive of their microbiome needs, she clarified that,

> I'm not ruling out that eventually it is possible that some groups might do something more direct, like work with the community directly using them as *reservoirs* and letting them know that they will be part of a project to do faecal transplants or something like that and if they are directly connected, they should be eligible to have some tangible benefits… You're probably familiar with this concept that's going around called restoration, that is the idea that we should go back to the original microbiota we had before westernisation happened. So, I think those projects might or that line of thought might produce more opportunity for that type of interaction (emphasis added).

Although Margret saw indigenous groups' inclusion in research as important, the imagery of 'reservoirs' positions indigenous people's bodies, and their genetic and

biological material as resources for others. This follows similar logics to the HGDP, notably referred to as 'the Vampire Project' due to the way that blood samples were collected exploitatively without informed consent from the indigenous groups (Crigger 1995, M'charek 2005). Margret's vision was not as obviously unethical as the HGDP, as she explained they had set up processes for clear communication, and also offered health checks, but it clearly relies on the objectification of indigenous people as resources for extraction. The primary beneficiaries of this extraction are western industrialised populations and in this way her vision clearly reflects colonial power dynamics and geographies of extraction. How both Margret and Charles observe indigenous people is exemplary of violent colonial architectures of power that dehumanises indigenous groups and justifies their exploitation.

This approach is common throughout the microbiome field. As Greenhough et al. note, for instance, **"**much of the Human Microbiome Project has been about natural history, documenting kinds of life and often conforming to a neo-primitivist story of 'this is what the original human microbiome looks like'" (2020, 6). Hobart and Maroney (2019) similarly depict the exploitative research practices on the Hadza tribe[53] where "Hadza bodies" were viewed "as reservoirs of microbial diversity that will one day restore depleted Western guts" (2019, 577). Such narratives echo traditional colonial narratives of dispossession and dehumanisation. As Benezar notes, "to seek answers to current Western woes in the idealised purity of the past and primitive gut in turn instrumentalises brown and black bodies in the service of white health" (2020, 883).

Benezar's point bears consideration especially when thinking about the value of an indigenous microbiome in a western industrialised context. As mentioned in the introduction, there is a large body of work demonstrating the ways in which industrialisation and the associated lifestyle contribute to microbiome diversity loss (Blaser 2014, Segata 2015, Velasquez-Manoff 2012a, Velasquez-Manoff 2012b). As Shotwell reminds us, there is no pristine or pure environmental setting to return to and efforts to do so are often ignorant to the political contexts and practices the contribute to the erosion of such environments (2016). To focus on indigenous microbiomes as a potential source to repopulate a western microbiome demonstrates ignorance of the

[53] The Hadza tribe are an indigenous community located in northern Tanzania.

structures of westernisation that are initiating microbial erosion. As Benezar succinctly explains,

> Salvage microbiomics wants to save valuable, vanishing microbes from modernisation without acknowledging the research's own embeddedness in technoscientific systems responsible for changes in microbial populations (Benezra 2020, 883).

Such dissonance was demonstrated by Margret as she justified why indigenous microbiomes would be beneficial to western populations

> In general, we have this expectation that indigenous groups might harbour bacteria, species or taxa that you're not going to see in other populations maybe because of the ecosystem where they live, but also it's possible that these are elements that were part of the human microbiome that we have seen lost over time because of the use of antibiotics and chlorinated water and all of this things that we have in more industrialised communities. So, for science in general, there is a wealth of information that we can win from that.

Margret, however, does not offer a way in which such indigenous microbiomes transported into western industrialised settings, exposed to, as she mentions, the consumption of antibiotics and chlorinated water, would gain resilience to microbially-erosive environments. While indigenous microbiomes may 'restore' western industrialised microbiomes, how durable these will be, is debatable and puts into question how useful microbes from indigenous bodies would fare in a western industrialised context.

Racism in microbiome research

Another mode by which a violent politics of exclusion and oppression have emerged is the ill-informed use of race as a biological classification in microbiome research. Because of this, the use of race has rightly come under fire (Benezra 2020, Delgado and Baedke 2021, Findley et al. 2016, Greenhough et al. 2020). As many have exposed, race and ethnicity are commonly and wrongly observed as biological or genetic differences. Pediatrician Dennis Fortenberry (2013) prominently highlights that race and ethnicity are used as predictive qualities rather than descriptive signifiers. As he explains, "American racial/ethnic categories are social and political in origin and

represent little meaningful biologic basis of between-group racial/ethnic diversity" (ibid, 165). A prominent example of microbiome research that operationalises an ill-informed understanding that views race and ethnicity as predictive is well demonstrated by Ravel et al (2011). As STS scholar Amber Benezra points out, Ravel et al's (2011) paper reproduces the racial stereotyping of black Hispanic women as hyper-sexualised by associating such groups with "multiple sexual partners, lack of condom use and smoking" (Benezra 2020, 886). She continues that the paper was hugely informative in a host of other vaginal microbiome papers that similarly "took the racial/ethnic groups as given, and began to place value judgments on 'risky behaviors', 'healthy vaginas', and 'good' and 'bad' vaginal microbiomes" (ibid, 887). A violent politics of the microbiome is enacted by Ravel et al's (2011) paper as it concludes that vaginal microbiome differentiation is due to inherent racial differences rather than appreciating "what it means to be a black or Hispanic woman in the United States" and how this too may impact vaginal microbiomes (Benezra 2020, 887).

Because of the common ill-informed use of race as a biological classification in microbiome research and its damaging implications, its use has been debated. While some have suggested that though often used inappropriately race continues to offer important insight into the microbiome, as Fortenberry argues, the ill-informed and uncritical,

> Use of race/ ethnic categories in microbiome research…does not suggest that microbiome research should be 'color-blind'; rather, quite the opposite. The challenge to microbiome research is to translate its insights into better understanding of health disparities without depending on the validity of the categories on which disparities are based (2013, 165).

Others, however, argue that because of the political complexities and nuances in what race means, it should not be used as a distinguishing factor in microbiome research. Helmreich, for example, explains, "… such inclusion [of race and ethnicity] then offers only off-the-shelf demographic categories, rather than taking the opportunity to explore whether other categories might be more revelatory" (2013, 67). Helmerich points to the potential issues that come from molecularizing race and class through attempts at observing microbes of oppressed groups. He goes on to say research that attempts to essentialise race or class through the microbiome "treats 'microbiomes' and 'class'

as concrete things, only to be brought into relation after they have been named as distinct" (ibid, 67). Similarly, Greenhough et al question if it is logical,

> To speak of microbes associated with poverty, social marginalisation, or unequal access to health resources? How far can we pursue this sort of enquiry before encountering a form of microbiological determinism, and rehearsing older associations between social abjection and pathogenic microbes? (2020, 8).

In their work on nutrition, Delgado and Baedke "address the empirical and methodological issues" in using "race as a category to determine health issues of certain human groups" (2021, 2). They do so by first situating the historical and cultural settings that distinguish the "problematic environmentalist narratives" that tie nutrition and race together (ibid, 2). Second, they argue "that the concept of race used in the field is taxonomically and conceptually inconsistent and ultimately leads to counterintuitive view of human races" that supposes human races are defined or can be easily distinguished (ibid, 2). Therefore they "strongly urge [researchers] to remove the concept of race from microbial studies to describe biological properties of human groups" (ibid, 9). They come to this position due to the risks that are inherent in essentialising race, something that cannot be reduce to a fixed or universal definition. As an alternative, Benezra calls to "interpret microbiomes as biosocial relationships in process rather than reinforcing the separation of biological and social influences" to observe "the dynamic process of embodiment" (2020, 89).

However, rather than debate the use of race as a biological classification in microbiome research, I argue that what is instead needed is greater attention to the role that racism and colonialism play in structuring knowledge. Fundamental to this is considerable critical deliberation on the onto-ethico-epistemology of dominant microbiome science that enforces a nature culture binary, where culture can and must be removed from nature to create 'objective truth', for knowledge to be seen as legitimate. Such hierarchical modes of knowledge production, that exclude knowledge that observes the unquantifiable and 'cultural' world prevents the integration of disciplines that pay attention to power structures and systems that can offer the conceptual tools to disrupt structures of racism and colonialism. Though there have been attempts by the natural and medical sciences to include the 'social' world in microbiome science, to assume one may simply include the social world creates a

simplified understanding of what the 'social world' encompasses.[54] It matters then, *how* critical social sciences are integrated into microbiome research.

More than merely including social categorisations into microbiome research (Findley et al. 2016, Rees et al. 2018), critical social scientists and their knowledge base are needed to properly evaluate and analyze these categorisations; as not doing so risks the reproduction of ill-informed analysis, as the inaccurate use of race and reproduction on colonialism exemplify. The conceptual and theoretical tools that work to expose and complicate the power structures within the construction of scientific knowledge have been well cultivated for many years by certain disciplines in the critical social sciences (STS, FSS, decolonial and anti-colonial scholars), yet the integration into the production of scientific knowledge remains limited. This occurs despite the increasing number of calls to integrate the critical social sciences into microbiome research (Benezra 2020, Delgado and Baedke 2021, Greenhough et al. 2020, Rees et al. 2018).

Formative in bringing attention to the important role critical social science can play in generating understandings of and research into the microbiome is Greenhough et al's 2020 paper. In it the authors note that some of their research participants (who represented members from important research disciplines and groups) stated that,

> It's important to make sure that, in future research on the microbiome, social scientists are not just observing the scientists, or enrolled by scientists to speak for the social perception of the microbiome (Greenhough et al 2020, 6).

Greenhough et al go on to suggest that,

> An interdisciplinary research agenda requires moving across different fields, and sustaining hybrid modalities of knowledge over time, instituting 'greater openness and transparency about the diversity of ways to understand and address particular problems' (Stirling 2014, np in Greenhough et al. 2020, 8).

Bringing attention to the hybrid modalities of knowledge is important work. More than exposing the benefits that critical social science can offer to understandings of the

[54] This speaks to wider assumptions that critical social science research can be done by anyone, similar to when Mark assumes he can be an artist without any training. This assumption ignores the importance of the specialist skills and training required for critical social science.

microbiome, I argue that the deeply hierarchical politics of knowledge production that observes the inclusion of the unquantifiable as illegitimate needs to be critically questioned. This is not to suggest that work in the natural and medical sciences cannot be decolonial and anti-racist, rather, that the power dynamics, politics, and knowledge hierarchies that are currently mobilised need to be critically questioned in order to allow other types of knowledge about the microbiome to also be observed as legitimate and contribute to understandings of the microbiome. It appears that until serious reflection on onto-ethico-epistemological assumptions of objectivity and truth that require the separation of nature from culture are taken seriously and employed, the inclusion of such disciplines will be limited.

The professionalisation of microbiome knowledge and the production of the periphery patient

While the section above observed how excluding social scientists in microbiome knowledge production in part has led to uncritical understandings of, and in cases has reproduced, oppressive power, this section analyses the exclusion of FMT users from producing microbiome knowledge. Specifically, this section focuses on the tensions that emerge as the microbiome becomes professionalised. I speculate on the relationship between a hierarchical enactment of microbiome knowledge and the exclusion of FMT users as producers of bodily knowledge. Like most medical knowledges, the ambition to professionalise has been driven by the intention to protect against 'quack' medicine, defend patients and maintain the status of medical science (Lupton 2012, Mol 2002). The legitimising of medicine has an important role in upholding standards and maintaining trust in the medical institution (Lupton 2012). However, this process also reinforces the power hierarchy between patient and doctor that has historically worked to violently exclude oppressed groups (ibid).

Going against the sterilising ontology of most dominant medical science, FMT, similarly to helminth therapy and other probiotic approaches, sits in an unusual space in medical discourse (Lorimer 2020, Wolf-Meyer 2017). Because FMT uses the body instead of synthetically produced materials as a form of treatment, it is still regarded by many users as alternative medicine. Many FMT users I spoke with and observed in the Facebook advocacy pages associate FMT with, and find great meaning from, the procedure's association as an alternative therapy. This is especially the case for those that had had traumatic experiences with medical professionals, with their

conditions either being caused or worsened by medical intervention (through, for example, over-prescription of antibiotics) or having conditions that dominant medical science does not have time or answers for. Key examples of this were chronic conditions such as autoimmune conditions, or where the condition could not be identified, as was the case for FMT user Sally. [55] FMT users often referred to being prescribed steroids, antihistamines, or were advised to undertake the FODMAP diet.[56] Feelings of discontent and dissatisfaction with such prescriptions were common as they target symptoms rather than the cause of conditions and in some cases worsened their symptoms and quality of life. Furthermore, as the existence, mechanics, and role of the microbiome in human health, autoimmunity and digestive illnesses have only recently emerged in dominant medical science, knowledge and awareness of the microbiome is inconsistent across dominant medical institutions. Some medical practitioners may know about the microbiome, some may not. Hence, as dominant medicine was not an option for FMT users, the alternative medical world was essential and life saving for many.

However, for some members in industry that I spoke with during my fieldwork, for FMT to progress and be taken more seriously in the dominant medical field it needs to be divorced from its alternative label. For example, when speaking to Harry, an industry member, about the history of FMT and its presence in Ancient Chinese medicine, he responded that,

> In some respects, this association is a risk for the field. The field has to be very careful to take a rigorous scientific approach and present itself as science – this is science. Public perception is incredibly important. If the world of microbiome research is associated with homeopathic medicine or probiotics, we need to clearly make sure that the microbiome is pushed towards a rigorous scientific approach. We really need to understand our bodies and not through marketing or through noncredible ways. We don't want to get caught up in noncredible things or things that don't have a strong

[55] Sally's experiences with dominant medicine are expanded on in greater detail in Chapter Six.
[56] "FODMAP stands for fermentable oligosaccharides, disaccharides, monosaccharides and polyols, which are short-chain carbohydrates (sugars) that the small intestine absorbs poorly" (Veloso nd, np). Common "FODMAP foods include foods that contain fructose, lactose, fructans, galactans and polyols", which many with IBS are sensitive to (the Gastro Clinic nd, np). The long-term implications of the FODMAP diet are unknown, but as the diet limits certain foods that are important in maintaining a diverse and healthy microbiome some research indicates that, over time, the diet may lead to a reduction of certain microbial taxa (Halmos et al 2015, Sloan et al 2018, Vandeputte and Joossens 2020).

> scientific basis. Chinese medicine, the scientific background of that is more interesting but homeopathic medicine is a better example – or probiotics – they are marketing based. We must develop the field in a rigorous based manner and don't want it to be associated to some fields of alternative medicine, we don't want microbiome to be put in the bracket of alternative medicine.

For Harry, for FMT to be taken seriously, it must have a strong scientific basis. But what basis is that? How does that get decided? Wanting to protect FMT from 'quack' medicine is well intended and important to ensure that FMT is safe. However, a complete refusal of any association to other modes of knowledge production enacts an exclusive and hierarchical politics of the microbiome that works to dismiss some FMT users' experiences.

The dismissal of FMT patient experience was demonstrated to me throughout my time in the field. Some Open Biome members observed the novel and emerging field of microbiome studies in medicine as a positive opportunity to enable doctors and patients to learn about the body together. The overwhelming message elsewhere in the field, however, was that patients need to learn from doctors and not vice versa. For example, at the Translational Microbiome Conference, in a discussion about probiotics with an industry member, I mentioned a conversation that I had had with an FMT user suffering with extreme dysbiosis who said that their arthritis symptoms had worsened after consuming probiotics. They responded, "you can't believe everything those people say because they don't have as good as understanding as they need to say some of that stuff. Some people attribute too much to those things [personal experiences]". During interviews, FMT users often said that medical professionals had told them they were overthinking their conditions. Billy, an FMT user suffering with dysbiosis, for example, was told by a medical practitioner that the symptoms he was experiencing were psychosomatic. Scepticism should be welcomed towards any form of knowledge production; however, the blanket dismissal of FMT users' experiences contributes to the disempowerment and disenfranchisement of such patient populations as I will now go on to explore.

The Periphery Patient

"The charismatic power of biomedicine" enforces a false sense of security for patients (Wolf-Meyer 2020, 233). It is assumed that by engaging with the technologies and

interventions of biomedicine one's body will be able to return to a state of normalcy (Davis 1995, Martin 2006, Wolf-Meyer 2020). As Wolf-Meyer summarises "biomedicine is predicated on the promise that a cure will restore an individual to full personhood" (Wolf-Meyer 2020, 233, see also Dumit 2012). However, this is often not the case. For many FMT users, after the wonders of biomedicine failed to return the patient back to 'normalcy', many experienced feelings of abandonment and rejection by figures that represent dominant biomedical discourse. The persistent dismissal of FMT users' experiences, for some FMT users that I spoke with and observed on the Facebook advocacy pages, led to a disillusionment with and dissociation from biomedical discourse. The concept of the centre and periphery are useful here to conceptualise how hierarchical and exclusive modes of knowledge production work to exclude alternative modes of knowledge production. The production of the periphery is an essential tool of colonialism that reifies itself as the centre, and in doing so it controls a politics of knowledge that is orientated to forms of epistemic and economic control (Dussel 1995, Dussel 2003). As Dussel clarifies, scientism plays a powerful role in operationalising a centre periphery model: "Scientism, the current ideology of the centre, is a subtle ideology…[and] is more dangerous inasmuch as it fabricates the instruments necessary for the power of the centre to be exerted over the periphery." (2003, 168)

It is here that I want to introduce my concept of the 'periphery patient'. If dominant medical science, embedded with scientism, represents and reproduces the ideology of dominant medical science as 'the centre,' where power, resources, and legitimacy are ascribed and enacted, those that fall outside, and oppose aspects of dominant medical science are coerced to the periphery. Movement to the periphery is perpetuated by figures in dominant medical science dismissing or rejecting patients' experiences with their microbiomes, their interest in holism, and their doubts, questions, and critiques of dominant medical science.

For some, information was harder to critically decipher after losing trust in biomedical discourse. Billy, for example, referred to his confusion about what and who to believe. While relaying to me how he saw the dichotomy in conversations and debates around medicine in the advocacy groups between pro-science and anti-science positions, Billy explained,

> I credit my mum for this because I would bring up some random website for some herb diet, and it looked like they were really onto something. But she would point out they have no medical training, like they aren't even nurses, they are calling themselves health engineers and they are saying 'I've spent years trying to figure this out and no one would help me, and I've finally cracked the code and here's this thing' and it can be very sales pitch like. And then they will also do things like quote people that call themselves doctors…and say lots of nonsense anti-scientific stuff, and there's a lot of that, and I think a lot of, some of those people pitching ideas may be onto something, but when they wrap it up in the way they do, it feels more like 'our way or the highway' and everyone else sucks. Why don't they say 'well, we're not doctors, but we found this thing and sometimes it helps people, so why don't you take a look?' So, you can either go to those guys who pretend they are doctors or go to your doctor and get 17 minutes where you say the word 'microbiome' and they will say, 'well, yeah, it's not that…'. It's very hard to find someone who can straddle that fence. And I found a couple naturopaths who don't just claim they have all the answers and that everyone else is wrong. But a lot of people, they go along with these narratives, and it's like, pretty soon there's all of this confirmation bias and they're forgetting that. There are people you want for some things and some that you absolutely don't want for others.

Billy notes the difficulties and complexities that are entangled in trying to decipher what to trust and who to listen to especially when interactions with professional medical institutions can be dismissive of patient experiences to do with the microbiome. Notable is a frustration with the binary between dominant and alternative medicine, where both parties consider the other to be wrong. What is important here is the impact that the enactment of a knowledge hierarchy, where 'experts' dismiss FMT users' experiences, has in generating mistrust in such expert discourse (Wynne 1996, Wynne 2001).

For other FMT users however, movement into the periphery was associated with the adoption of more extreme conspiracy theories. Though more accepting of alternative and untraditional modes of knowing the body, mistrust in biomedical discourse, for some, led to greater acceptance of pseudo and anti-science. Conspiracy theories and pseudoscience commonly came up in my interviews with FMT users and on the Facebook advocacy pages. For some, these conspiracy theories stemmed from legitimate critiques of the capitalised and unjust medical system but evolved into more sinister accusations. FMT user Earl, for example, who when asked about his opinions

on dominant medicine explained that “I think a patient cured is a customer lost, I think the reason people aren’t promoting FMT here, because there is not money in it, there is a lot of money in colonoscopy and drug markets”. He then went on to tell me about a series of “plant medicines from Africa” that would heal digestive issues; however, he claimed that the US government are withholding them to keep people reliant on immunosuppressant drugs. This viewpoint and other popular conspiracies such as the government poisoning the water supplies with fluoride, cancer treatments being a hoax manufactured by ‘big pharma’[57], and, since the Covid-19 pandemic, that Covid-19 has been manufactured by China and other governmental officials to control the population, commonly came up in my interviews and on the Facebook advocacy pages. For some, the deeper into the periphery and further away from any biomedical discourse and method, the harder the line between valid critique and misinformation becomes to distinguish. Without a critical assessment of information, and outside the realm of any trust in dominant medical science and biomedical discourse, many patients engage in dangerous treatments. The severe danger of undergoing the FMT procedure without adequate screening was dramatically exposed in 2019 when two FMT users sadly died after not screening the material of their donor (Rapier 2019).

The complete rejection of, and estrangement from, dominant medical science and adoption of pseudoscience and anti-science rhetoric demonstrates the very real dangers Harry posed regarding FMT being associated with alternative medicine. To a degree, the presence of such pseudo-science validates Harry’s wish to remove FMT from the alternative label. However, for many FMT users, their disillusionment with dominant medical science, in part, stems from valid critiques of and affirming experiences from alternative medicine.

Here I take inspiration from Theriault’s work that explores the ontological politics enacted in environmental governance in the Palawan Island in the Philippines (2017). Drawing from ethnographic work he observes that, while government officials resist the spiritual beliefs of the Palawan community, “Palawan land- and resource-use decisions are based, in part, on social relations with an invisible realm of beings who make their will known through mediums or dreams” (Theriault 2017, 114). To reject and disregard the Palawan’s beliefs and world views, does nothing to disempower or

[57] FMT user Marley mentioned Gerson therapy and the Hoxsey method, both of which use dietary changes and herbal, vitamin, and mineral supplements as an alternative form of cancer treatment and have been heavily disadvised by established cancer treatment centres.

negate them (ibid). As he continues, “whether one ‘believes’ in invisible beings or not, the relational ethics those beings inspire have an impact on the world” (ibid, 25). Similarly, here, by figures of dominant microbiome science simply rejecting FMT’s association and relationship with alternative medicine, such beliefs do not go away. By attempting to remove all remnants of the alternative label from FMT, rather than disempower the term, it works to push patients further to the periphery and away from biomedical intervention’s capacity to intervene with pseudo-science and anti-science rhetoric. Despite attempts to dissociate the practice of FMT from an ‘alternative label’ it is still used in association with FMT by many patients and users and will continue to be while FMT users find meaning from it. Rejecting or dismissing patients’ experiences of FMT (that align with its alternative label) creates an exclusive politics of the microbiome that dismisses FMT users as producers of bodily knowledge.

Conclusion

This chapter has unpicked the hierarchical mode of knowledge production that I observed in the microbiome field. I first explored how the notion of ‘real’ science and scientists emerged during my time in the field pointing out how this concept employed a nature culture binary. Laying out the reproduction of colonialism and racism in microbiome research, I set out how this hierarchy both employs a violent politics of the microbiome and restricts other modes of knowing the microbiome that are sensitive to the role and emergence of oppressive power structures and systems. While it is important to encourage critical social sciences’ contribution to microbiome knowledge, critically reflecting on how the hierarchy prevents this from occurring, both in the natural and medical sciences as well as in the critical social sciences, is vitally important in moving forward.

The chapter then examined how this knowledge hierarchy implicates FMT users. Many FMT users found meaning in FMT’s alternative label and the rejection of such, along with interactions that produce mistrust in dominant medical science, can perpetuate FMT users’ being pushed to the periphery of medicine. However, the distinction between the centre and periphery is not clear-cut or does not exist in fixed or definitive processes that can be assigned to singular actors; rather, it is a complicated and messy process. Reflection on current practices that result in the dismissal of FMT users’ experiences and the wish to remove FMT’s association with an alternative label is needed. Specifically, within dominant medical science spaces,

there seems an urgent need to approach and take seriously the multiple onto-ethico-epistemologies of the body enacted by FMT users and other vulnerable patients.

Exposing the hierarchical modes of knowledge production that the natural and medical sciences encourage have long been the focus of academics in STS and FSS (Hilgartner et al. 2015, Jasanoff 2004, Stehr 2015). However, while these observations are not entirely new, the identification of such in the microbiome field is important as the field emerges and understandings of the microbiome become cemented. I proposed both a diversification in the voices that get to contribute to the making of microbial knowledge as well as extensive reflection on the onto-ethico-epistemologies that are mobilised in contemporary natural and medical research on the microbiome and FMT. The microbiome, as a relational rather than discrete being, requires a multitude of approaches, both from the natural and critical social sciences as well as alternative forms of producing bodily knowledge, to even attempt to reflect the diversity of it. The rest of the analysis chapters continue to develop this narrative arc that complicates the modernist constructions of microbiome knowledge and that reproduce a politics of exclusion via colonial and racializing forces. The next chapter specifically seeks to unpick how this politics of knowledge production is orientated to cement forms of epistemic and economic control.

Chapter Five: Drug, tissue, or organ? How do you solve a regulatory problem like the microbiome?

Attending a drug pricing panel discussion

Two months into my second field trip to Boston, I attended the panel discussion 'Drug pricing in the USA' hosted by the Harvard University biotech club. The panel was made up of four members: Marie, from an independent think tank; Paul, from a biotech hedge fund; Andre, CEO of a pharmaceutical company;

and, Dylan, a policy advisor. I was expecting the usual dry conversation between members in various roles within relevant industries and organisations. However, I, along with everyone else (including the moderator), were all happily surprised by a fiery discussion that felt more like a sports match than an academic panel discussion.

The panel started in a usual enough way, with each panel member answering the moderator's first question: "what is the greatest challenge to health care today?". Marie answered first, giving the very general and uncontroversial answer that "Americans are not getting enough return for the price that they are paying…we need to invest in primary care and infrastructure". Paul's answer roused the crowd as he evocatively stated that "we need to invest in more innovative drugs". He then went on to give a compelling mortgage vs rent analogy to explain why drug patents held by single companies are superior: he argued that obtaining a patent is like paying a mortgage for the drug because once the patent runs out, the free market will allow for more companies to replicate the drug and competition will drive the price down. Therefore, he argued that patents are an investment in the drug. He contrasted this to complex generic drug development, which describes the development of a drug that is bioequivalent to an already produced drug that has a complex active ingredient. As complex generic drugs have multiple investors producing very specific drugs, Paul argued that the innovation is not generalisable and without market exclusivity, the cost of these drugs will never go down, hence complex generic drugs represent paying rent. Paul then reasoned that because of this, "patents are necessary for investment – we need to pay a mortgage for more innovative drugs". Furthermore, he argued that "societies should make sure patients can afford them; they shouldn't have to second guess physicians". Andre agreed, suggesting that "the system does not allow for innovation for diseases, I agree we should have a social contract where medicines for today make drugs free for kids tomorrow." What stood out for me in this interaction was first Andre's homogenisation of society, who the 'we' or 'society' he was referring to were both never defined, and, similarly, that society should have to sacrifice financially for potentially cheaper drugs in the future.

Things began to heat up when Dylan introduced himself. Turning to the moderator he asked: "is it okay to use my slides?" The next five minutes or so consisted of scathing, pointed, and expertly articulated 'take downs' of innovation being prioritised over the patient's welfare. He questioned why innovation gets more expensive over time, stating that "it's only in health care that it is normal that innovation should become more expensive over time". He commanded the audience by obliterating the justification of drug pricing in the name of innovation. The response and directed opposition to the two figures that represent very easily dislikeable industries and professions, a pharmaceutical company, and a biotech hedge fund investor, was met with immense glee from the crowd, of whom some gave him a standing ovation at the end. From this point on there was an eager buzz to the discussion, the energy of which carried on through the panel discussion largely with Andre and Paul battling with Dylan about the real cost of innovation.

Another heated exchange took place in which the role of profit enabling innovation was discussed. Paul argued against co-pays (a fixed payment that the patient must pay before accessing insurance services) suggesting that "innovation is enabled because of patents; generic drugs should be invested in (rather than specialised drugs) …patients should not pay for innovation because it is the job of society to pay for it. There needs to be transparency; investment by society is conflated with the cost to the patient. Investment is a social cost, not what the patient should pay, and there's a lot for society to pay for". To which Dylan responded, "it's a lie that society should pay, (points to slide demonstrating the margins of profit for pharmaceutical companies) …if no one is making a killing then why are drugs so overpriced? We need to look at the entire drug industry, if the industry went non-profit it would not have to answer to its shareholders, making money or executives making money would not be the problem, it would be elsewhere. The real question is: would America like to meet the unmet needs of the country?" This statement led to another wave of excitement from the crowd, with people hooting, clapping, standing, and cheering.

However, as the panel went on, it became apparent that the good vs bad rhetoric that had initially been set out towards the beginning, with the pharmaceutical and biotech hedge fund characters as the 'baddies' and the

policy advisor as the 'goodie', began to fall short. This was demonstrated when Dylan, who had the crowd mostly on his side, lost some momentum when advocating for patients being told the price of drugs. As Paul cautioned, this could mean patients going for the cheapest rather than the most effective drug. The panel ended in an anticlimactic way with Paul monologuing about the important role that the biotech and pharmaceutical industries play in developing drugs and the need to prioritise innovation and competition in order to stimulate the market.

While I was watching the panel unfold into an increasingly heated and, at times, emotional debate, the impending complicated, emotive, and politicised regulatory scene that the microbiome via FMT, and its regulation as a biologic drug[58], was emphasised. My initial impulse to distinguish the policy advisor 'goodies' against the pharmaceutical and biotech 'baddies' exposed in me a commonly held wish to simplify and make more understandable an extremely complicated field and bureaucratic system. Although pharmaceutical companies and, to a degree, life science and biotech figures, are easily targeted as the 'baddies', we may do well to exercise caution when reaching for this familiar labelling because the lines between care and profit are messy, complicated, and sometimes integrated.

Social scientist Catherine Waldby's (2002) work demonstrates well the enfolded relationship between the life science and biotech industries disciplined through capitalist reproduction. As Waldby makes clear, biovalue is incentivised through the promise of being able to provide "some viable contribution to human health" through "an improvement in functioning and well-being" (2002, 310). The benefits and drawbacks of biomedical innovation are not clear cut. Innovation that enables improved drugs offers potential health benefits for patients. Yet the bureaucracy and complexity of the medical system, and drug development process specifically, exposes how important questions regarding bodily intervention are transformed and rerouted to technocratic managerial discussions about regulation. By reducing ethical questions to technical ones, ecological and bodily matters are made

[58] Biologic drugs are drugs that "have been isolated from a variety of natural sources" (FDA 2018d, np). Compared to other drugs, such as chemically synthesised drugs, "biologics are complex mixtures that are not easily identified or characterised" (ibid, np).

more readily available to (bio)capitalist accumulation strategies employed in the neoliberal networks of drug production. Such reflections demonstrate the puzzle pieces that this chapter seeks to address.

The following chapter first sets out the complex and turbulent process of defining the microbiome, pointing out the political motivations and implications that such processes have within the specific context of the US regulatory setting. The chapter goes on to discuss the minutiae of regulating the microbiome as a drug via FMT, the practicalities of what this regulation entails, and the relationality that is informed via such regulation. Here, I first critique the presentation of regulation as solely technical by pointing to the moral and ethical implications that regulation invokes. Second, I argue that biological drug regulation exposes a humanist onto-ethico-epistemology because the basis of FMT regulation hinges on distinguishing the microbiome *from* the human rather than taking seriously the human's *relationship* to it. I then explore the neoliberal entanglements associated with the pharmaceutical and biotechnological industries and point to the violent forces that the microbiome is exposed to while regulated as a biologic drug. Last, I explain why the regulatory path of Human Cells, Tissues and Cellular and Tissue-Based Products (HCT/Ps) is widely regarded as the best alternative, pointing to the potential it holds for informing a human-microbe relationality that encompasses and utilises the microbiomes' more-than-human traits as opposed to blunting them. The chapter then pushes for a move away from technical, managerial onto-ethico-epistemologies deployed in current regulatory paradigms towards a more nuanced, careful approach that takes seriously the ethical and political ecologies of the microbiome. Throughout, I expose how systemic, structural, and emergent (more-than) human forces shape human-microbe entanglements. I argue that an approach that attempts to distinguish the microbiome from the human informs an estranged human-centric, capitalist-orientated human-microbe relationality that views the microbiome as a discrete object.

The politics of defining the microbiome

What the microbiome is depends on who you ask. One of my favourite questions to ask my interview participants was how they understand, perceive, and think of the microbiome. Below are some answers that demonstrate well the variation in what the microbiome is understood as:

Earl, an FMT user

> I think, the microbiome-brain connection is everything, I think 97% of the serotonin in your body is in your gut, and they found that 99% of people that have OCD have these bacteria in their gut so, I mean I think the gut easily routed into our identity and sense of self, one's wellbeing and sense of being alive and happy and productive is not only intertwined but dependant on a healthy microbiome

Jinn, an academic

> I view it as a complex system on its own that influences human health and what I mean by human health, is in three ways, food digestion, immune system, and hormones, if we understand how the microbiome acts as a complex system, we can then understand and start to tie the microbiome into properties of human health.

Simon, an industry member

> It's a bundle of relations it's not itself an organ… essentially you need them [microbial life] to survive but that doesn't mean that they should be seen as an organ, they are a resident. You need air to live, do you call air an organ? So, I think it should be a drug. You can culture it and combine it for doses and this kind of thing. I would describe it [the microbiome] as a druggable capsule basically it's like a medicine cabinet but you would store it at a temp, for example, a lot of this probiotic stuff now you carry that everywhere, so nobody is saying that it is part of an organ.

The above quotes represent the vastly different views on what the microbiome is from the three representative groups that are the focus of this thesis: FMT users, representing a lay community of people practising a novel treatment that has only recently been introduced into dominant natural and medical science; academics who research the microbiome through classic channels of dominant knowledge production; and, finally, industry members, who are intimately involved in the workings of biotech and pharmaceutical companies. Their answers expose the vastly different understandings and interpretations of the microbiome, which broadly can be distinguished as either part of, or integrative to, the human (as Earl and Jinn's answers demonstrate), or as separate to and distinguished from the human, something akin to a drug (as Simon's answer indicates). Their answers demonstrate the Pertinent fact

that the microbiome is not understood as one thing; its identity is still emerging. Though some ontological placements are held by more powerful actants, these are ridden with uncertainties and conflicts.

How the microbiome is regulated represents a key moment in the stabilisation of its definition. However, regulating microbial life is a complicated and messy affair. As an ecologically-dependant multitude of microscopic organisms, the reductive practices and processes inherent in regulation pose a vast array of problems. Social theorist Christy Spackman (2018) explores this in her work on the regulation of kombucha, where she highlights the difficulties in regulating microbial life. She makes clear that the qualities that make kombucha attractive, namely its liveliness and hence unpredictability, are also what makes it unattractive to regulatory bodies. She continues that, the unpredictability of microbial life presents a "regulatory conundrum" that stems from the effects of kombucha being "dependent not only on product formulation or production methodology but also on the beholder" (2018, 51). Though kombucha is a food and not a drug, it exposes regulatory issues similar to those that are seen in the attempt to regulate FMT. As a multitude of lively relations, the "human's microbiome def[ies] any easy attempt at control, either environmentally [or]…chemically" and, as I go on to show, the microbiome exceeds any simple attempts at human modes of governance and regulation (Wolf-Meyer, 300).

FMT expresses specific complexities that exceed the current dominant medical paradigms and their associated modes of medical governance. As TJ, an Open Biome employee, explained to me: "it [the microbiome] is a square peg in a round hole, so I think you [regulatory bodies] need to figure out a new square hole". The regulatory terrain is complicated with no straightforward solutions, as Timal, another Open Biome employee, explains:

> At first, it seems really weird that there are bacteria living inside of you that can communicate with the brain and can affect your brain physiology but if you think of the microbiome as an organ, just a pretty weird organ, it is totally not surprising right? That one of your organs communicates with another of your organs ha-ha, in any case, the FDA… has concluded that FMT is a drug rather than a transplant. It's like human tissue or human excretion in one sense, and a kind of organ quote on quote, but it is not primarily human tissue in the sense that it is not homo sapiens cells, it's like bacterial cells, right? It's definitely a place where like science and medicine have discovered

> something new that doesn't fit in the old framework, so whatever, the FDA has decided to put it into this 'drug' box.

What Timal and TJ demonstrate here is that regulatory bodies have a powerful role in defining the microbiome. Such definitions also have a considerable part in determining the human's relationship to the microbiome. Not only are these regulatory decisions contentious and political, but, inspired by the important work of feminist philosopher of science Karen Barad, we may also begin to see the way that they generate differing 'onto-ethico-epistemologies' of both the human and nonhuman (Barad, 2007). To further borrow from Barad (2007), the definition of the microbiome in regulation can be witnessed as part of the process of an agential cut.

Agential cuts can be understood as the "specific material-discursive[59] intra-actions through which particular boundaries and properties of 'entities', including of one's identities, are produced and become meaningful" (Corlett and Williams 2016, 2). As Barad explains,

> Cartesian cuts are undone. Agential cuts, by contrast, do not mark some absolute separation but a cutting together/apart – a 'holding together' of the disparate itself… Agential cuts – intra-actions – don't produce (absolute) separation, they engage in agential separability – differentiating and entangling (that's one move, not successive processes). Agential cuts radically rework relations of joining and disjoining (2010, 265).

Intra-acting, as compared to interacting, problematises the ontological separability of events, phenomena, and materiality. As she explains,

> Distinct entities, agencies, events do not precede, but rather emerge from/through their intra action. 'Distinct' agencies are only distinct in a relational, not an absolute sense, that is, agencies are only distinct in relation to their mutual entanglement; they don't exist as individual elements (2010; 267).

[59] A concept that "emphasises the entangled inseparability of discourse and materiality" (Orlikowski and Scott 2014, 4)

Agential cuts, then, do not represent moments of complete estrangement. Instead, they denote moments where boundaries are informed and reproduced. They also represent a space where common understandings and identities are reinforced.

The boundary forming induced via regulation exposes a means by which scientific knowledge is animated in world-making. Researching the role of regulation and science in the process of agential cuts has been performed by a number of researchers in the STS and FSS vein of the critical social sciences. Sociologist Myra Hird (2013, 31), for example, looks at "the myriad agential cuts that make waste a phenomenon (including the various political affiliations that attend these cuts)". She does so by examining the science and engineering research that determines the boundaries of waste via regulation, by, for example, determining the "thresholds of 'acceptable' chemical toxicity in groundwater" (ibid, 30). Similarly, sociologist Madeleine Pape explores and critiques the regulatory and policymaking practices that determine "sex as a biological variable in animal research" (2021, 275). Following on from Barad, Pape observes regulatory practice as materially discursive as it "necessarily engages diverse material entities and has material effects in the world, calling for new modes of sociological response-ability" (ibid, 277). Pape explores "the boundary-drawing efforts implicated in policymaking as a means to investigate where and how 'the world kicks back" (Barad, 2007, 215 in Pape 2021 279). Following both Hird (2013) and Pape (2021), I unpick how the materially discursive modes of regulating the microbiome are both shaped by and are generative in shaping a politics of the microbiome. I explore FMT regulation as a mode by which a relationality and entanglement with the microbiome is established legislatively, specifically delving into how regulation shapes what, and how FMT is understood, who has access to FMT, and what the future of FMT is.

As a mode by which to examine the regulatory iterations and boundary forming of the microbiome, the following chapter performs a political ecology of how an entangled microbiome is stabilising in governance regimes. The regulation of the microbiome is fiercely political and susceptible to broader power dynamics due to the ontological complexity that it poses to current medical paradigms of the body and its relationship to the more-than-human. A key focus of political ecology is on the structural and systemic rationalisations, which stress the "importance of social position[s], and the unevenness of power, in the composition of material ecologies" (Hayes-Conroy and Hayes-Conroy 2013, 81). While a political ecology approach is

usually employed at a macro scale to observe “how decisions to transform the natural environment are…produced by political and economic systems operating across multiple scales” (King 2010, 39), I take insight from authors who apply a political ecology approach to the body (Hayes-Conroy and Hayes-Conroy 2013, Hayes-Conroy and Hayes-Conroy 2015) and specifically, health (King 2010) and disease (Hanchette 2008, King 2015, Oppong and Kalipeni 2005, Turshen 1977). These scholars regard the body as a site where multiple entangled social, economic, and political forces emerge. Taking inspiration from such scholars, the chapter aims to set out “how unequal power structures and knowledge production reproduce” (Allen 2020, 79) human-microbe relations via the attempted regulation of FMT. In doing so, the chapter presents a political ecology by exploring how the microbiome is defined via FMT regulation as an important moment in the agential cutting and boundary forming of the microbiome.

Regulating FMT as a drug

The difficulties in governing microbial life via FMT is demonstrated by the patchwork regulation found internationally. Currently, recurrent *C. diff* infection (rCDI) is the only procedure that FMT is being regulated for in standard medical practice on an international scale (Khoruts et al. 2019, Sachs and Edelstein 2015, Scheeler 2019). All other conditions that FMT is being considered for require the patient to be part of a clinical trial (Scheeler 2019). There are broadly four core regulatory routes through which FMT is delimited internationally: (1) FMT as a medical product (employed in Norway and the United Kingdom), (2) a practice of medicine (currently employed in Ireland), (3) a biologic drug (employed in the US and Canada) and, (4) as a human cell or tissue product (employed in Belgium and Italy) (Scheeler 2019). While each regulatory praxis sets out different implications for access to FMT, it hence informs different entanglements and relationalities with microbial life. This chapter focuses on the tensions between regulating FMT for rCDI as either a Human Cell or Tissue Product HCT/P or as a biologic drug because this debate was the most prominent one during my time in the field and in online debates.

Within America, the Food and Drug Administration (FDA) are responsible for the regulation for FMT. As a federal agency, “the FDA is responsible for protecting the public health by ensuring the safety, efficacy, and security of”, among other things, “human…drugs, biological products, [and] medical devices” (FDA.com n.d., np). As

“faecal microbiota meets the statutory definitions for both a drug and a biological product”, the FDA are leading the regulatory conundrums that the microbiome and FMT pose (Sachs and Edelstein 2015, 398) . The development of FMT regulation by the FDA has been tumultuous and remains complicated. In 2013, the FDA labelled FMT as an Investigational New Drug (IND) as FMT’s effectiveness had not been proven in a controlled clinical trial setting. Patients would only be treated with FMT for conditions of recurrent *C. diff* in clinical trials, reducing access to the treatment dramatically. This decision was met with an outcry from the medical, scientific and patient community, which led the decision to be revoked two months later and changed to give FMT enforcement discretion, meaning that FMT could be used where “*C. difficile* infection [is] not responding to standard therapies” (Sachs and Edelstein 2015, 401). Further proposals were made in March 2014 wherein

> The FDA proposed revising the enforcement discretion policy to require that the stool donor be ‘known’ to either the patient or the physician and to require that all donor and stool screening be conducted with oversight from the physician performing the FMT (ibid, 532).

This change in regulation would have prevented Open Biome operating and was successfully opposed by patients and medical professionals who pointed to the complications this could cause for patient access to donation material. In 2016, the FDA published additional guidance overruling the proposal offered in March 2014 for public comment only, which

> Proposed that physicians using material from public stool banks to treat rCDI must do so under an IND. The FDA actively sought feedback on how to implement this proposal so that it would not be excessively burdensome for physicians. The public comment period for that proposal ended in May 2016, and there has been no further draft guidance or finalised guidance released (Scheeler 2019, 532).

For the time being, the FDA has given FMT the “yellow light” (ibid, 532). Until a drug is approved by the FDA, FMT is being treated as an unapproved biologic drug with special enforcement discretion and regulatory leeway for rCDI (Scheeler 2019, 396). This has left FMT in what an interviewee at Open Biome described as “novel regulatory

purgatory" and has led to scrutiny of the FDA for both over and under regulating the procedure (Khoruts et al. 2019).

As a biologic drug, what protocols will FMT need to go through to be developed into a marketable drug? Perhaps most notably, regulating FMT as a drug means that FMT products will have to complete the notoriously complicated and costly drug development process to be approved by the FDA. This process usually starts with the discovery of a new molecular compound that has the potential to become a drug (FDA 2018a), or, in the case of FMT, the discovery of an ecology of single-celled organisms that can be utilised to achieve a set of desirable functions. These new potential drugs then need to undergo preclinical research, file for Investigational New Drug (IND) status, and complete various pathways in order to receive approval from the FDA and continue on to clinical trials (Norman 2016, 176, see also FDA 2018b).

After these pathways are complete, the drug development process moves on to clinical research, which encompasses four phases of clinical trials done on humans (FDA 2018c). The first phase, Phase 0, is the primary trial and "first-in-man use of a proposed drug therapy" (Norman 2016, 174). The main aim of Phase 0 trials is to test the safety of the therapy to see if further research needs to be performed before progressing to Phase 1 trials. This is done by testing the therapeutic on a very small group of people (between 10-15) to see whether the therapy is dangerous in even low doses (ibid). Phase 1 trial objectives "are to provide initial safety evaluation, determine safe dosing ranges, and identify common side effects and the toxicity profile of the drug" (ibid, 175-176). Following a successful Phase 1 trial, "single and multiple ascending-dose trials" will then be completed, known as Phase 1a and Phase 1b trials (ibid, 176). Phase 1a aims to find the upper limits of the drug dose before adverse effects emerge. Phase 1b observes "what the body does to the drug" by examining bodily fluids under differing drug concentrations (Mehrotra et al. 2007, 254). Phase 2 trials continue "to investigate the efficacy of the drug while also establishing safety" (Norman 2016, 176). Phase 3 intends to confirm the safety, "evaluate effectiveness, monitor side effects, and compare the drug with commonly used alternative treatments" (ibid, 176). The last phase, Phase 4, aims to further explore the safety and efficacy of the drug. Once all four phases are complete, the "clinical data… drug samples… product facilities and… proposed labelling" will be sent to the FDA reviewers to evaluate and analyse (ibid, 176). If the review is accepted the manufacturer can begin making and marketing the approved drug. It is worth noting

that this drug development process values – and even requires – uniform and repeatable results throughout each phase, something that is at odds with the vast ecological multiplicity and variation of the microbiome between human populations and within individuals.[60]

The development of the microbiome within FMT as a drug has two distinct paradigms – "the complete community… [and] well- defined consortia" models (Khrouts et al 2019, 450). The first route, respectively, more accurately represents FMT as a procedure or "the fundamental FMT paradigm" (ibid,485). A complete community model aims "to deliver the complete and healthy intestinal microbiota into the colon to achieve a donor-like normalisation in the intestinal microbial community structure of the recipient" (ibid, 485). The 'defined consortia' model, however, aims "to develop consortia of extremely well-characterised cultivated microbial strains, which are intended to deliver specific beneficial functionalities for a target disease" (ibid, 485). The latter is the most attractive in regulatory terms as it "conforms to typical drug requirements like batch uniformity" (Scheeler 2019, 525).

In 2019, there were four "stool-based products for prevention or treatment of rCDI unresponsive to standard antibiotic therapy that [were]… in the clinical trial phase of the IND process" (Khoruts et al. 2019, 486). As of 19th of January 2022, Seres Therapeutics[61] has announced the completion of Phase 3 trials for the drug "SER-109", which

> Is an oral microbiome therapeutic candidate consisting of a consortium of highly purified Firmicutes spores, which normally live in a healthy microbiome. SER-109 is designed to prevent further recurrences of CDI by modulating the disrupted microbiome to a state that resists *C. difficile* colonisation and growth (Seres Therapeutics 2022, np).

Other companies are similarly making their way through the drug development process. In 2021 Rebiotix "announced positive results from a phase 3 trial of its recurrent *C. difficile* treatment, a filtered stool product delivered as an enema" (Servick 2022, np, see also BioSpace 2021). Similarly, Finch Therapeutics and Vedanta

[60] As is well recognised, the microbiome changes dramatically throughout a human's lifetime (Cho and Blaser 2012, Jašarević 2016, Koren 2012, Mehta 2018)
[61] A US-based biotechnological company.

Biosciences both completed Phase 2 trials in 2021 for a freeze-dried stool pill and a bacterial strain therapy respectively (GlobeNewsWire 2021, Servick 2022).

The political decision by the FDA to regulate FMT as a biologic drug has wide-reaching implications for human-microbe entanglement and relationality because of the role that regulation has in dictating access to FMT. FMT as a biologic drug imposes lots of regulations with very restricted access (Scheeler 2019, 527). Restricted access to FMT has largely been justified due to safety concerns over FMT as a procedure, with a considerable representation of microbiome-related industry members and academics supporting the replacement of FMT as a procedure with a drug. Those that support regulating the microbiome as a biologic drug do so under the guise that the variability of stool material presents too many risks (Ossorio and Zhou 2019). Ossorio and Zhou argue "that if stool composition is dynamic and difficult to characterise, then a minimally manipulated stool product for allogeneic transplant is possibly the most dangerous type of microbial product for a recipient" (2019,106). They continue that: "stool from a symptomatic donor is more likely to contain novel or uncharacterised viruses, bacteria, or protozoa that could be pathogenic, particularly for an already sick recipient" (ibid, 106). Instead, they support the development of an FMT consortium drug over "a minimally manipulated stool product" (ibid, 106). In other work (where they have declared personal fees from Genentech-Roche[62] (Eisenstein 2020), they argue that there is not enough evidence to suggest that FMT is successful in treating rCDI due to there not being enough clinical data to support this claim (2019). They argue that current regulation is prohibiting stool-derived products from being made because raw stool material is still allowed for procedures, and patenting of raw stool is near impossible. To prevent this, they suggest forcing FMT users to use trials instead of DIY methods by making FMT donation material inaccessible and requiring patents for clinical trials on consortium drugs (ibid).

Important here is that the variability of the microbiome is framed solely as a risk. Though patient safety is, of course, an important concern, to assume that such risks require that FMT be regulated as a drug engineers FMT as a technical and logistical problem to be solved. This, as I go on to show, overshadows other important moral and ethical implications that also occur as a result of FMT's regulation, such as patient

[62] As Genentech-Roche are a pharmaceutical company who have various investments in microbiome start-ups, this puts their intentions for encouraging the replacement of FMT as a procedure with a drug into question as they are set to benefit from this decision (https://microbiotica.com/partnering/).

access, the future of FMT and how we understand the microbiome. Some have already questioned the ethical implications of FMT, calling into question a patient's ability to give informed consent for a procedure which is not well understood, relatively new, and very high risk (Grigoryan et al. 2020), while others have commented on the ethical dilemmas of patient access to the procedure (Grigoryan et al. 2020, Scheeler 2019). These accounts have a considerable focus on the technicalities and processes of FMT regulation, as opposed to the ethical and moral debates regarding both the specificities of the FMT patient population and how we come to understand and relate to the microbiome as an ecology of relations rather than an object or technical process. Such debates are the focus of the rest of this chapter, specifically in thinking about how regulating FMT as a biological drug entangles the microbiome in neoliberal networks, the human-microbe relationality that biologic drug regulation informs, and the significance of the FDA choosing drug regulation as its chief interactive modality rather than perhaps more appropriate alternatives, which are used elsewhere in the world.

Neoliberal entanglements via biologic drug regulation

Biological drug regulation materially entangles the microbiome into neoliberal networks because the production of an FMT drug emerges via biotechnological companies. While there are many conflicting approaches to neoliberalism, a critical geographic approach understands neoliberalism as an economic ideology that upholds "the utopian idealism of free-market narratives and the chequered, uneven, and variegated realities of those governing schemes and restructuring programs variously enacted in the name of competition, choice, freedom, and efficiency" (Peck et al. 2018, 3). Much work in the social sciences has been done to unpick the close relationship between the biotechnological industries and discourses and practices of neoliberalism (Birch 2006, Cooper 2011, Rajan 2012). Importantly, as social and political scientist Melinda Cooper (2011) makes clear, the 'neoliberal revolution' and its attempts to reform America's economy was crucial in establishing the 'biotech revolution'. The legislative and ideological functions imparted by Reagan's neoliberal economics (Cooper 2011) have been formative in shaping the international biotechnological industries we see today as they seek to enclose the capabilities of manufacturing life (Prouse 2021). Or, as Cooper succinctly explains, as a "result of a whole series of legislative and regulatory measures designed to relocate economic

production at the genetic, microbial, and cellular level… life becomes, literally, annexed within capitalist processes of accumulation" (2011, 19). Thus, FMT conceptualised as a drug emerges through the framing of biotechnological industries that materially produce the microbiome as a commodity able to be enclosed within the free market. It is to this neoliberal ideological embedding that I now turn.

A notable expression of the microbiome being annexed into capitalist processes of accumulation is via the enclosing and privatising practices of patents. Patents act as "variable code source[s] from which innumerable life forms can be generated" (Cooper 2011, 24). Hence, a patent's value comes not from rights to knowledge, but from the product which the knowledge describes. As Hilgartner expresses, "knowledge is made in the laboratory; property is secured in the worlds of law and commerce" (Hilgartner 2004, 131). While patents are a core component of biotech ecology, protecting companies from the billions of dollars of investment that are required in the drug discovery process (Thumm 2004)[63] they have been heavily critiqued (Haraway 1997, Murray and Stern 2006, Prudham 2007, Thumm 2004). Particular scrutiny has been applied to how patents privatise knowledge through the manufacturing of knowledge "as exclusive, alienable, and [as a] saleable property" (Prudham 2007, 412). Such conceptual and material advances

> Are critical junctures in the creation and value augmentation of the capacity for capital… to circulate in and through biophysical nature, propelled by the value expanding tendencies of generalised and specifically capitalist commodity circulation (ibid, 412).

Facilitating the privatisation and exclusivity of knowledge consequently prohibits the sharing of expertise and information. Hence, patenting enables the production of "private knowledge monopolies" (Birch et al. 2018, 599). This was witnessed in the field as I struggled to gain access to members in biotech industries that would not speak to me due to very strict IP policies adopted by their biotech employers due to

[63] It is incredibly costly and difficult to complete all phases of the drug development process, with only 10% of applicants completing all phases and achieving drug approval (Norman 2016). The exact cost of developing a new drug is debatable, Norman (2016) estimated that in 2003 to complete Phases 0 and 1 took two and a half years to complete and cost $15.2 million, Phase 2 took two years and cost $2.4 million and Phase 3 took three and a half years and cost $86.5 million. Wouters et al (2020) however, estimate that between 2009-2018, the mean cost of developing a new drug came to between $314 million to $2.8 billion.

patent concerns. Similarly, at the Translational Microbiome Conference, during a talk on 'patents and the microbiome,' the speaker relayed that

> There isn't a patent on the microbiome yet, we are in the formative stages, companies are playing nicely until the industry develops. We are all part of the same crowd with the same resources at this point. The potential is huge, but no one's cashed in yet, that's when you will see the patents flying.

Implied in this interaction is that the discovery of patentable knowledge regarding the microbiome will initiate the beginning of perhaps more hostile interactions and restricted or exclusive access to resources.[64] During my time in the field at conferences, talks, and networking events, it was often communicated that to solve the problem of the microbiome, the field must be interdisciplinary.[65] Noticeably, then, patents pose potentially significant barriers to achieving greater understanding of the microbiome as they restrict the sharing of research and microbiome knowledge.

The detrimental role that knowledge monopolies have is particularly relevant to FMT. For instance, the Seres Therapeutics FMT drug SER-109 has been granted Orphan Drug status within the US when used as a treatment for *C. diff*. The Orphan Drug Act (1983) was formulated in the US to incentivise the production of drugs that targeted rare (under 200,000 patients) diseases specifically (Tabarrok 2001). Orphan drug status allows for "monopolistic market position" (Villa et al. 2009, 34) as laws allow bringing together opportunistic incentives, such as, "tax breaks, subsidies, and (most importantly) seven years of market exclusivity to sponsor drugs for rare diseases" (Tabarrok 2001, 10). These factors combine to enable pharmaceutical companies to spend less on processes such as research and development (R&D), whilst simultaneously accruing profit from high prices. Such monopolies put access to FMT at risk due to the potential cost of the drug produced. As TJ, an Open Biome employee, communicated to me during an interview,

[64] Interestingly during my time in the field, the biotech industry was often referred to as an ecology, which seems an inappropriate metaphor considering the rejection of ecological functions that patents applications call for.
[65] Although, as discussed in the previous chapter, this interdisciplinarity never alluded to the social sciences.

> I think a lot of it will depend on the order and the number of products that hit the market. If only one gets approved, well, now. You've got a monopoly, market exclusivity. If a few breakthrough at around the same time, I think it will hopefully keep prices a little bit more reasonable, I think that's really a very legitimate concern for the field. Part of the reason prices are going to be high, or go up, you know all the corporate greed or profit maximising or whatever you want to call it, part of it is that by making it a drug they are requiring it to be expensive because clinical trials need returns, there's no other way around. Unlike the Gates Foundation, which just isn't how the medical field works, you're going to end up with the requirement to price fairly high even if you have well-intentioned executives of the company and I think that's also a very different outcome than if it were regulated by like a tissue.

TJ raises important points regarding the inevitability of high prices of an FMT drug due to the systemic restrictions associated with the immense cost of the drug development process as opposed to other forms of regulation. Since this interview took place, the Seres drug SER-109 has a likely chance of being approved with orphan drug status.[66] Due to the exclusivity granted to orphan drugs this "will essentially prevent other manufacturers from receiving approval of the same drug for the same disease or condition until seven years from the date of the first applicant's approval" (Khoruts et al. 2019, 495). As the production of an FMT drug holds the possibility of preventing the procedure of FMT to continue (ibid), the monopoly associated with Orphan Drug status poses a significant risk of reduced access of FMT patients due to increased costs. This is especially important to consider as many FMT users are in precarious employment or are in vulnerable situations due to their conditions.[67] Many FMT users that I spoke with were in unstable employment with no access to medical insurance.

Beyond the material neoliberal mechanisms and practicalities that keep the biotech industry going, a culture of neoliberal ideology plays a formative role in the emergence of the microbiome in and through the biotech world. A pertinent example of this is how time is constructed through neoliberalism. As an ideology, neoliberalism encourages a particular "understanding and experience of time" (Strzelecka 2021, 3). "The neoliberal transmutation of time" (Harvey, 2010: 37–38) produces time as a commodifiable good, as a valuable asset. Time is money, to "be distributed, used, or

[66] SER-109 only has to complete Phase 4 trials and undergo review "from the FDA in" order to complete "the drug development process" (Seres Therapeutics Inc. nd, 8).
[67] The politics of the microbiome and FMT user precarity is discussed in Chapter Six.

stored" (Strzelecka 2021, 3). Due to the "malaise of acceleration", neoliberalism fosters a "culture of urgency" (Sugarman and Thrift 2020, 807). Taking more time to research and produce a product, method, or technology, for example, is synonymous with increased spending. Therefore, reducing the amount of time, and, hence, money spent is advantageous. This sense of urgency was witnessed in a particularly potent way during a panel discussion at the Translational Microbiome Conference. Sharon, a biotech investor, was part of the panel discussing reference standards for microbiome research. She explained,

> I'm, we're, looking for companies that will deliver products, companies that come with product sequencing efforts and preferably have a platform. When they are at the investment stage, we need to know, how strong is the data? We need to know before we put in millions to take it to market. To get a product out, to have success, the questions that concern me, I'm paranoid about the quality of the data. Beautiful news to industry if we have standards. We must have standardisation.

Harry, an industry member and interview participant[68], then questioned Sharon about the rush for standardisation, highlighting his fears and concerns about what gets missed out when speed over accuracy is prioritised in deciphering standards, as he explained,

> Standardising is important…yet there are significant risks that we standardise and make comprehendible results, but these results [standards] are all equally inaccurate. We must be aware of the limitations of standardisation trying to push too far and too quick…no matter how much we standardise workflow there are also inherent complications with the possibility of missing bacterias by standardising, different clustering algorithms, and different results. If we are assuming NGS[69] is ground truth I think we're making a mistake, and 16s[70] can't give you enough, I think we need to be honest…were dealing with a system with so much variance no matter how much we

[68] I interviewed Harry, an industry member, after this interaction because of his hesitant approach to rushing standardisation, which materialised as the less popular opinion in the room.
[69] Next Generation Sequencing (NGS) is a metagenomic sequencing technology that "determine[es] the sequence of DNA or RNA to study genetic variation associated with diseases or other biological phenomena" (ThermoFisher Scientific ND, NP).
[70] 16s is a sequencing "method for studying bacterial phylogeny and taxonomy" (Eurofin 2022, NP). It offers a "way to profile the bacterial make-up of a microbiome" by revealing "which genus is present and in what relative quantity", however, it does not "tell you which species are present, what their function is, and will likely miss low abundance bacteria and viruses/fungi" (Maurer 2022, np).

> standardise – are we getting the right answers for those situations? We need a paradigm shift in sequencing, what we have is good but we need to move to absolute abundance.

To which Sharon replied,

> I take your point, but you can't always say something is imperfect, there has to be some framework, there has to be standardisation and it needs to be now. Going on towards absolute abundance, it's impossible.

Standardising is a crucial process within the scientific method. As Callum Karn explained to me when discussing the politics of standardising the microbiome, "when you have standardised procedures...it's easy to compare the results between different projects and integrate them into a single analysis". Standards allow for consistency within and comparisons between data sets. However, as Harry points out, in rushing for standards there are also risks that the standards chosen are not the most appropriate leading one to question, what might get overlooked when there is not enough time?

The application of other models and approaches was also suggested as a mode of figuring out the microbiome more quickly. Later on, in my interview with Callum Karn, he relayed how he had witnessed some regulatory boards trying to apply standardising models from the Human Genome Project (HGP) to the microbiome. As he explained,

> There was a meeting in 2008 where the sequencing centres were basically talking about how they were going to characterise the core human microbiome and I showed work done just looking at what happens when you plot the number of subjects vs the number of sequences that were found in that number of subjects just showing that all sequences we found were unique to 1 subject and then it tailed off very rapidly. So, by the time you got to 50 subjects very few of those sequences were found in that many people and by the time you got down to 10 it was none. And that was not well received and in fact, they completely ignored it and acted as if the data didn't exist.

Here, Callum makes clear that, in some spaces of microbiome research, the search for standards uses models that are potentially inappropriate for microbiome diversity.

As he suggests, the appeal of a core microbiome is attractive because it puts aside the vast complexity and unpredictability that microbiome diversity poses. Callum did not explicitly reference urgency in these decisions related to trying to characterise a core microbiome, however, replicating standards would inherently be more convenient and shorten timelines.

Similar suggestions were mentioned at conferences that I attended where approaches and techniques that were used in genome research were suggested to be applied to the microbiome. At the Translational Microbiome Conference, a presenter pushed back on such a suggestion, pointing out that, though in the past applying other models to new contexts has been fruitful, the microbiome is too different to apply genetic approaches. Inherent in these impulses to apply other methods is that there is not enough time nor money to formulate bespoke standardisation that pays attention to the specific nuances that distinguish the entwined and multiple characteristics that are unique to the microbiome.

The neoliberal networks that entangle the microbiome via biological drug regulation work to compress it into a discrete object. While there may be other benefits that stem from a quick turnaround in deciding on the standards for the industry including the faster production of microbiome-related products and good quality data, both Sharon's distinct sense of urgency as a biotech investor and the sequencing centres' wish to replicate methods from the Human Genome Project require critical consideration. Similarly to regulatory debates, both moments contribute to processes of agential cutting and boundary forming of the microbiome and FMT and do so through a culture of urgency (Strzelecka 2021). This is not to suggest that standardisation should be slow, but rather, as Harry suggested, it is important to spend time considering how processes of standardisation get decided and by who. Adequate time is needed in order not to lose or overlook important methods, processes, or specific details. However, thinking back to Harvey's "neoliberal transmutation of time" (2007, 37-38), where time becomes a commodifiable good, we see how material, discursive, and conceptual neoliberal entanglements generate the microbiome's agential cutting and boundary forming. By rushing to standardise or characterise the microbiome by recycling the same characterisation methods as the Human Genome Project, the specificity of the microbiome and the inherent traits that distinguish it from the genome are overlooked. This contributes to the production of a discrete microbiome as an object devoid of unique and important qualities. Hence, currently,

FMT regulation as a biological drug within the US, and as emergent through biotechnological companies, renders the microbiome privatisable. Enclosure practices like patenting, together with neoliberal ideologies that prioritise urgency as a demand of regulation, preclude and prevent alternative conceptual possibilities and practices for the microbiome, even whilst these same processes also call for inter-disciplinary understanding and widening of the scope of therapeutic intervention.

FMT as Human cells, tissues, cellular, and tissue-based products (HCT/Ps)

What makes the political decisions of the FDA particularly salient is that an alternative mode of regulation is possible and is being implemented elsewhere in the world. Within America, there is burgeoning disagreement to the FMT-as-drug classification due to questions around drug regulations' appropriateness and suitability for the microbiome. Some have argued that this variability also inhibits the ability to either scientifically or economically fully characterise the microbiome (Khoruts et al. 2019, Scheeler 2019). Foremost, the huge variety in, and autonomy of, the microbial ecologies used in FMT present considerable resistance to the possibility of maintaining batch conformity and reproducible results. Put another way, the microbiome does not behave in a way that is conducive to drug regulation. Or as one research participant at a conference told me, "to put it simply, it's because it [the microbiome] isn't a drug… that's why people are so caught up about it [FMT regulation]".

The other dominant, and, as some argue, more fitting mode of regulation is via Human Cell and Tissue-Based Products (HCT/Ps) (Sachs and Edelstein 2015, Scheeler 2019). Items regulated using this paradigm include, "human cells or tissues that are intended for implantation, transplantation, infusion, or transfer into a human recipient, a group that includes bones, ligaments, skin, and cord blood" (Sachs and Edelstein 2015, 409). This regulation would implicate FMT within what has been referred to as "Process-Focused Regulation" (Scheeler 2019, 528). While there are universal rules for HCT/Ps regarding the manufacturing process, other factors such as market authorisation and the use of clinical outcome data in such authorisation vary from item to item (ibid). Hence, to a degree, HCT/P allows for item specificity in informing how it is processed and regulated (ibid).

Significantly, adopting an HCT/P regulatory model would avoid entangling the microbiome into damaging neoliberal networks of privatisation that enclose and distort it once a drug is made, restricting access to FMT. Under HCT/P regulation, the FDA

would allow for FMT to be accessed for *C. diff*, and for other conditions, an IND would be required. Hence *C. diff* patients would still have access to FMT stool, while also allowing for research on new potential applications of FMT (Sachs and Edelstein 2015). Thus, although HCT/P could still be critiqued as a form of enclosure, as any form of regulation requires coercion of biologic material as a means to human ends, it also offers an improved relationality than that imposed by biologic drug regulation. HCT/P regulation could inform a politics that is underpinned by wanting to utilise and work with the nonhumanness of the microbiome.

As HCT/P allows for variation, regulating the microbiome through it also provides the opportunity to utilise its unique qualities of multiplicity. This method of regulation would still allow for FMT to be used in its raw state and for more varied uses, as Scheeler explains, HCT/P "permits robust oversight of donor screening, preparation, storage, and handling of stool treatments, while also allowing for the collection of comprehensive safety data and flexibility in indication use" (Scheeler 2019, 529). While there is resistance to keeping FMT as a procedure available after a drug is made, others believe that as a procedure, FMT has many more applications and uses. This position was communicated to me during a conversation with Lara (a PhD student supervised by a prominent microbiome researcher) at the Translational Microbiome Conference.

> I used to think that once a drug had been discovered that it would replace FMT as a procedure, but I've since gone back on that decision…it's not an open-and-shut case…there are so many potential indications that FMT can be used for, it would be a waste to only use it as one thing and not explore those other possibilities.

HCT/P exemplifies a mode of regulation that would utilise the microbiome's ecological diversity, encompassing the other possibilities of FMT. While many have argued HCT/P regulation would enable both better access and more diverse use of the treatment, by incorporating the nuances of the microbiome, a more conducive understanding of the nonhuman arises, one that is attentive to the "irreducible multiplicity" (Haraway 2008, 334) of the microbiome instead of coercing it into reductive and stringent models. As Scheeler confirms,

> The HCT/P classification adapts oversight to maximise safety while acknowledging that human-derived products are not produced in a lab, and therefore defy some typical drug requirements like batch uniformity (2019, 525).

Applying HCT/P to the microbiome requires a legislative shift in the US in what gets to count as a human tissue or cell. Regulating FMT as a drug, medical "product, or practice of medicine" does so because the microbiome is made from nonhuman cells and hence is not observed as part of the human (Scheeler 2019, 527). The application of HCT/P is largely resisted as nonhuman bacteria does not fall under the classification of a human cell or tissue product (Scheeler 2019). In contrast to the US, Belgium has been heralded for its regulation of FMT. Although this project did not perform any research in Belgium, as a country they have employed novel and noteworthy regulation for FMT. In 2015 the Superior Health Council (SHC) issued a report requesting that the Federal Agency for Medicines and Health Products (FAMHP) observe faecal matter "as human body material, the equivalent of a human cell or tissue-based product" and regulate FMT under HCT/P (Scheeler 2019, 533). The FAMHP agreed to do so, but what is notable about this example is that to champion the SHC's recommendations the FAMPH had to change "the 2008 law defining human body material, which specifically excludes stool" (ibid, 533). Belgium, then, represents the possibility of changing regulation in line with appropriate members' advice to make the regulation more fitting by changing their definitions of what gets to count as a human cell or tissue. Legislative recognition of the nonhuman microbiome as *part of*, and *integral* to the human, would work to complicate humanist conceptions of an individual and autonomous human. Scheeler similarly argues for "HCT/P to allow for the inclusion of stool, and specifically the bacteria within stool", continuing that "this proposed shift is grounded in changing societal and scientific understanding of human-to-other boundaries" (Scheeler 2019, 536). Citing Belgium as an example of altering regulation to make it more fitting to the nuances of the microbiome, she makes clear that optimistic public health outcomes can occur when relevant members are invested in challenging "calcified definitions" (ibid, 537). Hence, HCT/P regulation of FMT would be informed through the relationship that the microbiome has with what the human can *become* as opposed to outdated and strict understandings of what the human *is*.

What kind of politics does biological drug regulation inform?

There are, of course, benefits for patients if FMT becomes a drug. Many have noted that the procedure of FMT, which involves using human stool, is unpleasant. As an industry member, Rhianna conveyed "the microbiome isn't exactly palatable". While many FMT users that I spoke with did not have a problem with the intimacy required for the procedure[71] others felt scared and unqualified to undergo the procedure without medical oversight. Making FMT into a drug would make the procedure more accessible in terms of the ease of taking a pill as opposed to undergoing the intimate, and for many, unpleasant, procedure of FMT. Relatedly, within an American context depending on medical insurance access[72], FMT as a biological drug would be more accessible, for some, as the drug would be able to be billed via medical insurance. Currently, while some of the medical instruments used for the procedure can be claimed on insurance, the costliest part of the procedure – the donation material – is not billable. Within the UK, a drug would be more readily available due to socialised health care. This is significant as – by way of reference to the financial burden of FMT – the Taymount Clinic FMT programme costs £3968 (Taymount Clinic 2022a).

A mechanism that would allow for the increased access to FMT as a drug, is via the use of 'off-label prescription'. Off-label prescription describes the practice of prescribing a drug outside of the condition it has been approved for. This is allowed to happen if the physician has just reason or cause to believe the drug could be beneficial to the patient and is already a common practice in America. Although the FDA could provide regulation to prevent certain off-label prescriptions for a "multitude of non-CDI (*Clostridium difficile* infection) conditions", this is unlikely to occur due to the huge amount of the population that suffer from gut-related conditions (Khoruts et al. 2019, 499). A key concern shared by many in the microbiome field, including those at Open Biome, is the inevitable loss of potentially important data concerning the effects and success of using an FMT drug for additional illnesses and disorders. As the following excerpt from TJ, an employee at Open Biome demonstrates,

[71] This was primarily due to their conditions being so bad that they were desperate to try anything to help, rather than an affinity with faecal matter.

[72] As was revealed in my interviews with FMT users, many American FMT users were in precarious employment and hence did not have access to reliable and good medical insurance.

> I think what's going to be interesting is if and when one of these FMT products gets approved, what the off-label usage looks like. If I were to guess, I would say that off label prescription for IBS patients, will exceed *C. diff* prescriptions, almost definitely. Even though there's no compelling evidence, and all of the IBS studies have been inconclusive. But that's kind of what happens when a drug gets approved, you can prescribe it off label at the discretion of the physician. So, I think that's what's going to happen, and it's going to very much change the world and unfortunately, it's going to go wildly undocumented, and I don't know exactly how we're going to ease out the evidence or data. I mean on the one hand, the nice thing about that is there are anecdotes that lead to clinical trials, but the problem is that you may also treat way more people than it would benefit. But I don't know maybe, if it's safe maybe it's not a big deal.

Off-label prescription also informs a politics (as a mode of relating) that distorts the microbiome's multiplicity and autonomy. While off-label prescriptions may help ease some conditions, to offer blanket prescription of an FMT drug demonstrates a lack of respect for the autonomy of microbial life and the microbiome within dominant medicine. The premise of off-label prescription is that there must be a just reason or satisfactory evidence that the drug will help the condition. However, much remains unknown about how the microbiome interacts in differing disease states or conditions. This appears specifically the case for IBS, as it is a highly complex condition that is challenging to diagnose and treat because of its inherent diversity and its unclear cause (Agnello et al. 2020, Chong et al. 2019). Furthermore, *C. diff* and IBS are completely different gut conditions: the former is where one microbe has overpopulated (Leffer and Lamont 2015), the latter is where there is chronic inflammation and dysbiosis with a multitude of factors effecting its state (Agnello et al. 2020). As TJ expresses, there is little evidence to suggest that a drug that has been developed for *C. diff* would be applicable for IBS. It appears that to prescribe off-label reduces the complexity and multiplicity of gut conditions. Instead, the drug produced is viewed the same as any other drug, where the prescription and consumption of the drug intends to fix a health-related issue within the body without due consideration to the nuances and complexity of the microbiome from person to person.

The ecological diversity of gut conditions that a *C. diff* drug may be prescribed for (such as IBS and ulcerative colitis) vary so dramatically that outside of *C. diff*, adding this hypothetical FMT product to a treatment regime for other conditions feels akin to

how probiotics are viewed. Because probiotics are not seen as harmful, their addition to the body is seen as automatically beneficial (Beck 2019). The defined consortia developed by Seres Therapeutics may be useful for some with IBS or Crohn's disease, for others it may not. This is not to suggest that the only way to use the microbiome in medicine is for personalised medicine.[73] Rather, I argue that the development of an FMT drug contributes to a reduction of FMT and the microbiome to a one-size-fits-all panacea. This is especially important to consider if the procedure of FMT gets banned or more stringently regulated, or if the orphan drug status of the Seres Therapeutics drug requires that another FMT drug cannot be made for another seven years due to market exclusivity. Hence, a reductive politics of the microbiome emerges via diminishing the vast multiplicity in potential indication and use of FMT as a procedure to one type of drug to possibly be used for a wide range of gut-related conditions.

Significantly, biological drug regulation is generative in its 'agential cutting' of what the human is (Barad, 2007). Explicitly, regulated as a drug and not a human cell or tissue, the microbiome is very distinctly defined as not human. As Timal explained earlier on, the microbiome does not contain human cells - they are noticeably nonhuman. However, the microbiome's relationship with the human, its vital role in human functioning - immunity, neurological cognition, and many more vital processes - puts strain on classic understandings of what the human is. To regulate FMT as a drug overlooks these varied and important relationships between the microbiome and different areas of human health. Hence, if regulation is to determine an agential cut or a unified legal understanding, regulating the microbiome as distinctly nonhuman exposes a material-discursive move. In other words, current US regulation achieves a proactive reinforcement to divorce the microbiome from the human as a nonhuman other. This contributes to a wider humanist ideology that reproduces the dualism between nature and culture, human and nonhuman (Haraway 2008, Hinchliffe 2007, Tsing 2010, Tsing 2012). Rather than "understanding the body, not as an organism or entity in itself, but as a system, or series of open-ended systems, functioning within other huge systems it cannot control" (Grosz 2005, 7) made up of both human and nonhuman entities, the microbiome as a drug obscures the human's entanglement with the more-than-human, reifying the humanist concept of the bounded individual human body.

[73] As mentioned previously, there are benefits to FMT being developed as a biologic drug.

The fruits of this reinforcement can be witnessed in the absence of any moral debate regarding the future of the microbiome and microbiome interventions. While certain members in industry, including those I spoke to from Open Biome, as well as FMT users and microbiome illness communities, are very invested in FMT still being accessible, there is a notable lack of moral public debate regarding the development of microbiome interventions. This absence is particularly striking when compared to the debates surrounding research on the human genome. The human genome represents a similar medically-induced paradigm shift in discovering a hugely influential piece of biology that significantly altered how we understand the human. Much of the societal moral panic that ensued stemmed from fears "regarding genetic determinism: on the one hand, the genes govern us like a puppeteer, while on the other hand, once we gain control of the strings, we can become our own puppeteers" (Peters, 2014). While it has since been revealed that genes are not as prescriptive as perhaps once depicted, research on genetic modification and testing are still politically fraught with religious communities and others opposing such research due to fears of scientists 'playing God'. Thus, what we can see emerging is an important difference between the genome and the microbiome, in that the genome represents the revered human form. As Haraway explains, "with all its stunning power to recuperate, out of the endless variations of code fragments, the singular, the sacred image of the same, the one true man, the standard—copyrighted, catalogued, and banked" (2013, 87). Despite the microbiome's considerable role in changing human behaviours, similar fears, or concerns regarding how the microbiome is researched or intervened with are absent.

I witnessed a pertinent example of this at the Microbiome Engineering conference where I saw a paper that demonstrated how manipulating a lab mouse's microbiome could enable an improved adrenaline response, which could then be applied to soldiers. When talking to the presenter, he explained that these findings would hopefully lead to a probiotic that would advance the quality of soldiers by enabling better battlefield responses. For example, they might be less likely to 'freeze up' in the traumatic environment of war. If produced, this product would represent a significant expression of biomanipulation, one that changes emotional processing and behaviour, a topic that should be subject to much moral discussion and concern.

Aside from lacking the reverence accorded to the human genome, the lack of public debate or concern regarding the microbiome could in part be down to the

materiality of the microbiome. Faecal matter is both waste and commonly regarded as disgusting (Houf 2021). Once out of the body, it is ‘matter out of place’ (Douglas 1966). For good reason, attempts have been made throughout history to remove faecal matter from human proximity because of the risks it poses to health as well as its unpleasant aromas (Laporte 2002). However, there seems to be particular importance in how the microbiome is considered nonhuman and as separate to the human. It is the microbiome’s conceptual and practical production as nonhuman that allows for it to be so easily integrated into networks of capitalist accumulation.

The microbiome understood as both waste and as a nonhuman part of the human, exposes a capital-orientated politics of the microbiome. As others have pointed out regarding the capitalisation of macro nonhuman life, animals are

> Raised as products and are also harnessed as tools of production…As unprotected natural resources, animals are managed for profitability, while ignoring their physiological, ecological, and social requirements for existence and co-existence with other organisms (Stuart and Gunderson 2020, 932).

Regulating the microbiome as a drug demonstrates what Escobar has referred to as “post-modern ecological capitalism” or “free-market environmentalism” (Escobar 2020, 38), where nature is observed as a “free good” ready to be exploited and where “the logic of commodification” is used to resolve “local and global environmental problems” (ibid, 39). Where the integrity of the physical human body is understood as ‘sacred’, with the manipulation and selling of organs presenting a troublesome threat to these traditional beliefs (Andreescu 2016), the nonhuman microbiome sits outside of such narratives. While other bodily fluids, such as semen and cord blood, can be commodified due to their status as ‘waste’ (Brown 2018, Mitchell and Waldby 2006), the nonhuman microbes in faecal matter, however, while also produced as waste, play a much more significant role in human health and functioning than cord blood and semen (Cho and Blaser 2012, Clemente et al. 2012, Madupu et al. 2013, Nie et al. 2019).

The ease with which the microbiome is being integrated into capitalist markets is further compounded by the lack of public debate. Unlike the public discourse of other, more distinctly human, medical waste products, the microbiome remains relatively undisturbed. For example, cord blood, which although observed as medical

waste, is a rich source of stem cells, remains entangled in highly fraught ethical debates (Jeong 2016). As molecular biologists, Mauron and Jaconi (2007, 330) summarise, “few developed countries have failed to entertain fierce ethical debates about the morality of deriving stem cells from early human embryos, often driven by conservative opponents of abortion”. While the gut-brain axis and its role in mood and behaviour have made headlines (Gallagher 2018, Hotz 2020, Pennisi 2019), notably, the potential ramifications and biotech investment into products that utilise the gut-brain axis have not. This remains the case despite the significant research on the gut brain-axis that demonstrates the hugely central role that the microbiome has in dictating neurological functioning and behaviour (Bercik et al. 2012, Cryan and O’mahony 2011a), such as in cases of mental health (Evrensel and Ceylan 2015, Foster and Neufeld 2013), autism (Srikantha and Mohajeri 2019, Yu and Zhao 2021), and even neurologically degenerative conditions such as multiple sclerosis (Camara-Lemarroy et al. 2018, Malinova et al. 2018). This is not to suggest that there *should* be a politicised debate. Rather, I suggest that the absence of debate indicates a lack of interest due to its nonhumanness and this enables a less fraught integration of the microbiome into capitalist markets of accumulation.

It appears then, that regulating the microbiome via FMT as a drug, as something to be profited from, hinges on its nonhumanness despite its integral role in human functioning. Situating the microbiome as distinctly nonhuman, and as such, something that can be commodified exposes the capitalist-orientated politics of the microbiome. The impact of such politics was apparent in many FMT users who observed the production of an FMT drug as an actant within a wider corrupt medical system. The FMT user Earl demonstrated this when discussing the implications of FMT being turned into a drug. He relayed that “a patient cured is a customer lost” when referring to his experiences in the American medical system. A deep mistrust was present, most transparently in American FMT users who saw the medical system as one that favours profit over patient welfare.

Conclusion

This chapter has performed a political ecology of the body and microbiome by exposing the multiple and entangled networks of actants and hierarchies of power that determine human microbiome relationality via the regulation of FMT in an American context. Specifically, the chapter has made clear the role that the political decisions of

the FDA have in dictating a relationality with the microbiome. Perhaps most obviously, this has been shown in how regulation determines the ability of FMT users to access FMT. More subtly, however, is the implication of regulating FMT via its nonhumanness as opposed to the microbiome's relationship with the human. For the FDA, the microbiome via FMT should be regulated as a drug, simply because the microbiome is not human. These regulatory decisions are powerful in determining the agential cutting of the microbiome as distinctly not human.

By regulating the microbiome as a drug, it becomes entangled into neoliberal networks of capitalist accumulation that reduces the nuances and multiplicity of the microbiome, which represent its novel and exciting aspects. As I have shown, the drug development process opposes the ecological expansiveness and multiplicity that the microbiome poses. Hence, drug regulation works to reduce the microbiome via the production of a defined consortia that has materially less microbial diversity, and by potentially preventing the procedure of FMT to go ahead after a drug is produced. Through such an approach this mode constitutes the microbiome as a technical problem to be solved.

While in some respects FMT as a drug reduces some risks of the procedure, it also has its own ethical and moral implications. As others have argued, FMT regulated as HCT/P would allow for better access, however, as I have shown it would also trouble the current reproduction of the microbiome via a humanistic onto-ethico-epistemology that seeks to dominate and coerce the microbiome for specific human centric gains. Instead, HCT/P would inform a relationality with the microbiome that first complicates notions of human individuality, and superiority to nonhuman life. Second, and importantly for FMT users, HCT/P would also enable more varied access to FMT, utilising the microbiome's multiplicity.

While the thesis up to now has explored the broad overarching structural and systemic institutions that contribute to the production of the microbiome, the following chapter explores the modes by which the microbiome becomes known through *personal* practice. I first draw from interviews with FMT users to unpick how FMT users situate themselves within the regulatory structures and governing practices discussed above and use the corporeal bodily sense as a way of coming to know their microbiomes. I then critique how testing products (that are accessible to the general public) inform modes of coming to know the microbiome.

Chapter Six: Bodily identity: Exploring an FMT-induced hospitality

While the previous chapters have explored how the politics of the microbiome emerges via macroscale systemic modes of knowledge production and governance, this chapter explores the personal and everyday means by which FMT users experience and engage with their microbiomes via the novel procedure of FMT. The procedure, to remind readers, involves transferring a diverse microbiome from a donor into a patient. Depending on where the patient is performing the procedure, the faecal material is administered via the 'bottom up' method either via colonoscopy or with a DIY funnel, or 'top down' using freeze-dried material or (less commonly) via a nasoduodenal tube (Hecker et al. 2016, Kim and Gluck 2019). As FMT necessitates introducing lively microbes (guests) into the human body (host), this chapter analyses these host-guest dynamics using philosopher Jacques Derrida's foundational theorisation of hospitality.

The chapter seeks to unpick how, through the procedure of FMT, the microbiome changes FMT users' understandings of their body and microbial relationality in contrast to broader structural regulatory forces that determine legislative parameters[74] in which FMT users operate. The chapter draws on materials gathered during interviews with FMT users, many of whom can be described as periphery patients,[75] and explores the processes and practices by which FMT users reconceptualise their (human) bodies. Significantly, these revisions emerge by reconsidering or 're-seeing' their bodies as hosts to the nonhuman ecologies of the

[74] The constraints placed on FMT practice by the law.
[75] As discussed in Chapter Four.

microbiome, as opposed to in terms of dominant humanistic understandings of human autonomy from, and superiority over, the nonhuman. As well as remaking their bodies as hosts, they engaged in practices of bodily and human hospitality via the procedure of FMT.

The chapter starts by re-contextualising Derrida's theorisations of hospitality to the body. Derrida, a French Algerian migrant, observes how hospitality is negotiated in a world where the ability to welcome and be welcomed is always contingent and increasingly monitored (Van Dooren 2016). By applying such theorisations of hospitality to the microbiome, the chapter updates the traditional human-centric accounts of hospitality and contributes to posthumanist and more-than-human literature that complicates how we understand the human and human-nonhuman relationality in an everyday setting. From this starting point, I then go on to develop the concept of corporeal communication[76] which refers to the practices of corporeal attentiveness and microbial care that some FMT users animate in bodily hospitality.

Moving beyond more traditional observations of human-nonhuman entanglements made in posthumanist and more-than-human studies (Haraway 2008), I highlight how a politics of care emerges in and determines both microbial and bodily hospitality. I demonstrate how FMT users' relationality with their microbiomes is determined and often restricted by wider societal and political structures as FMT users specifically may be faced with immense precarity because of the nature of their conditions. I explore how this emerges biologically in their microbiomes, where some are more vulnerable to microbiome disruptions (due to exposure to stress and poor diet), and socially, in terms of the risk FMT users face of becoming alienated from biomedical discourse and exposed to false, conspiratorial, and anti-science information. I argue that while a politics of care emerges in bodily hospitality and corporeal communication, these are subject to, and determined by, broader societal political forces.

Hospitality

Before exploring the intricacies of the microbial and bodily hospitality employed by FMT users, an introduction to Jacques Derrida's formative work on hospitality is needed. Unpicking the etymology of the word 'hospitality', Derrida highlights the

[76] First developed in my MRes dissertation.

relationship between ‘hospitality’ and ‘hostility’, as *hospes,* the root from which both words originate, means “both ‘stranger’ and ‘enemy’” (Aristarkhova 2000, 11). The original meaning of hospitality, as *hostilis* (stranger and enemy) and *potes* (having power) was to have power over the stranger and the enemy (Derrida 1999). Through this etymology, Derrida points to the tensions and contradictions within the word’s meaning. Derrida sets out the complexities involved in hospitality by first introducing the concept of unconditional hospitality, which can be understood through the following circumstance:

> If I am unconditionally hospitable, I should welcome the visitation, not the invited guest, but the visitor. I must be unprepared or prepared to be unprepared, for the unexpected arrival of any other. Is this possible? I don’t know. If however there is pure hospitality or a pure gift, it should consist in this opening without horizon, without the horizon of expectation, an opening to the newcomer whoever that may be. It may be terrible because the newcomer may be a good person, or they may be the devil (Derrida 1999, 70).

However, as Derrida makes clear, hospitality necessitates a power play between the host and guest. For hospitality to occur, something must be offered to the stranger. The host has the power as they offer something of theirs to the guest, something the guest did not have before the occurrence of hospitality. In offering this thing unconditionally to the guest, the openness that is required for unconditional hospitality “requires that which it negates; the mastery of the home in which to welcome the guest” (Candea 2012, 38). The labels of master and guest are disrupted as, for unconditional hospitality to be completely unconditional, the flatness in power and access to resources would mean that the master is no longer the master and the guest no longer the guest. However, Derrida argues that unconditional hospitality should inform conditioned hospitality, where hospitality is restricted by certain qualities that exist along the lines of resources, politics, and religion. As Derrida suggests, “the ideal of hospitality … provides the *inspiration for the pursuit of virtue or virtues of hospitableness*” (O'Gorman 2006, 52). He refers to this form of conditioned hospitality inspired by unconditional hospitality as an ethic.

Explorations of hospitality have largely focused on the tensions that arise in human’s movement within and between material borders, such as asylum seekers and

migrants (both illicit and authorised) (Bell 2010, Rosello 2001). However, the concept of hospitality has also been animated and discussed in relation to the nonhuman. Extinction studies scholar Thom Van Dooren explores Derrida's hospitality in relation to the culling "of house crows in Hoek van Holland" in 2014 (2016, 194). The proposed cull was prompted by an inaccurate prediction that the crow's population would grow to a hazardous size, deeming them a 'pest'. Van Dooren criticises Derrida's use of hospitality when applied to the Anthropocene, where humans have marked the Earth enough to observe themselves as hosts and (inaccurately) assume they are in control of the boundaries of hospitality. He posits that a better way of being and living with nonhuman life is possible through, in fact, not using the notion of hospitality. As he argues, "the notion that any place is exclusively 'ours' is not a helpful foundation" and continues that hospitality encourages a possessive posture, in which there is a master to invite the guest (2016, 203-04).

Although this is a valid critique, I would argue that outside of the context of critiquing the concept of the Anthropocene, Derrida's theorisation of hospitality remains conceptually and materially fruitful to complicate traditional and outdated understandings of the human body. As Derrida (2002) emphasises, hospitality retains its capacity to *encourage* greater acceptance of people, as unconditioned hospitality comes to inform conditional hospitality. Hence, although the labels of guest and host are underpinned by the discourse of master and guest, they still offer a format through which to conceptualise how we might share space and resources without the intention of benefiting from the offer of hospitality or it being requited. I contend that, although no definitive line between the human and microbiome can be drawn, and despite the concept of hospitality operating within a humanist framework of human master and nonhuman guest, hospitality is useful as a conceptual tool for observing the nonhuman relationships humans are always entangled within. Furthermore, expressions of hospitality adopted by some FMT users recognise the limits of human control over nonhuman life.

In other areas of the critical social sciences, and specifically within geography, work on immunity has been used to explore host/guest dynamics in the body and beyond (Brown 2018, Esposito 2008, Esposito 2013, Hinchliffe and Ward 2014, Hinchliffe et al. 2016). Significant in immunity literature is the work of philosopher Roberto Esposito (2008, 2013), who challenges the idea that immunity, protection

against the 'other', is oppose to the concept of community, being *with* the 'other', observing the same etymological root word, '*munus'* (understood as an obligation for reciprocation or gift) in both *immunitas* and *communitas*. He proposes an immunity model, which Hinchliffe et al. (2016, 130) paraphrase, explaining that, "community and immunity make one another - they are folded together rather than in opposition". Hinchliffe and Ward (2014) also explore the dynamics and material thresholds of the immunity model that Esposito refers to. They explain that the "hypertrophic security" that occurs through increased biosecurity and attempted control of pathogens and other microbial life in industrial agricultural environments is "arguably producing the very conditions that it supposedly aims to eradicate" (2014, 137-138). Sociologist Nik Brown similarly uses Esposito's reworking of immunity to explore "the tensions between gifts and commodities, the public and the private, *communitas* and *immunitas*" in cord blood banking (Brown 2018, 83). Brown argues that, in some cases, donating cord blood enables *immunitas* and *comminitas* via the life-giving properties of donation material between bodies and international borders (ibid).

Similarly to hospitality, immunity involves complex host-guest dynamics. In Esposito's paradigm, the process of immunity involves being open to the unexpected arrival of the 'other' (2008, 2013). Whereas work on immunity has focused on the complicated relationship between community and immunity and their role in offering protection, in this thesis, hospitality provides a mode of relating to the other as they enter the host. Using Derrida's working of hospitality (1999, 2002) this thesis is concerned with the varying forms of relationality and politics that emerge through the procedure of FMT, together with the politics of the microbiome, by specifically thinking about how and in what ways human hosts act or perform hospitality via FMT.

The concept of hospitality has been previously adopted in posthuman and more-than-human work within geography to explore human-nonhuman entanglement, notably by Jamie Lorimer in his research on helminth worms (Lorimer 2016, Lorimer 2017b, Lorimer 2017c). In this work, Lorimer explores using helminth worms as an alternative treatment for autoimmune conditions (ibid). Referring to helminth worms as 'gut buddies' he explains that "hookworm users are willing to make bodily sacrifices to preserve their worms' vitality, but only to the extent that the worm functions well as a keystone agent" (Lorimer 2016, 72). He highlights that this relationship differs from other mammalian pet relationships, as helminth worms act as a form of internal microbial rewilding (Lorimer 2017c, Lorimer 2020). Similarities emerge between the

procedure of FMT and helminth worms as they both employ a probiotic approach (Lorimer 2020). However, rather than one organism being introduced into the hosts gut, as is the case when using helminth worms as an alternative treatment, FMT introduces multitudes of organisms, some of which remain unknown. Both the unusual gift of faecal matter and number of organisms meeting through the procedure of FMT introduce new conceptual spaces to consider hospitable relations in and towards the microbiome. Furthermore, operating as an ecology, once inside of the body, there is no easy or accessible method of knowing what and who has stayed in the host. While one might be able to gauge their microbiome from their faecal matter (Hadizadeh et al. 2017, Vork et al. 2021), exactly what is being transferred and welcomed in FMT and everyday eating is not visible, leading one to negotiate the relationship through a heightened consideration of bodily corporeal sense, something I discuss in detail later in this chapter. By employing Derrida's conceptualisation of hospitality in the context of FMT, I explore another dimension of human-microbiome relationality and so consider how we understand these relations in the microbial human.

From Derridean hospitality to microbial and bodily hospitality

We don't know what hospitality is.
Not yet.
But will we ever know? (Derrida 2000, 6)

One of the first spaces in which the concept of hospitality was drawn to my attention was through FMT users' frequent references to their bodies as hosts. Whereas Derrida theorised hospitality at a macro scale where state legislation informs interpersonal hospitality (Derrida and Dufourmantelle 2000), FMT, like in Lorimer's work on Helminth worms and van Dooren's work on crows, notably alters both who hospitality occurs between and where it takes place. Through the procedure of FMT, hospitality is practised *within* the body instead of *between* bodies. Demonstrating this well were Benny and Mike, who showed how they revised themselves and their bodies as hosts as they explained,

> You're a host for all of these organisms that actually can make you healthy or sick if you don't treat them well. It's interesting not just how I think about my body, I mean it

> has made me realise, I guess my doctor told me it's like a garden and you need to weed it and feed it, but it's not even just your insides, it's the surface of your skin. (Benny)
>
> The first step was realising that I needed to be rebooted with good bacteria, and then the next step was realising that I need to be a host that keeps that good bacteria happy and healthy and reproducing. (Mike)

The procedure, for many FMT users, forces a re-evaluation of what they consider their bodies to be. Both Mike and Benny demonstrate reconsidering their bodies as multispecies entanglements and that this entanglement requires engaged practices of relationality. Both men felt they were not alone – that they were not one but many. Coming to understand the powerful role that the microbiome has in determining how their bodies function, they witness the nonhuman part of themselves as necessary but also transient, requiring attention and care. For Benny and Mike, respecting and valuing their microbial guests and being good hosts are important for them to maintain success from the procedure, and, importantly, this requires consistent practice.

Revising the body as a host to nonhuman life puts commonplace individualising humanistic notions of the body under stress. An appreciation that the human requires nonhuman life works to irritate "humanist aspirations of autonomy and individualism" (Roy 2018, 68). The image of humans as superior to and distinct from nonhuman life is further unsettled by FMT's openness to and intention of having a multitude of guests. Colonisation resistance theory – the theory often employed to elucidate why FMT works, according to which invading bacteria can be prohibited by a more diverse ecology of microbial life – is underpinned by a motivation to encourage a more diverse range of microbial life to be present in the gut, and in some cases prevent one microbe from overpopulating (Pamer 2016).[77] The aim of the FMT game is to invite as many guests as possible in hope that enough new bacteria will stay, thereby enabling the host microbiome to move out of dysbiosis. In the UK, treatment from Taymount Clinic (an FMT clinic) involves ten different donors to introduce as much microbial diversity via the procedure of FMT as possible (Taymount Clinic 2022a).[78] While colonisation resistance theory has been problematised for its passive representation of the body (Wolf-Meyer 2017), it also works to expose the dangers of seeing the human as

[77] *C. diff* is a prominent example of the dangers to health that occur when one microbe overpopulates.
[78] This contrasts to Open Biome treatments which involve donation material from one person.

autonomous from the nonhuman, as well as showing the importance of the multiplicity of microbial life in human health and functioning.

Revising the body as a host and maintaining a hospitable human-microbiome relationality requires consistent upkeep. As a procedure, FMT differs from the onto-ethico-epistemology of antibiotics and other medicines in dominant medicine, where a pill or "magic bullet" (Lupton 2012, 66) can be taken to fix a bodily ailment, or what bioartist Kathy High refers to as the "fix it with a pill" ideology (High 1989). Rather, for maximum success from FMT, long-term changes to one's lifestyle and habits are required. While some FMT users may only need one round of FMT for rCDI as a one-off procedure, to maintain any success from the procedure continuous hospitality is required, as Sally demonstrated when differentiating between FMT and other medicines she had been prescribed:

> Everybody wants the immediate effects, and I think the answer is that you have to change your life too. If you get these new cells, and then you carry on as before, it's not going to work, because clearly, the way you have lived your life has damaged the cells you had in your body initially, so you have to make changes.

What Sally evidences here is that respecting the nonhuman self to enable co-flourishing between the guest and host is a long-term project. In this way, microbial hospitality becomes a process rather than a single event. Benny also became more aware and considerate of his microbiome over time:

> I had two different types of antibiotics, to clear everything out, and then [did FMT to] populate your gut with the population you are trying to grow…[it is] like gardening, you weed the garden and then bring in some healthy soil and plants to grow, so then you have to constantly keep feeding them nutrients and fertiliser with prebiotic and probiotic foods, so that changes your ongoing outlook on why you continue…so it's like ongoing health if you have that good bacteria in you…you have to keep on feeding it healthy stuff.

FMT necessitates long-term changes for continued success, as both Benny and Sally indicate. This temporal aspect of FMT is significant: the procedure introduces the new microbiome in the host but maintaining a relationality that is mutually beneficial over

the long term is not guaranteed. Considering how and in what ways one's lifestyle may impact the success of the procedure and relationality between oneself and one's microbiome is important to persistently maintain the new microbiome. The purpose of the procedure is for the guest to become part of the host. Despite Derrida's suggestion that "the true gift of hospitality is an act of generosity experienced by the 'guest', which turns a stranger [the guest] into a friend for a limited period of time" (O'Gorman 2006, 6), FMT users intend for this period of time to be extensive, if not permanent. In other words, FMT users intend for their new microbiome to make their gut its new home, and therefore for a transition to occur from 'guest' to a part of the host.

With the guest intended to become part of the host, the hostility that underwrites Derrida's version of hospitality is erased in bodily microbial hospitality. Derrida sets out the dominant notion of hospitality not as a profound act of welcome, but as an admonition to respect the host's property, to always remember that this is not the guest's own home. As he explains,

> 'Make yourself at home', this is a self-limiting invitation… it means: please feel at home, act as if you were at home, but, remember, that is not true, this is not your home but mine, and you are expected to respect my property. (Derrida in Caputo 1997, 68)

This transition from guest to host complicates the hierarchy that Derrida argues is implied within hospitality. As Derrida explains, the 'guest' and 'host' labels of hospitality depend on hierarchy because of the power relations that exist between the host (the owner and giver of space or resources) and guest (the receiver of space or resources) (Derrida 2000). Unlike the human-to-human hospitality that Derrida refers to, the hierarchy between the guest and host is unsettled as the dependence and the intention from the procedure, which is not always fulfilled, is for microbial life to stay and make a home in the new gut. In FMT, a situation where the guest has more to offer the host than the other way around, the human is unable to control the microbial ecologies they are welcoming into their body. Here then, beyond FMT merely putting stress on humanist assumptions of individualism by bringing to the fore the presence and importance of the more-than-human within the body, FMT distorts humanistic ideology by altering the hierarchy of power on which it depends. The master/guest relationship is complicated when the host requires or needs the guest; although, the procedure is for human health. The relationship still seems to exist in a

hierarchy in which the master (human) and guest (microbiome) power dynamic orders life and prioritises the human. Often, the procedure occurs when there are no other options. The context of hospitality in FMT, then, shifts the power dynamic of guest and host/master. A guest is usually in need of a host; however, here the inverse is true. While the new microbiome will gain a new home, the human host has more to gain from the hospitable interaction than the guest. So, though the intention of FMT is for improved human health, it necessitates a revision of the human as nonhuman. The 'sacred' and 'superior' human body (Andreescu 2016) is instead in debt to the nonhuman.

In human-to-human hospitality, a stricter hierarchy is entrenched through the guest coming into the host's house. Derrida argues that through this interaction, both may change, but the guest is more at the mercy of conforming to the host/master's ways. Mireille Rossello (2001, 176) suggests "that the very precondition of hospitality may require that, in some ways, both the host and the guest accept, in different ways, the uncomfortable and sometimes painful possibility of being changed by the other". Success in the process of FMT intrinsically entails the host changing. As Seekatz et al (2014, 1), in their work on the recovery of the microbiome after the procedure of FMT, explain, "the faecal microbiota of recipients following transplantation was more diverse and more similar to the donor profile than the microbiota prior to transplantation."[79] In most cases, the microbiome loses similarity to the donor microbiome over time (Angelberger et al. 2013, Hamilton et al. 2013). Hamilton et al's (2013) study follows three FMT patients four months post-procedure and observes that, although taxonomic presence becomes less similar to the donor, structural similarities remain. Though it is not known exactly how much or for how long the remnants of the donor's microbiome will exist in the host microbiome, while this co-existence is occurring, the new 'healthy' diverse ecology enables the dysbiotic host-microbiome to be supplemented.

The microbial guests, however, may change the host beyond specifically improving microbial diversity. Sally, for example, detailed very clearly how the procedure of FMT had changed more than just her microbiome. While FMT contributed

[79] Although as the authors clarify later, what the FMT is used to treat will determine how long the donor microbiome stays in the host.

to her condition improving, she also commented on other bodily changes that arose after the procedure. As she explained,

> Because I will tell you since the FMT procedure there have been some weird things. It's like my body chemistry has changed … I now smell different, my own personal body odour is different so there are chemical differences that can happen after you do FMT. My body type changed too, I was very bottom heavy before and now my body is balanced out, which is the first time in my life that that has ever happened. And I have to think that it is a little bit due to that procedure.

While the exact changes that come from the procedure cannot be precisely anticipated, a considerable motivation for the procedure is for the microbiome to be changed by the microbial ecologies welcomed into the host. Thus, in FMT, the bodily host changes thanks to the invited microbial guests. Yet this process is inherently risky, because as Sally exemplifies, the exact bodily or microbial changes cannot be predicted. Though it is intended for the changes to be permanent, and some FMT users enact bodily microbial hospitality in attempts to keep the new guests, there is no way of knowing and guaranteeing that the new microbes will stay in the host.

So far in this chapter, I have extended the Derridean notion of hospitality, showing that, through FMT, the traditional humanist hierarchies upon which hospitality depends are unsettled. However, the practice of negotiating a bodily microbial hospitality is not straightforward. Instead, the relationality that emerges between the human host and microbiome in the process of FMT is ongoing and unpredictable. To come back to the epigraph by Derrida at the start of the chapter, FMT informs a bodily microbial hospitality that is a process. There are no predefined or universal rules to follow, and the vast diversity that exists between individuals' microbiomes, their invisibility, and the immense number of factors that affect the microbiome muddy the waters of coming to know and understand one's microbiome.

The next section goes on to first detail the attentive and considerate attunement to the corporeal bodily senses that some FMT users engage with as a part of what I am calling a *bodily microbial hospitality*. This broadly describes microbially-minded and diligent changes to one's consumption and lifestyle practices. Finally, I reflect on how FMT users' ability to enact such hospitality is determined by and susceptible to broader systemic forces.

Practising bodily microbial hospitality

> *We do not always know in advance what world is knocking, or what will be the consequences, and yet how to care remains a question of how we relate to the new.*
>
> *(Puig de la Bellacasa 2017, 92)*

Many FMT users that I spoke with described what I refer to as a bodily microbial hospitality as a means of ensuring that the microbial guest would become *part of* the host. A common material practice involved in a bodily microbial hospitality was an increased awareness of consumption. In particular, FMT users' diets were one of the first changes users mentioned. Some FMT users noted that they tried to consume now only organic and homemade food as well as foods that contain naturally occurring pro- and prebiotics. For example, when talking about changes he has made since undergoing FMT, Paul explained that,

> Now I have added… dietary microbiome improvement stuff, so I eat a lot of fermented foods. I have consciously improved my diet significantly. I eat a lot more fibre, fruit, and veg and [I eat] a lot less processed food. I have cut out sugar to do stuff like that.

As Paul makes clear, after undergoing FMT he made specific changes to his diet; consuming foods that he understands to be beneficial for his microbiome while avoiding others that he thought might have a detrimental and unwanted effect on his microbiome. Foods that are commonly found in a western diet, such as those that contain high amounts of fat and preservatives such as fat-derived amino acids and lipids, are usually avoided by FMT users as they are associated with increased inflammation (Tilg and Moschen 2015). This appeared as a consistent theme throughout the interviews with FMT users[80] and represents an initial and significant way FMT users enact hospitably towards their microbiomes.

[80] A lot of FMT users were well versed in the scientific language of the microbiome as those with the most debilitating conditions would spend much of their time researching the microbiome and reading microbiome-related literature. However, without the benefit of a scientific background, their understanding of the science was not consistently accurate, a topic discussed in more detail in Chapter Four regarding the emergence of the periphery patient.

Alongside diet, medication and antibiotics were also mentioned as something that FMT users reflected on and started to decrease, if not cut out. Even if the procedure is successful, an FMT user's microbiome may still not be as resilient as a pre-dysbiotic microbiome. While experiencing microbial precarity, many FMT users I spoke with were hesitant to take medications and antibiotics due to fears of unwanted effects on their microbiomes. Their awareness and altered consumption habits were prompted by an increased microbial awareness, wanting to avoid certain microbial life, and come into contact with, cultivate, and nurture others. As Joe made clear when responding to a question about his views on dominant medical practices and institutions,

> Haha… My feelings about medical practices! Well… I don't take medication anymore. None whatsoever. No antibiotics, no over the counter pain relief, no medicated creams or cough lozenges. Nothing. This can be a huge problem at times because I have Crohn's Disease, which means I have to manage it naturally through diet, sleep, exercise, sun exposure and stress relief.

As Joe explains, his awareness and altered consumption habits were prompted by wanting to avoid certain drugs or antimicrobials that may have an unwanted negative ecological effect on his microbiome diversity. Hence, for Joe, acting hospitably towards his new microbiome included both avoiding drugs and medicines (that he knew would negatively affect his microbiome) and giving other factors such as sleep and exercise special attention. Broadly, the FMT users that I spoke with relayed that unless it was necessary, as in cases of surgery or infection, medications such as antibiotics were to be avoided. This decision was based on the non-discriminatory nature of antibiotics and the negative effects they can have on microbial diversity within the gut (Stecher et al. 2013).

The use and approach to medicines such as antibiotics or other drugs represent a complicated picture in terms of enacting a bodily hospitality. Avoiding antibiotics in some cases may characterise a bodily hospitality; however, if medicines are being avoided when they are desperately needed, putting the patients' life at risk, then this can be observed as inhospitable as this could negatively impact the microbiome and overall bodily health. However, the distinction between bodily hospitality and inhospitality is complicated and not always easily defined. Taking antibiotics may get

rid of an infection but cause long term harm if the host's microbiome is already fragile, as is the case for many FMT users. Some FMT users reflected on the difficult process of having to choose what part of their body to prioritise. Benny experienced this dilemma after he underwent back surgery and FMT at the same time:

> Even when I said to doctors and say 'oh they [immunosuppressor drugs] give me dodgy guts', talking to the back doctors … they don't really know anything about the long-term effects it is having on my guts ... I quit taking those and painkillers for a good few years after changing my diet to an anti-inflammatory diet … and I have noticed the difference completely.

Although immunosuppressor medications are able to ease autoimmune conditions, they also increase the ease with which pathogens may spread within the microbiome (Proal and Marshall 2018). Benny was confronted with the uncomfortable situation of having to decide between which bodily ailment to treat. Earl similarly expressed his frustration at his microbial precarity as he relayed how a recent prescription of antibiotics affected him:

> I just can't tell you, I'm really freaked out because the antibiotics that I have taken in the past month, I'm not able to do things I was able to do in the past few years, I can't think as straight as I did before.

Both Benny and Earl expose the microbial vulnerability and precarity of FMT users, where the decision to take certain medications involves weighing up the risk of damage to their microbiomes. Resentment arose when FMT users referred to being prescribed antibiotics that made them more ill or when they felt them to be unnecessary (in cases where an infection was not present). For many FMT users, having experienced traumatic and in some cases, life-threatening sicknesses that have been aided by FMT, the thought of returning to such a reality led some to prioritise their microbiomes over other forms of treatment that might have been necessary. Such resentment at times led to valid critiques of the health care system with which they had engaged. However, on the Facebook advocacy pages I observed, these same critiques also often turned into the anti-science conspiratorial arguments used to discourage members from certain drugs and vaccinations. Decisions around taking medications that may or may not enact bodily hospitality are not clean-cut. FMT

users often complained about finding themselves in the vulnerable position of having to choose on their own what bodily condition (or medication, or health behaviour, etc.) to prioritise as dominant medical professionals would or could not offer them guidance that was microbially-minded.

Beyond just consumption, some FMT users also reflected on how their broader lifestyles might negatively impact their microbiomes and their ability to be a good host. A recurring theme was the impact of stress, both as a factor in the development or worsening of the conditions that necessitated FMT and in relation to the success of the procedure. Exposing most dramatically the impact of stress were accounts from Sally and Mike. Recalling the stresses that either caused their condition or prevented the FMT from working, Sally first recounted,

> I went through a really stressful time in my life, with a relationship, with work, with my son going off to a private college and I don't think I fully understood how much emotional stress can affect your physical wellbeing. What happened was, my body just started shutting down a little bit by little bit.

Mike recalled unsuccessful FMT procedures due to stress:

> I was just a really stressful person, not breathing easy, not being outdoors or relaxed, no matter how healthy I ate and all other external factors, I would still get sick [after doing FMT].

Both Mike and Sally point towards the enmeshed relationship between their mental and physical wellbeing, which manifests in their microbiomes. Both went on to explain how they have made alterations to address the damaging impacts that the stress was causing them. Sally remarked how she observed her body before FMT as she explained:

> Prior to getting sick, my idea of how the body works was very mechanical, like a clock … I didn't listen to my body. I just pushed it too hard.

This contrasts dramatically with how Sally now views her body:

> I really try to look at my whole body not as one living organism but as many. I will try and treat it a little kinder … When I eat, it's not just eating healthy, it's understanding that my body needs a little bit of everything … I think that just it gave me a broader look at life and how to treat my body for longevity.

Mike similarly referred to how FMT pushed him to take the role that stress played in his health more seriously:

> I was once really stressed and of an anxious Western mind and I found a way to have a little stillness in the storm [through FMT]. I think that people are caught up in a conversation about 'what can I do outside of myself' … But I want to preach relaxation, rest, and oxygenation, so I think that's where the conversation is really designed to go … I think that's the most effective conversation.

However, as I will discuss later in the chapter, such practices of bodily microbial hospitality for many are much more difficult to enact and less accessible to change than Mike's convictions would imply.

Thus far, this section has paid close attention to empirical cases of FMT users. I now want to conclude by tying this back to philosophical considerations of humanism. Microbial hospitality is a politics of care. This politics echoes the writings of feminist philosopher Maria Puig de la Bellacasa. For Puig de la Bellacasa, practices of care contribute to "thinking and living in more-than-human worlds" (2017, 1). Specifically, in her writing on caring for soil in Foodweb[81] models, she explains that a shift to observing "soils as multispecies world[s] involves changes in the ways humans maintain, care, and foster…liveliness" (ibid, 191). This revisionist approach to soil, which exposes the deep and dependant entanglement between humans and multispecies soil, disrupts the dominant "nonreciprocal qualities of care" which entrench the roles of 'carer' and 'cared for' (ibid, 192). Instead, Puig de la Bellacasa explains that

> Caring for soil communities involves making a speculative effort toward the acknowledgement that the (human) carer also depends on the soil's capacity to "take

[81] A foodweb "describe[s] the incredibly complex interactions between species that allow the circulation of nutrients and energy" (Puig de la Bellacasa 2017, 191)

> care" of several processes that are vital to more than her existence … Foodwebs are therefore a good example to think about the vibrant ethicality in webs of interdependency, the a-subjective but necessary ethos of care circulating through these agencies that are taking care of one another's needs in more-than-human relations (ibid, 192).

Similarly, in FMT user practices of bodily microbial hospitality and caring for their nonhuman selves, their microbiomes also 'take care' of certain processes. Enhanced ecological functioning enables the improvement of the condition that FMT was used for, but this is an iterative process that requires continued maintenance. Although FMT intends to improve human health, seemingly benefiting the human over the microbe, I suggest that nevertheless, the procedure exposes the substantial interdependence between human and microbiome. As Haraway (2008) reminds us, the aim of resisting humanism is not (and cannot) be to completely deconstruct the differences between humans and nonhumans. Instead, as she argues, the aim is to disrupt the notion of human autonomy and superiority. Through the practices of bodily microbial hospitality, then, some FMT users care for both their human and nonhuman microbial selves.

Corporeal Communication

> *While we may all ultimately be connected to one another, the specificity and proximity of connection matters – who we are bound up with and in what ways. Life and Death happen inside these relationships (Van Dooren 2014, 60)*

A key part of maintaining a relationality with the microbiome is what I have referred to elsewhere as corporeal communication.[82] 'Corporeal communication' refers to the heightened attentiveness and sensitivity to "the corporeal as a way of communicating with the microbiome to understand what the microbiome can and cannot process and manage — a felt way of understanding" human-microbiome relationality (Beck 2019, 368). A recurring theme that arose throughout my interviews with FMT users was their increased attentiveness to corporeal bodily sensation as a mode of negotiating a

[82] I first proposed this concept in my MRes dissertation. It was then developed further in my paper 'Microbiomes as companion species: An exploration of dis- and re-entanglements with the microbial self" (Beck, 2019).

bodily microbial hospitality. Post-FMT, an awareness of bodily sensations for some users was an important mode of communication with their new microbiomes. Corporeal communication embodies traits akin to what Haraway has referred to as "embodied communication," which she defines as "co-constituting naturalcultural dancing, holding in esteem, and [being sensitive to] those who look back reciprocally. Always tripping, this kind of truth has a multispecies future" (Haraway 2008, 27).

Though similar to embodied communication, corporeal communication has some distinctive nuances. Haraway uses her relationship with her dog, Cayenne, to explore embodied communication (2008). She explains how she and Cayenne learn to relate to each other through the physical movements that occur during dog agility training and practice (ibid). Haraway highlights the fruitful interactions that occur when species physically meet, she describes "that the truth or honesty of non-linguistic embodied communication depends on *looking back* and greeting significant others, again and again" (Haraway 2008, 27 emphasis added). On the microbial scale, Greenhough (2012) explores the embodied communication that occurs *within* the human body in the Common Cold Research Unit (CCU) between 1946-90. Unpicking the embodied communication that arises among the human subject and the common cold virus in terms of the physical effect that the virus has on the human body, Greenhough comments that the materialisation of such symptoms was used as a way for CCU scientists to understand the virus (ibid). However, unlike the viral companions in Greenhough's work and outside of the highly-controlled environment of the clinical trial setting, the status of the microbiome is tricky to come to understand (ibid). While one may speculate on the status of one's microbiome from the consistency and appearance of one's stool (Hadizadeh et al. 2017, Vork et al. 2021), the status of the microbiome when inside the body[83] is much harder to assess due to the limited accessible technologies for microbial visualisation. Because of such, many of the FMT users that I spoke with referred to paying special attention to bodily and corporeal sensations.

Corporeal communication describes a sustained sensitivity to "corporeal bodily functions as a way of communicating with the microbiome" (Beck 2019, 368). Some FMT users referred to becoming more observant of bodily functions as modes of

[83] The microbiome ecology changes throughout the human digestive tract (Hellman et al, 2017)

corporeal dialogue between themselves and their microbiomes. Benny explained this when recalling his experiences with FMT:

> Immediately you notice your bowel movements improve and your energy improves. Long term it's just the same. That's what I was aiming for, to improve the bloating and pain, the constipation and diarrhoea and all the IBS symptoms. So yeah, it improved all of that. Also, going on such a healthy eating plan improved all the inflammatory triggers as well, and tiredness and whatnot.

For Benny, the sensations of bloating, constipation and diarrhoea are all prominent corporeal signifiers of microbial unease, or what Haraway would refer to as "painfully out of sync moments" (Haraway 2008, 26). As he detailed later, being 'in sync' with his microbiome manifested for Benny as the absence of symptoms or more regular and painless passing of stool, reduced bloating and improved skin and mental health.

In order to become more 'in sync' with their microbiomes, some FMT users referred to a heightened attentiveness and consideration towards bodily senses that might denote microbial expressions of discontent or stability. Mike demonstrated this when he described the shift in his relationship to his microbiome before and after the procedure: "I mean I have to listen to its [his microbiome's] nature and that. Like, even though I've been healed to a certain extent, I don't want to abuse myself". Sally also observed a corporeal communication that enacted a bodily hospitality when explaining the changes that she has made since undergoing FMT:

> I also don't eat a lot of animal products, but that being said, if my body craves something I *listen* to it, so I think the whole moral of this is that I listen to my body a lot more now than I did previously… So now, when I feed my body, I feed it more well-rounded nutrients, so I think that, just, it gave me a broader look on life and how to treat my body for longevity… I didn't *listen* to my body; I just pushed it too hard… I was probably averaging about 3-4 hours of sleep at night... So I wasn't listening. I was just burning myself out. Now I *listen* to my body. I don't know a good way to verbalise this, but it's just a way less intense environment that I am putting my body in… so when it's tired, I don't work out. When I feel like I have the energy, I might do a little bit more working out. I think the whole moral of this is that I listen to my body a lot more now than I did previously.

Sally exemplifies microbially-minded behaviours that enable her and her microbiome to be in sync. For her, attending to corporeal sensations and paying closer consideration to when she felt fatigued or rundown are ways of listening to her microbiome and taking what she hears seriously.

Emily, a microbiome industry research participant, demonstrated similar practices of corporeal communication.[84] She referred to her frustration with the dominant medical system as her condition worsened to the point where she could no longer work. Not being satisfied with the treatments offered to her, she decided to investigate herself.

> I had seen a few different doctors, both of which gave me the same diagnosis and also kind of like, just told me to take lots of antihistamines haha. I remember being like, I was 33 at this time, I could live for another 50 or 60 years and antihistamines is what you're recommending? Hah, so then this is really starting to get out my scientific training because I'm thinking, what's the root cause, why am I having these issues? And they are like, I don't know, but here take this, and I'm like, *but maybe my body is trying to tell me something?* (Emphasis added)

Emily then went on to explain that she started to listen to her body more, by first paying much more attention to her diet, taking seriously what disrupted her microbiome, and paying attention to her mental health, noticing when she was calm or in a state of heightened anxiety and how this affected both her body and microbiome. Though not an FMT user, Emily also engaged in practices of corporeal communication by being inquisitive to what her body was trying to tell her and, where possible, acting on such communication.

Corporeal communication speaks to Wilson's "phantastic theory of biology" which takes seriously mind-body relations rather than dismissing them as mere bodily sensations (2015, 43). This engagement with corporeal sense takes seriously the "sucking-sensing-feeling-phantasying" that Wilson points out are present throughout a human's life yet are often only attributed to children as they lack the ability "to stand at an affective distance from the body" (2015, 40-42). Importantly, however, engaging

[84] Emily is an industry member who started her alternative medicine website after having huge success in treating her autoimmune condition by addressing her PTSD and with alternative medicines such as acupuncture. She is also mentioned in Chapter Four on page 84.

with corporeal sense, for some FMT users, encouraged a revision of their understanding of their bodies and greater appreciation for their nonhuman selves. Some FMT users used corporeal sense as a form of phantastical imagining of the relationships that they have with their microbiomes, and through such, revised their human selves as more-than-human.

The practice of listening to the body and microbiome through a corporeal register was pivotal for some FMT users to enact hospitality to their nonhuman selves. I imagine this practice of corporeal listening as akin to what anthropologist Anna Tsing calls 'arts of noticing' – instead here the subject is not necessarily noticing the world around them but the microbial world within (Tsing 2015, 37). This practice of listening is also in sympathy with what Puig de la Bellacasa refers to as 'thinking with care', where practising corporeal communication generates bodily hospitality (2017). She explains that,

> For me, thinking with care stems from an awareness of the efforts it takes to cultivate relatedness in diverseness, which means, too, collective and accountable knowledge construction that does not negate dissent or the impurity of coalitions. It speaks for ways of taking care of the unavoidably thorny relations that foster rich, collective, interdependent, albeit not seamless, thinking-with (2017, 79).

Building from Puig de la Bellacasa's feminist theorisation of embodied knowledge and care, I suggest that this thinking with care is also appropriate in rethinking the microbiome specifically. Reimagining the body through human microbial relationality, where the human host has a responsibility for fostering the newly acquired microbial guests, for some FMT users, encouraged behaviours that enacted thinking with care for their microbiomes.

Attempts at corporeal communication are, however, not always successful in coming to fully understand the microbiome. Moments of mistranslation are frequent, as Billy frustratedly explained:

> But I have never been able to tie anything together to create much understanding … well if I upset it [my microbiome] enough my health might shift, but I can't, I could never … I visited Spain in 2015 for about two weeks. I felt really awful. I was really sick for hours every morning and just terrible, and I am kind of accustomed to symptoms

> shifting while I'm traveling, traveling somewhere else that has a different microbiome enviroment or different water, different so and so, but I couldn't say why it was so bad and I felt so awful. It's transient I guess. So I haven't really been able to, I can only make an educated guess as to why symptoms shift or why things happen why my microbiome reacts a certain way to certain stimuli … I still try though … that's all I can do.

Billy makes clear that corporeal communication is a means by which meditating on bodily sensations can guide one into attempting to know the microbial self but does bring up questions regarding the limits of knowing the nonhuman. Bodily sensations are not always directly revealing of specific behaviours and sometimes the host and microbiome speak different languages. A relationship between an FMT user and their microbiome may remain turbulent, enigmatic, and, at times, could indeed be thorny and painful. Though complicated and requiring continuous attention to, and interpretation of, physical bodily sensations, corporeal communication operated for many FMT users as one of the few ways that they could at least attempt to redress their relationships with their microbiome. What remains important is a continued attentiveness to the microbial as a form of care, though miscommunication may occur. As Krzywoszynska argues, "the inseparability of care and attentiveness means that attentiveness is always already present in care practices" (2019 664). Though Billy struggles with trying to understand his microbiome, he remains attentive to it. Such practices exemplify thinking with care to enact and maintain bodily hospitality that represents attempts at thinking *with* the microbiome. To refer back to van Dooren's quote at the start of this section, corporeal communication describes attempts to notice the microbial life that "we are bound up with and in what ways," to be attentive to the "life and death [that] happen[s] inside these relationships" (Van Dooren 2014, 60).

The politics of bodily microbial care

However, the human-microbiome relationship does not stand alone in the world. The external limiting factors that impact FMT users' ability to enact corporeal communication and bodily/microbial hospitality are important to consider. Krzywoszynska's (2019a) observations of some of the structural limitations that exist in maintaining soil human relationality are useful here. She explains,

> To put it bluntly, while we may all be ultimately interdependent on a Gaian scale, this cosmic interdependence does not absolve us of the practical work of inclusion and exclusion indispensable to the delivery of care for specific lives/things in specific places, at specific times. While the food-web model seeks to bring all cares together, with the care for one entity necessitating the need for another, and another…that care(s) are always multiple, and often in tension. The creation and maintenance of a "good world"/"good life" for one entity or set of entities inevitably encroaches on the good world or good life of some others. (ibid, 665)

Here Krzywoszynska shows that human nonhuman relationality is not without limits (Krzywoszynska 2019a, Krzywoszynska 2019b). Giraud (2019) too suggests that sometimes exclusions are needed to enact a firmer politics than more-than-human and posthuman work often implies. While some exclusions are necessary and proactive, there are also moments when external factors dictate entanglement. For example, Krzywoszynska observes the practical constraints that ecosystem service pressures involved in agricultural business models have in maintaining and upkeeping a soil human relationality:

> By focusing on anthropocentric functions, be they exclusively productivity or the broader "ecosystem services" package, these approaches continue to marginalise soil ecosystems as valuable in and for themselves, and as crucial to the survival of more-than-human lives in ways that may be beyond scientific understanding, and that may challenge current land-use decisions (2019a, 671).

Although the limitations that Krzywoszynska draws attention to are context-specific and perhaps do not observe the full spectrum of systemic and politically determining factors that affect human-nonhuman entanglement, her assessment of soil-human relationality takes into account some broader structural limitations. Importantly, she notes that dominant industrial attitudes that see soil as a commodity materially restrict the relationality that can occur between farmers and the soil they farm. I suggest that taking the sociocultural and political contexts that determine, and, for some, limit entanglements between humans and nonhumans requires more attention by more-than-human and posthuman studies generally. While human-nonhuman entanglement works to disrupt humanistic notions of individuality and in many ways offers conceptual potentialities for optimistic futures that are attentive to and caring for the nonhuman

(Haraway 2008, Haraway 2003, Gilbert 2017, Nading 2013, Tsing 2012, Tsing 2015), how these are experienced differently by different groups has not always been given the attention that it requires to guide us towards generative ethical action (Giraud 2019, Shotwell 2016). The restrictive forces that operate to determine the abilities of individuals and certain groups to enact and nurture human-nonhuman entanglement are important for furthering our understanding of the nuances of ethical and intentional relations between humans and nonhumans. More pressingly, there is an ethical responsibility to highlight areas of inequality that require urgent action. It is not enough to only focus on how the microbiome exposes human-nonhuman entanglements. There is a pressing need to further consider how such entanglements are shaped by structural and systemic forces that impact the development and wellbeing of the microbiome to consider the systems of exclusion involved in practicing bodily microbial hospitality. Therefore, by unpicking the powers that work to exclude some from financial and dietary resources, we may also see how such forces prohibit one's ability to enact a bodily microbial hospitality.

Within the FMT community, a significant limiting factor in achieving a nurturing and successful human-microbiome relationality is the relationship between FMT users' conditions, precarious employment, and financial instability. Many FMT users interviewed relayed how they had to change their jobs to more unstable work because of their conditions. As Earl demonstrated when explaining his experiences with FMT,

> I paint houses. Here it's a big thing. I went through ten or sixteen jobs. I got laid off from all of them. I couldn't show up to them. I didn't have… I could only paint when I felt good enough to do it, so that's how I started off, and I was going nowhere. It was something to do while I felt good enough to work. But after I got the FMT done, things have just skyrocketed. I am self-sustaining now, so that's what I do now – I run my own painting company and it's small but growing very quickly. It's been my whole life, it's all I do really. I don't have a girlfriend because I could not, I'm not always well enough to deal with even myself let alone someone else, or kids. I have to plan my whole life around my illness. I don't regret my life – I love it, but I don't live a very conventional life. It's just, I do the best I can with what I have. I have experiences and knowledge that I have gained along the way that I want to spread because I feel like it gives it, you know, purpose. My whole life is basically painting and my illness … but if I didn't have a mother who has taken care of me when I couldn't, I couldn't earn money

> or do anything, I wouldn't have had the opportunity to go to England [and receive FMT] and have this done. I would be on the street or dead.

And Billy:

> But it's [FMT] expensive. It's not even really even about the … I mean, a lot of folks with regular jobs, it's hard to get away from the States for a week or two. In the States you can do it, but it's challenging. I could do it, but it might cost me $10,000 to make the trip and pay for everything. So, um, since I have tried it twice and since I don't have money to burn, I have been hesitant to give it a third go [but some things would lead me to try again.] The first is that if and when I get my income to a better place where I have a stable income, I like to say that, well, it probably happens everywhere but there are people here who are like, 'oh, look at my new car' or 'look at my house with all these extra rooms' that they bought because they have money for that. But when I have that kind of money it goes into my health. I don't care if my car is ten years old, I want my body to cooperate … [and one thing] would be having much more disposable income and saying, 'oh well, I guess now my income isn't a concern and I can work towards my health.'

Both Earl and Billy expose the intricate interplay between juggling their health and financial stability, something comprehensively written on in disability studies (Edmonds et al. 2021, Galer 2012, Jetha et al. 2020, Schur and Kruse 2021). While Earl and Billy's experiences are somewhat specific to living in a country without universal healthcare, nor legal entitlement to paid annual leave, for many of the FMT users I spoke with outside of the US, their conditions prevented them from obtaining more secure employment. Because of their insecure incomes, Benny, Earl and many other FMT users simply do not have the time or money to focus on and invest in their microbiomes or health as they would like. Such financial restrictions and uncertainty hence inhibit their ability to enact corporeal communication and practice a bodily hospitality by, for example, slowing down, taking time from work to rest, and investing in microbially-minded foods. Hence, while a politics of care emerges in bodily hospitality, these are, for some, restricted by the temporal and financial conditions of their employment.

While the FMT users I spoke with were exclusively white, broader systemic forces that may play a role in determining the treatment and experience of microbially-

related conditions, such as systemic racism, are also important to note. A study released in 2016 showed that *C. diff* is less ubiquitous in Black than white Americans, "however, black race was independently associated with mortality and [more] severe CDI [*C.diff* infection]" than it was for white Americans (Argamany et al. 2016, 1). Some have speculated that this could be due "to anti-Black racism and discrimination in medical treatment in addition to disparities in health care coverage and access" (Cohen 2008, 116). The specific violent history of the medical establishments' abusive treatment of black people, as Argamany (2016) shows, still shapes Black experiences in medical spaces with microbial implications. The anti-Black racism that leads to lower rates of prescription of antibiotics (Argamany et al. 2016, Cohen 2020)[85] may reduce antibiotic microbial erosion, a key factor in developing a greater susceptibility to the overgrowth of *C. diff* (Blaser 2016, Ji et al. 2017). Although Black Americans had lower rates of *C. diff* than white Americans, they may suffer more when experiencing the conditions and face a higher risk of mortality due to decreased medical attention (Argamany et al. 2016, Cohen 2020). Here, it is important to recognise that microbial entanglement is restrained by broader systemic oppressive forces as, in the case of *C. diff* in Black Americans, anti-Black racism, absence of treatment and prevention of microbial entanglement is a life-or-death matter. This is but one example of the complex and interwoven relationship between structural oppression, microbial abundance, and overall health.

Conclusion

This chapter has explored FMT users' conceptions of their bodily identities through the human-microbe relationality that emerges via the procedure of FMT. Through FMT, some users I spoke with revised their understandings of their bodies from a singular subject to a host, one that homes the multitudes of lives that make up the microbiome. Some users re-conceptualised the body, recognising that human health and functioning is a multispecies achievement. Or, as Tsing would suggest, "human nature", as FMT shows, including the physical material human body, "is an interspecies relationship" (2012, 114). This conceptual understanding, for some, contributed to practices that enable the new microbiome to call the host's gut its new home. I have suggested that, once inside the body, the donation material that is used

[85] Where Black people's pain is not taken as seriously by medical professionals as white people's pain.

for FMT interacts with host behaviours informed by unconditional hospitality as FMT users adapt to welcome and maintain as much material from the procedure as possible. This, I have argued, sympathetically shifts Derrida's hospitality into new multi-species terrain as the procedure intends for the many nonhuman guests to *become part of the host*. These practices of care that intend to make the human body more hospitable first emerge in the changes to consumption and develop into broader reflections on lifestyle behaviours and habits, along with the role of emotions such as stress.

A bodily microbial hospitality is a continuous process that is not easily defined nor clear-cut. For many FMT users, attempting to enact hospitality to their microbial selves was challenging and although easing of symptoms indicated achieving a version of bodily microbial hospitality, those moments are transient and fluid. There are no set, predefined, or sure-fire ways of enacting bodily hospitality to maintain a beneficial relationality with the new microbiome. Instead, it is a process of finding what works, a process of considering and respecting the nonhuman self as vital. Whereas an ethic of hospitality for Derrida centres on when a guest will arrive, for FMT users an ethic of hospitality engages not with who is welcomed as a guest (due to the unknowable and unpredictable traits of the procedure) but instead on practising care via bodily microbial hospitality for longevity. FMT signals a significant step in attempting to reach a more stable and appreciative relationship between the users and their microbiomes. As the FMT users highlighted, to take good care of and maintain the microbiome, a more considered approach to the body is needed, one that values the role that microbial life plays in human health and functioning. I argue that for some FMT users, bodily microbial hospitality was maintained via corporeal communication, a heightened awareness of bodily senses that is taken seriously as a form of communication between users and their microbiomes. Underpinned by a politics of care, some FMT users employed a greater attentiveness to their microbial selves, which they recognised was important in attempts to regain more stable ecological functioning.

Relatedly, while bodily microbial hospitality and corporeal communication illustrate moments of human-nonhuman entanglement or "multispecies worlds" (Haraway 2008, 336), these worlds for some are precarious. For many FMT users, the ability to enact corporal communication or bodily microbial hospitality is also dictated by broader structural and systemic forces. Financial and temporal limitations occur for

many FMT users whose conditions prevent them from maintaining secure employment, stable finances, and the ability to invest in their microbiomes and general health.

Though the potentialities of human-nonhuman entanglement are conceptually exciting, also important are the external systemic and structural forces that shape such entanglements and need to be taken seriously within posthuman and more-than-human discussions. This chapter has centred FMT users' voices as a way of understanding the personal politics of the microbiome that emerge via FMT. How microbiome understandings emerge outside of FMT and in the public more generally remains unanswered. The next chapter critically assesses publicly available microbiome testing kits that make promises of greater microbiome understanding and observes the politics that are entangled in such technologies.

Chapter Seven: Coming to know a microbial self via microbiome testing kits

This chapter explores how the microbiome becomes known through Direct-to-consumer (DTC) [86] microbiome testing (MT) kits. While much has been written on genetic testing as a way of uncovering genealogical ancestry and kinship (Nash 2004, Roth and Ivemark 2018), as a now fundamental practice in reproductive technologies (Almeling 2011, Franklin 2006, Goodwin and Goodwin 2010, Spar 2006), as a mode by which genetic difference is stigmatised (Raspberry and Skinner 2011), and as an opportunity for the public to gain a molecularized understanding of their bodies (Rose 2007), due to the recentness of microbiome testing, the theoretical and conceptual limits of DTC MT are yet to be explored by critical social scientists. DTC MT kits are a focus of interest within this thesis broadly as they represent a method by which the microbiome can be made knowable. They were often the topic of discussion on Facebook advocacy pages. Some FMT users used the tests to track microbiome diversity before and after their FMT procedure. However, the products are mostly advertised to members of the public. This chapter explores the instances and limits of coming to know the microbiome that microbiome testing companies offer to the public and speculates on the 'self' that these microbiome testing kits produce.

[86] Direct-to-consumer healthcare products are sold without the oversight or involvement of healthcare professionals, instead they can be purchased and used directly by consumers.

While the tests offer the ability to track microbiome diversity over time, I point to the very real limitations of what recording the taxonomic presence of one's microbiome can offer. In particular, I lay out how these tests work to individualise the microbiome and are oblivious to, and do not consider, the wider societal structures that play a role in microbiome development. The chapter starts with an auto-ethnographic vignette to set the scene of what is involved in using the testing kits. I then critically review what the microbiome testing kits can contribute to improving one's microbial, bodily knowledge. Using Nikolas Rose's concept of ethopolitics, I then assess the conceptual work that microbiome testing products perform as modes of self-governance. I propose that while the kits animate the discourse of ethopolitics and individualised responsibility for the maintenance of one's body, the tests do very little to improve consumers' microbial understanding of themselves beyond introducing the concept of microbial multiplicity to the human body. To do so, I first critique the methods by which the tests obtain information about the microbiome and second, by pointing out that important personal information is not considered in the tests. I argue that these factors combined expose how the kits reproduce a false sense of embodied control while also individualising the microbiome. Drawing from ethnographic experiences of uBiome's sudden and unexpected closure, I draw attention to the risks that exposing one's microbiome into private companies presents. I suggest that such companies produce a privatised politics of the microbiome and expose users to the vulnerabilities of engaging one's microbiome into the flows of a biocapitalist economy. Finally, I propose an onto-ethico-epistemic shift as a mode through which to diversify how the microbiome is and can be made known that animates corporeal sensing and avoids engaging with such privatising microbiome testing companies.

Using microbiome testing products

I was motivated to engage with microbiome testing products as a way of coming to know my own microbiome. Both uBiome and Atlas Biomed, using 16s rRNA sequencing methods, provide the consumer with various taxonomies of microbial life present in a faecal sample, which users take themselves and send off for analysis. At the time of taking the test (2019), uBiome was attempting to pivot the microbiome testing kits towards medical diagnosis (Farr 2019b, Marcus 2021, Morse 2021, Vinluan 2018). As not enough is known about the microbiome to integrate it into medical analysis and intervention, at the time, uBiome were critiqued for trying to implement

their microbiome testing kits into medical practice (by billing medical insurance companies for the kits) (Marcus 2021). Atlas Biomed, however, has positioned the tests as modes by which to improve your diet and nutrition by providing food recommendations based on your results. The excerpts below describe my experiences of using both tests.

2nd April 2019

I have been in Boston, MA for a week and I wake up to find that my uBiome explorer test kit has arrived. I have waited a week to use the test after speaking to a microbiologist at a conference, who told me this is roughly the amount of time it takes for your microbiome to acclimatise to a new environment. I hope that this test result will represent my 'American microbiome'. I open the kit, unpack all the components (pictured below) and read the instructions.

Figure 3 uBiome 'Explorer' microbiome testing kit

I am first told to fill out a detailed survey online. Questions largely focus on diet, bodily descriptors, physical and mental health, family health conditions and medical history, medical treatments (either received or ongoing), antibiotic and medication history, known allergies and conditions, supplement consumption,

stool qualities, and lifestyle information such as exercise habits, diet, and if/how much I smoke and drink.

When taking the sample, I am told to fill the toilet bowl up with toilet roll and to try and keep urine away from the faeces to prevent cross-contamination. As instructed, after a bowel movement I run the swab over the used toilet paper, just enough to colour the entire swab. I then insert the swab into the sample tube provided and stir for one minute. After disposing of the swab, I close the test tube and shake for one minute more. I then register the test tube online by entering the barcode on the uBiome dashboard page, pack it away into a plastic bag and then into an A5 box and head to the closest mailbox to send it back to the uBiome lab.

Taking the faecal sample is intimate, smelly, and unsettling. Having spent most of my life avoiding my own faecal matter, the experience of doing such a process for my doctoral research was amusing and novel. I receive the test results two months later, after a considerable delay in processing my sample.

05th November 2020
After a brief stint in hospital and many courses of antibiotics later, I purchase my second microbiome testing kit from Atlas Biomed (pictured below). The instructions are mostly the same as before. However, this time I am given a faecal catcher and a small shovel to assist with picking up the faecal matter. I am similarly directed to fill out a detailed survey, with questions paralleling the ones asked by uBiome.

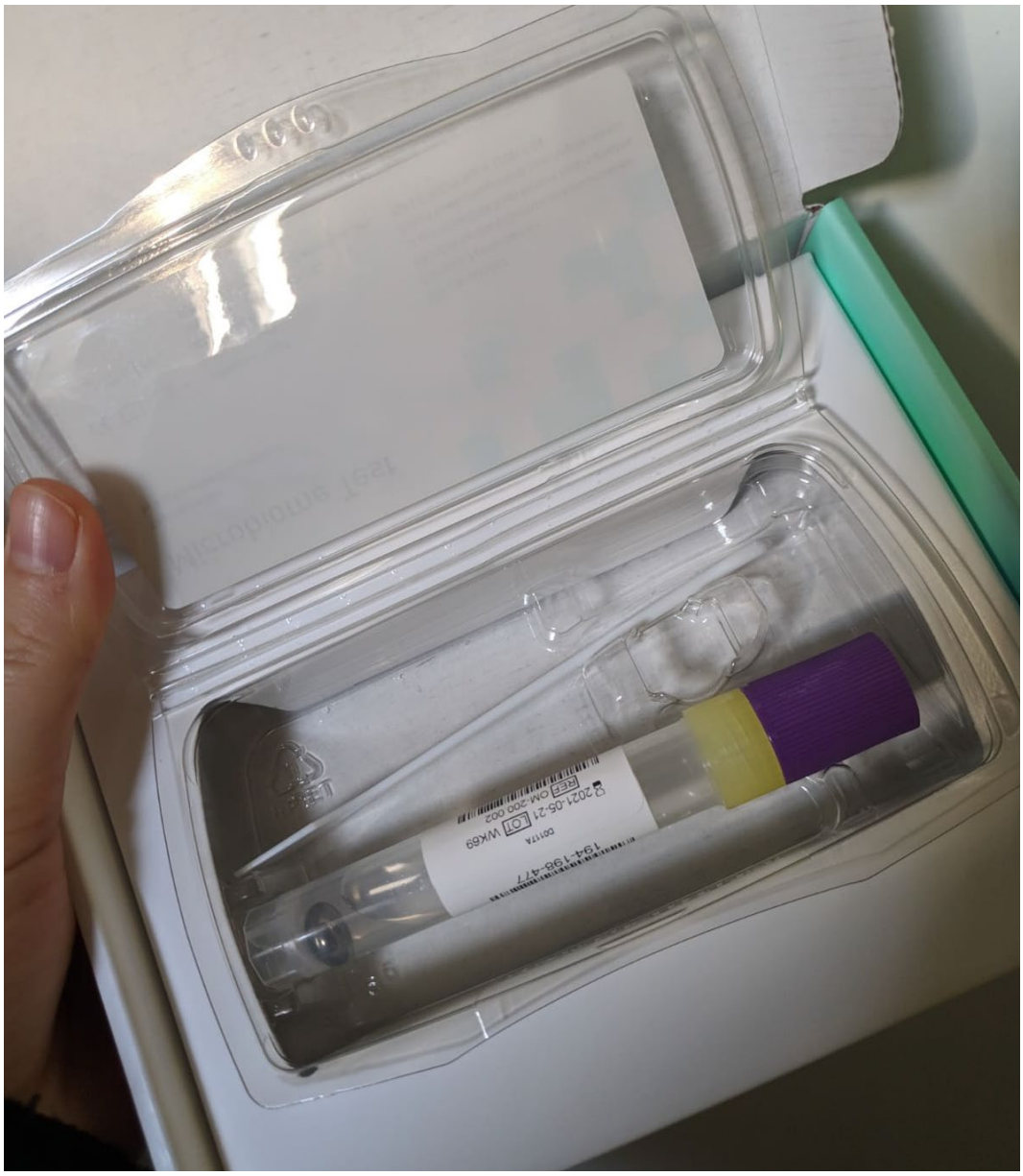

Figure 4 Atlas Biomed microbiome testing kit

To take the sample, I am directed to use the toilet with the faecal catcher strapped across the toilet bowl. I use the little shovel provided to pick up an amount of faecal matter close to the size of a pea and insert it into the provided test tube. What results is a messier and more significant clean-up process than my uBiome test. Collecting the faecal sample is similarly unpleasant but having previous experience, the process is less shocking. I seal the test tube, register the barcode on the tube, pack the tube away into a similar opaque plastic bag

and then into an A5 cardboard box and drop it into a letterbox across the road. This time the results come promptly after four weeks.

Test Results

uBiome

As I lost my data from uBiome I am not able to provide my results. Pictured below are some that I have sourced from an online article by Jill Duffy (2019) who reported her experiences with uBiome's Explorer test. However, from memory, notable findings from my uBiome results included having a microbe associated with deep sleep, low amounts of butyrates and a handful of bacteria that are very rare. Because of the loss of data, I was not able to make the comparison between my 'American' and 'English' microbiome.

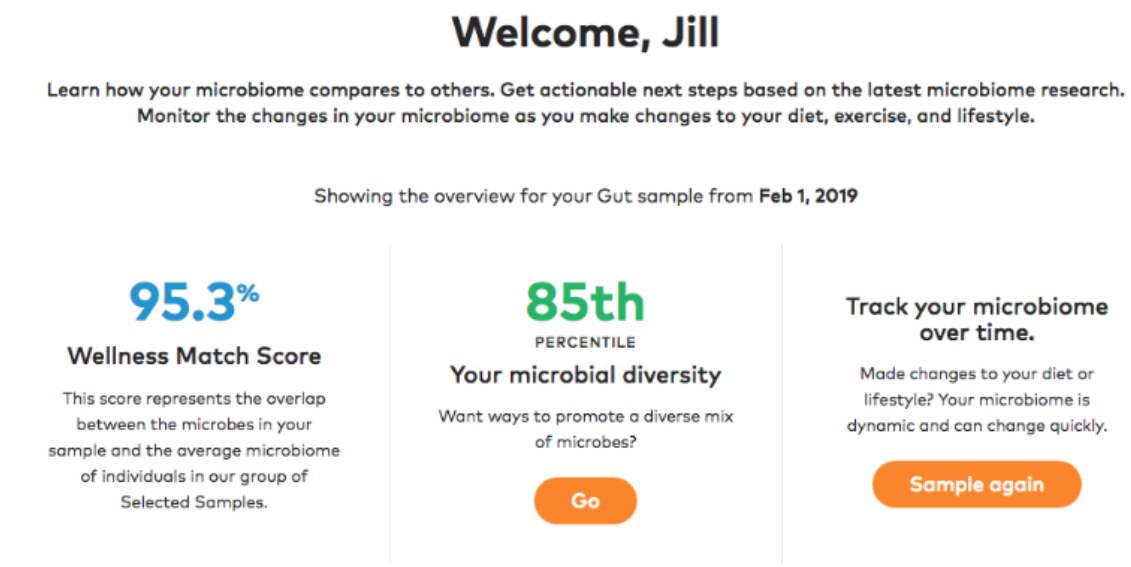

Figure 5 uBiome 'Dashboard' page, Image credit: Duffy 2019, np

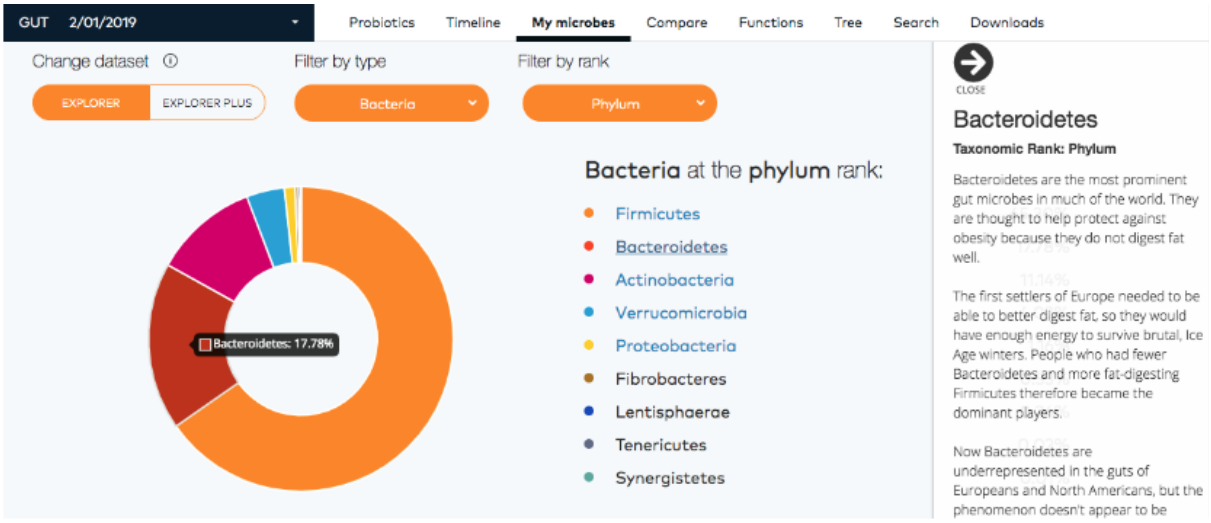

Figure 6 uBiome 'Microbiome breakdown' page, Image credit: Duffy 2019, np

Atlas Biomed

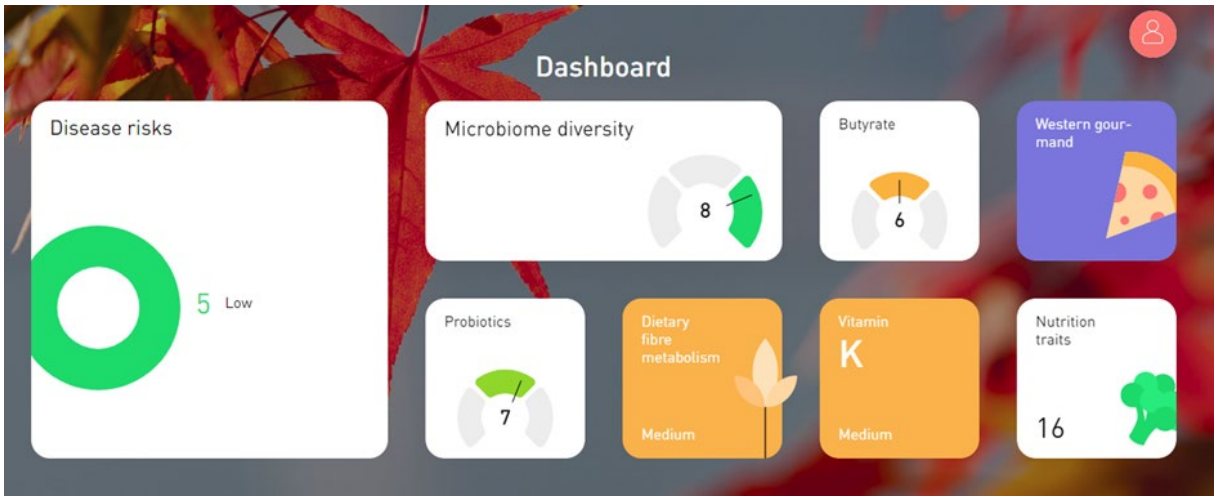

Figure 7 Atlas Biomed test results, 'Dashboard' page, 2022

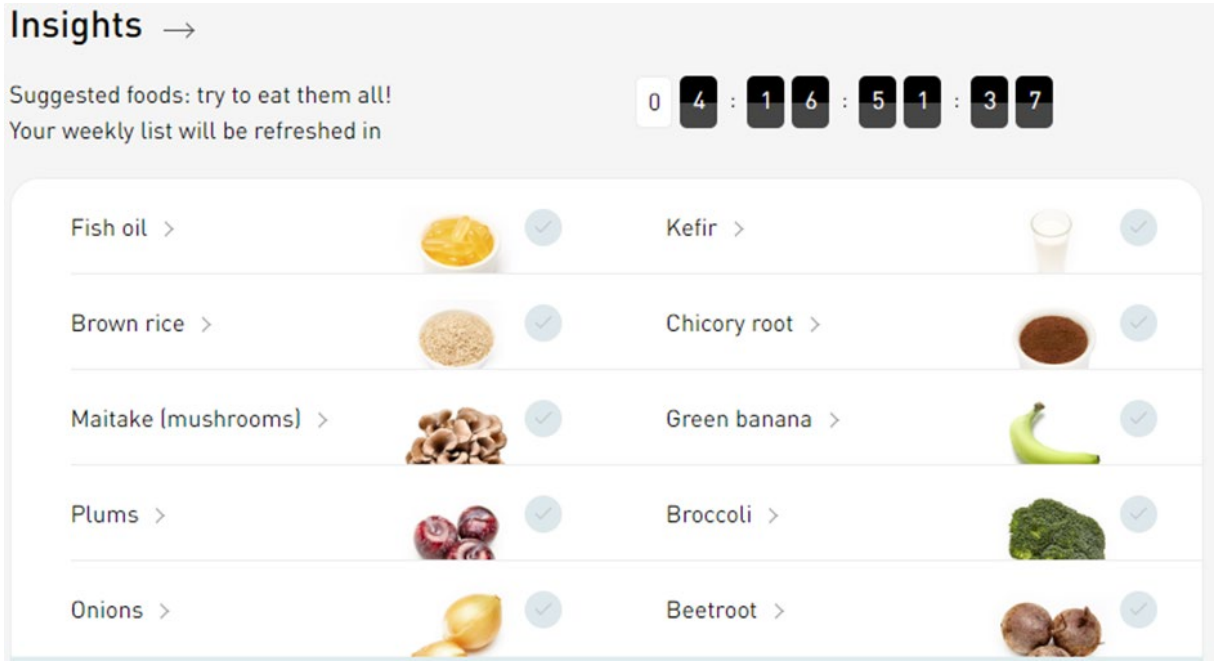

Figure 8 Atlas Biomed test results, 'Insights', 2022

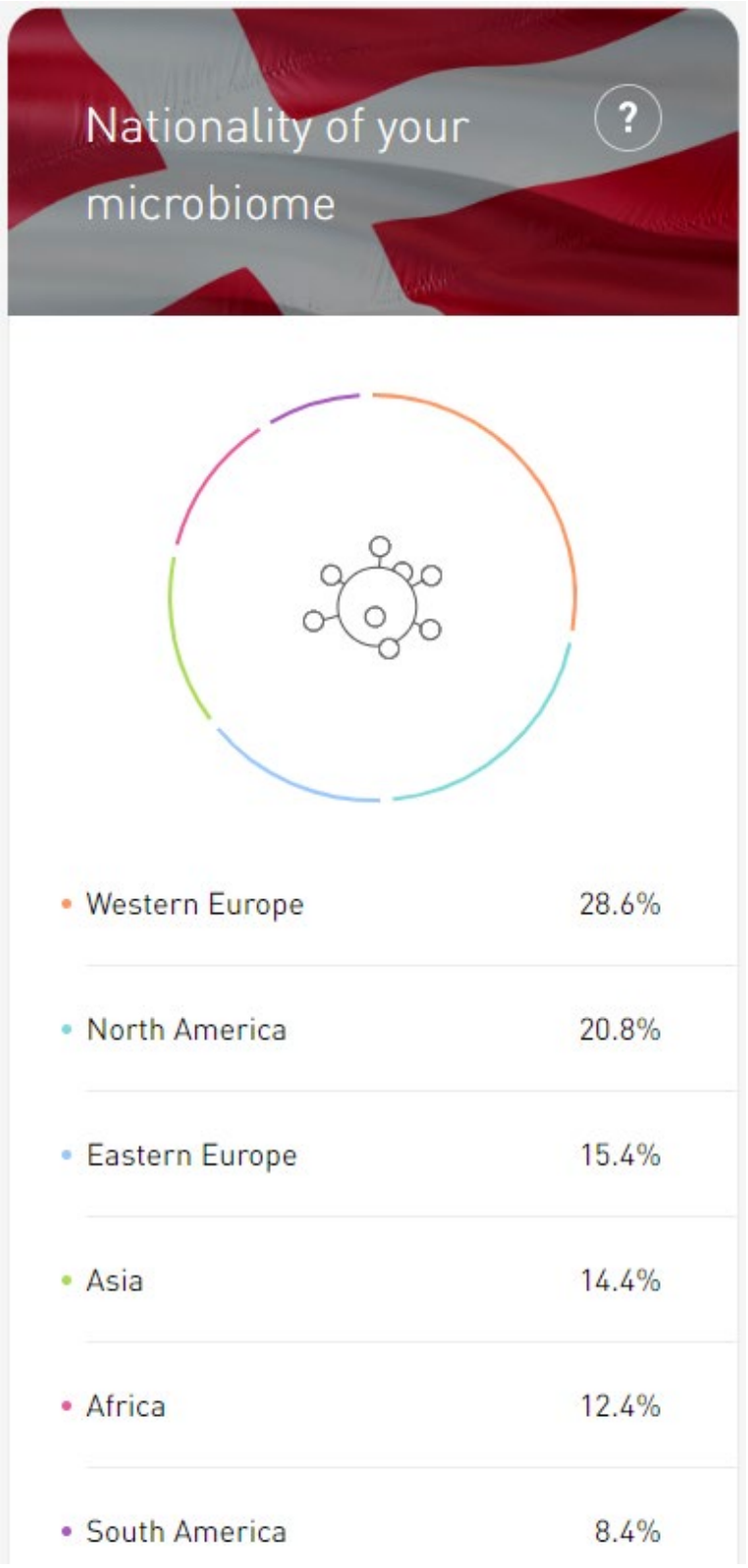

Figure 9 Atlas Biomed test results, 'Nationality of your microbiome' page, 2022

Disease risks

Your disease risk profiles are calculated using the most current research in the field of genetics and human health. The risks are organised from high to low, so you know where to focus your efforts. This information will help you to design a personal disease prevention programme with the help of your doctor.

Name	Your risk	Data sources
Ulcerative colitis Digestive system	Low	
Diabetes type II Endocrine system	Low	
Obesity Endocrine system	Low	
Crohn's disease Digestive system	Low	
Coronary heart disease Cardiovascular system	Low	

Figure 10 Atlas Biomed test results, 'Disease risks' page, 2022

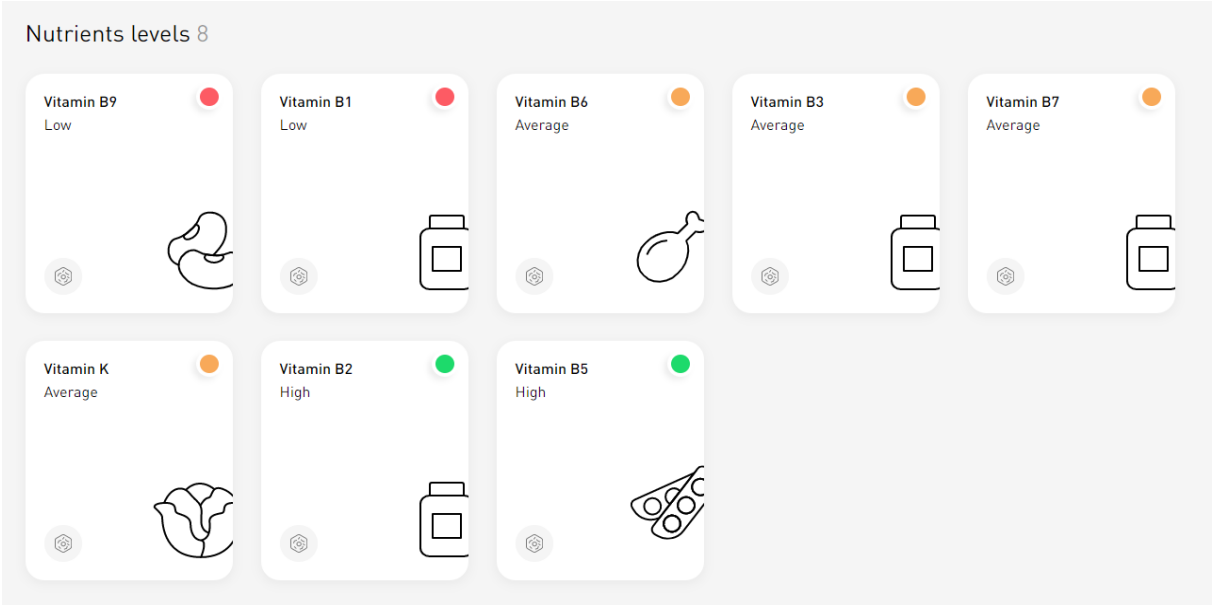

Figure 11 Atlas Biomed test results, 'Nutrient levels' page, 2022

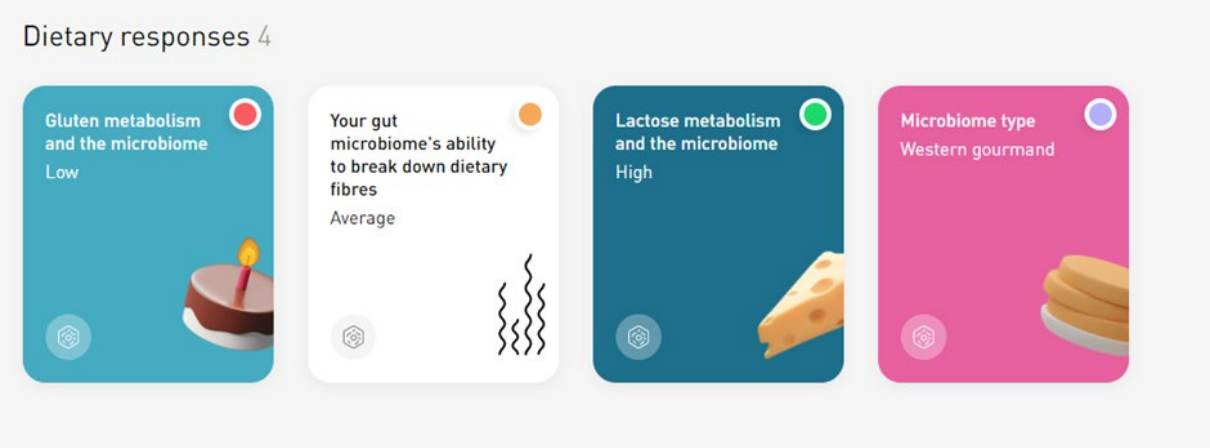

Figure 12 Atlas Biomed test results, 'Dietary responses' page, 2022

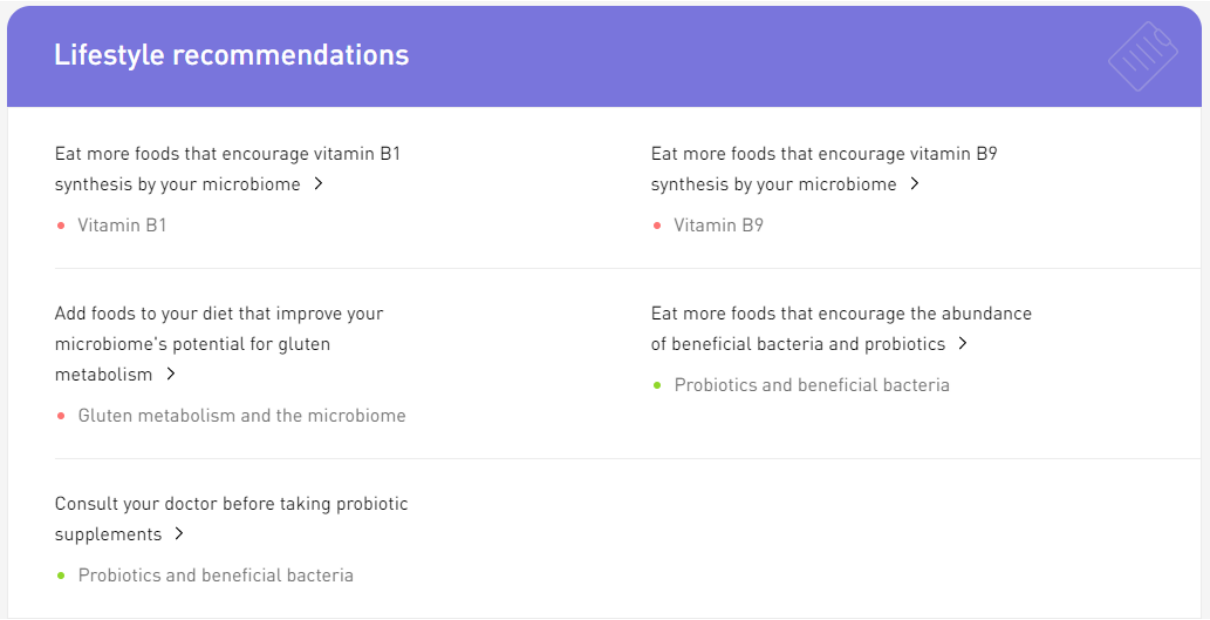

Figure 13 Atlas Biomed test results, 'Lifestyle recommendations' page, 2022

What do microbiome testing kits do for microbial, bodily understandings?

The visual representation of one's microbial life that the tests results offer represents a potential onto-ethico-epistemological moment for the user to reconsider what the human is. Being able to see the abundance of microbial life that inhabits the body may enable one to recognise the nonhuman diversity within the human and recognise that the human self is part of a broader ecological plurality. In part, the test results offer a moment to engage in ethical recognition that the individual is part of a broader multispecies ecology that helps to sustain oneself and that the 'self' is multiple.

However, similarly to Direct-to-consumer (DTC) Genetic Tests (GT) (Helgason and Stefánsson 2022), the validity and usefulness of the DTC MT results are questionable. The microbiome testing kits only represent the aerobic microbial life from the lower intestine, which excludes all anaerobic and upper intestinal microbes. Thus, from the start, the breadth of your microbiome being analysed is relatively narrow. Furthermore, these microbiome tests only reveal what the microbiome is at the specific time of taking the test.

> It would be like taking a photo of your garden and sending it to a friend to get their input on how well the garden was doing year-round…Everything from seasons to the weather that day (did it rain? was there a drought?) could influence how the garden appeared in the picture (Brodwin 2019, np).

Though the visualisation of the vast multitudes of microbial life that inhabit my body was initially striking, after deeper reflection, I realised that Atlas Biomed and uBiome told me nothing that I did not already know: that I have a western diet; and, should eat more vegetables and fibre. Being given a large list of microbial taxonomies was not very helpful for telling me about my body. Along with many other FMT users that I witnessed on the Facebook FMT advocacy pages, I was unsure of how to interpret the results leaving me to feel confused. In fact, broader critiques of taxonomic recording also weaken the explanatory value of the test results that such testing companies offer. Further, different microbial communities can perform the same function despite differences in the taxonomic presence of microbial life (Doolittle and Booth 2017). Philosopher Austin Doolittle and evolutionary biologist Ford Booth use the metaphorical image of microbiome ecologies performing functions as singers singing a song to explain this (ibid). Different ecologies of singers (microbes) will sing from the same song sheet (functions). They suggest that

> Songs can be performed by choruses composed of different singers, in different venues at different times, perhaps employing distinctive arrangements or unusual instrumentation in each instance, but all are recognizably versions of the same song (ibid, 15).

Hence, microbiome relations and patterns of interaction should be involved concurrently when thinking about "manifestations of metabolic relationships" (ibid, 15). Put differently, ecologies can perform the same function independent of the taxonomic presence of microbial life. In relation to the microbiome test results then, discovering only the taxonomic presence of your microbiome is limited in what it can tell you as taxonomy does little in revealing what the microbes *do*.

More than revealing the taxonomic presence of your microbiome, similarly to the HGP and genetic testing more broadly, the microbiome tests produce a "genetically pure, isolated and distinctive human" (Nash 2004, 4, see also Hayden 1998, Marks 2002). Unlike genetic testing, however, the microbiome is represented as changeable by testing companies, shown by the encouragement to take the tests frequently. The use of taxonomic representation, alongside the limited list of influencing factors, work to individualise and initiate a false sense of embodied control. To represent the microbiome only by taxonomy reduces the importance and weight of the vast ecological diversity that is central within its functioning. These factors combined enable the user of the test to remain ignorant to the broader ecological enmeshment that they are entangled within. When the externally influencing systemic and societal factors that implicate the microbiome (e.g. how one's income or cultural background may dictate one's exposure to stress and risks from the environment such as air pollution), are not communicated to the consumer, it is assumed that merely taking dietary advice from these companies will work to improve one's own microbiome. Hence, by decontextualising the consumer from the broader ecological and sociological settings, the testing kits work to individualise and subjectify the microbiome

The method by which the DTC MT analyse the consumers microbiome also work to produce a universalised microbiome. First and foremostly, the legitimacy of how one's data is interpreted and represented by both Atlas and uBiome is questionable. uBiome and Atlas Biomed interpret your data in aggregate, by comparing samples against the other samples in *their* databases. It is unclear who is in their databases, and for uBiome it is now impossible to find out as they have since declared bankruptcy and closed. As for Atlas Biomed, I had to email them to find out how they interpret and represent individuals' data as it was not clear from their website. They replied saying that they compare individual data to a "specially selected subset of data from healthy samples" (personal email). The demographic of 'healthy' samples

is not detailed. It may seem fair to suggest that, considering the relatively high cost and experimental nature of the product, those contributing were largely white, affluent westerners who could both afford the test and were happy to contribute their data. Without clearly distinguishing the demographics of the population that one's data is being compared with, there is an assumed universal standard microbiome against which one's own test results are compared.

A universalising approach to the body is further perpetuated by the surveys that both companies requested be done before the faecal sample was taken. For example, a number of factors that could provide insights into microbiome variation were not included in the survey. Absent were important biological and socio-cultural questions. For example, questions about where someone is in their hormonal cycle and the use of Hormonal Replacement Therapy (HRT) were not included in the survey. It is known that hormones impact the microbiome, as is evidenced in the changes in the microbiome that occur during pregnancy (Koren et al. 2012), puberty (Jašarević et al. 2016) and the menstrual cycle (Bharadwaj et al. 2015). There is currently little research on microbiome variation during a woman's menstrual cycle, and the lack of questions by Atlas and uBiome perpetuate ignorance to how microbiome variation might be implicated by a monthly (female) instead of daily (male) hormonal cycle. Furthermore, neither race nor ethnicity were included in the survey. This tendency to assume certain universal standards of the human microbiome is supported similarly within genetic testing where "the status of science as rational, objective, disinterested and authoritative" can reproduce such statements as truth (Nash 2004, 3). To insinuate the existence of a universal microbiome, that is irrespective to age and geography and adopts the white male as the norm, is misleading to understandings of the microbiome and reproduces a damaging politics of exclusion. As is well recognised the microbiome is vastly different between and within populations (Yatsunenko et al 2012). As Callum Karn explained when answering a question about the possibility of a universal microbiome

> It's certainly not true that there's a group of microbes defined by taxonomy that are common in everyone who's healthy even when you're restricted to one western country for example, so I think the search for a core or typical microbe is something

> that is attractive conceptually but is strongly contradicted by the evidence, although people don't want to believe the evidence because the concepts so attractive.

More than misleading, what the universal standard is assumed to be also requires attention. Those that use the testing products are more likely to be affluent. To suggest that the demographic of testing product users represents the universal standard diminishes the vast microbial diversity present across demographics.

To summarise, the visualisation of the immense amount of microbial lives that inhabits the body and being introduced to the multiplicity of the microbiome at a general level, for some, may encourage a critical reflection on the human as an individual organism that is distinct from nonhuman life. However, beyond introducing the consumer to the vast array of microbial life that inhabits the human body, the DTC MT results do not offer entirely useful or practical information about the microbiome or body. Instead, and as I have argued, the testing kits work to individualise and universalise the microbiome by decontextualizing the consumer from broader societal factors and politics that contribute to microbiome health and functioning, such as stress and environment, and, further, to produce the consumers results only against the population within their own data set, assumes the universal standard is there data set, which can be assumed to be largely white and affluent.

Biopolitical ramifications of testing kits

While the section above explored how the DTC MT products produce the microbiome for the consumer, I now want to look at the broader biopolitical implications of the tests. As biological technologies, beyond providing microbiome data, microbiome tests operate along biopolitical terrains. Biological technologies are powerful beyond their design functions. More than telling people about their microbiomes, such technologies are influential in how we understand and interact with our microbiomes and consequently the practices associated with our bodies and general health. As Rose shows in relation to "reproductive technologies", they

> Entail much more than the craft skills of doctors using new instruments and techniques. They engender certain ways of thinking about reproduction, for the subject and for the expert, certain routines and rituals, techniques of testing and practices of visualisation, modes of advice giving and the like (Rose 2007, 17).

He then uses organ transplants as an example of how medical technologies conjure

> New sets of social relations bringing together donors and recipients across time and space, entailing, and generating new ideas about end of life, new sense of ownership to the body and rights to a cure, as well as complex financial institution relations that make the procedure possible…these new biotechnologies, then, must be understood as hybrid assemblages oriented toward the goal of optimisation (ibid, 17).

Rose argues such technologies have implications beyond their practical uses to modify and improve health: “they are technologies of life” (ibid, 17). These technologies are productive as modes of governance that dictate how one conducts oneself (Foucault 1980) and are formative in Rose’s conception of ethopolitics, which he describes as being “part of a political and ethical field in which subjects are compelled to treat their lives as planning projects and look for ways to augment their life possibilities” (2007, 38). If “biopolitics’ collectivises and socialises, ethopolitics concerns itself with the self-techniques by which human beings should judge themselves and act upon themselves to make themselves better than they are” (ibid, 27). A material way through which these discourses are propelled is via medical products and services. Rose explains “patients are increasingly urged to become active and responsible consumers” of such products “ranging from pharmaceuticals to reproductive technologies and genetic tests [DTC GT]” (ibid,4).

The popularity of DTC GT products, in part, stems from their ability to offer the consumer with novel bodily understanding (Nordgren and Juengst 2009), what Rose refers to as a ‘molecularized’ understanding of the body “where contemporary biomedicine envisages life at the molecular level” (2007, 5). DTC MT products work in a similar way as they offer the possibility of improving the health of the consumer by providing them with increased bodily and microbiome knowledge and offer personalised modes of bodily intervention (Knoppers et al. 2021). At first glance, DTC MT products, such as uBiome and Atlas Biomed, seemingly exemplify Rose’s concept of ethopolitics. Similarly to genetic testing, the framing of the microbiome testing kits offered by uBiome and Atlas Biomed arose by stressing consumers’ responsibility for their futures (Rose 2007, 27). In particular, Atlas Biomed, by offering both genetic and microbiome testing, emphasises the ability of the test to help secure a healthy future.

By giving users more information about their bodies genetically and microbially, the tests seemingly offer the consumer practical ways to prevent future illness both through disease risk management and food recommendations. The statement “take care of the future today” is littered across Atlas Biomed’s webpages (Biomed 2021). Both Atlas Biomed and uBiome encourage consumers to test consistently in order to see the fruits of lifestyle changes recommended by both companies. By providing recommendations for improving one’s health based on microbiome data, the tests fit into broader biomedical discourse that contributes towards “the objective of optimizing and enhancing the human body” (Wehling 2011, 238). Atlas Biomed exemplify this as they encourage consumers to engage with their product by suggesting that the testing kits and recommendations enable one to “optimise microbiome vitamin synthesis” hence improving one’s health (Biomed 2021).

Emphasising one’s duties to maintain their health is instrumental in the production of the biological citizen and somatic individual, central cogs of the ethopolitical machine (Rose and Novas 2005, Sparke 2017, Wehling 2011). Biological citizenship describes how “the duties, rights, and expectations of human beings in relation to their sickness, and also to their life itself reorganise the relations between individuals and their biomedical authorities” (Rose 2007, 6). In this process, what Rose refers to as the semantic individual is developed and enacted, where behaviour is shaped in relation to the “corporeal bodily experience” (ibid, 6). uBiome was founded using ‘citizen science’ as one of its key selling points, establishing “the citizen scientist as a prosumer, both producer and consumer, of scientific and biomedical research” (Ironstone 2019, 164). In Jessica Richman’s (the founder of uBiome) TED Talk[87] titled “Could a citizen scientist win a Nobel Prize”, she encourages citizens to engage with uBiome’s testing products to enable (seemingly) anyone to learn about their biological make up (TEDMED 2013, np). While the accessibility of paying for the kits is not mentioned, this mode of citizen science expands the biological citizen from patient groups to the wider population.[88] Although the motivations to engage with these kits ranged from general curiosity to seeking solutions to sickness, the citizen science selling point of the product encouraged the general public and patient groups to

[87] TED talks, run by the company TED are short punchy and often motivational talks given by influential speakers usually covering themes of “education, business, science, tech and creativity” (TED nd, np).
[88] Examples of expanding the biological citizen are also present in the work exploring female fertility management, see Hamper (2020).

engage with their bodies on a molecular microbial level and position themselves as authorities (Ironstone 2019). The public, via uBiome, were made to think that they could contribute to scientific advancement and, as Richman's TED Talk would make one believe, engage more lay members of the public in the production of scientific knowledge (ibid).

However, for FMT users specifically, their ability to engage in the biological citizenship practices that intend to restore one's health or prevent one's health deteriorating are determined by more than the marketing practices of biotechnological companies. While some FMT users did engage with uBiome's products, with some (more commonly American users) using their products instead of other health services and health insurance, many more FMT users could not afford such products. The closure of uBiome greatly contributed to some FMT users' movement into the periphery of biomedical discourse and increased mistrust of the biomedical establishment.[89] Despite selling itself as 'citizen science,' access to uBiome's products were limited by high costs ($110 per kit), and Atlas Biomed's testing kits came to £199 (£208 including shipping).[90] While Rose's work well exposes the increasing individualised responsibility to manage one's health, as he suggests ethopolitical tools, products and technologies produce

> Associations that link us to others with whom we share aspects of our biological identity. Our very biological life itself has entered the domain of decision and choice; these questions of judgment have become inescapable. We have entered the age of vital politics, of somatic ethics, and of biological responsibility (2007, 40).

The ability to action this responsibility is not equally available to everyone. Instead, the inequality in accessing tools and practices of biological citizenship brings to the fore Sparke's critiques of the biological citizen and somatic individual (2017). Forced into insecure employment due to their conditions, many FMT users represent the sub, rather than biological, citizen (2017). As Sparke maintains, ethopolitics needs to be contextualised within broader oppressive systems and structures, such as neoliberalism, as such forces have a role in determining one's access to

[89] As discussed in Chapter Four.
[90] Though in comparison to the cost of processing and sequencing microbiome data the cost of the testing kit is relatively low, this price remains inaccessible for many, especially FMT users in precarious employment with insecure incomes.

biotechnologies and hence the production of the biological and sub-citizen (2017). While ethopolitics operates in novel spaces and registers, there is a need to recognise the dynamic and overarching structural forces at work because of the powerful role that they play in dictating how biological governance pans out and affects differing populations differently. The next section goes on to explore in more depth the role that the broader structural forces of neoliberalism and free market capitalism have in dictating the impact of such biotechnologies.

Musings on microbial knowledge and the free market

A breakdown of uBiome's demise

January 2019

uBiome shifts the company's focus from citizen science to drug development by attempting to incorporate their microbiome testing products into Medicare (Keown 2019).[91]

April 2019

The following email is sent to customers from uBiome,

On Friday, April 26, 2019, federal authorities, pursuant to a search warrant, searched uBiome's facilities in San Francisco. We are cooperating fully with federal authorities on this matter.

Our Board of Directors has appointed John Rakow, our General Counsel, as Interim CEO of uBiome, effective immediately.

Our Co-CEOs, Jessica Richman and Zac Apte, are currently on administrative leave as we conduct an independent investigation into the company's billing practices, to be overseen by a Special Committee of the Board. Once complete, we will take any corrective actions that are needed to ensure we can become a stronger company better able to serve patients and healthcare providers.

[91] Medicare is a federal health insurance program that offers insurance to the disabled and those over 65 in the United States.

We will also be temporarily suspending clinical operations**. At this time and until further notice, uBiome will not be offering SmartGut or SmartJane. **We will continue to offer and process our Explorer product.

*It is important to reiterate that this is a **suspension**. This does not mean we will not offer clinical products in the future, nor does this insinuate a lack of value or utility in our products. There is significant clinical evidence that demonstrates the utility and value of uBiome's products as important tools for patients, healthcare providers, and our commercial partners. We look forward to continuing to demonstrate this clinical utility and value* (original emphasis Farr 2019a, np)

The email also stated that if your sample was yet to be analysed that it could be destroyed. After googling, I see that the FBI had raided uBiome due to possible insurance fraud. Speculations emerged that the fraudulent practices were due to patient billing via Medicare (Farr 2019b).

May 2019

The uBiome website becomes inactive, showing a holding message saying that the website would be back online soon. The uBiome results portal page also becomes inactive with a similar holding message.

September 2019

News headlines clarify that uBiome has filed for Chapter 11 bankruptcy, meaning they are reorganising the business while continuing to operate (Keown 2019). I go to the website to see if I can retrieve my data again, however both the results portal and website are inactive with no holding message.

October 2019

uBiome goes into liquidation (Ebemidayo 2020).

December 2019

Psomagen, "a North American sequencing-based contract laboratory service and data analysis provider" (Psomagen 2022b, np), acquires uBiome's assets – these include patents, data, samples, lab site and equipment for $7.7 mil

which was approximately 1% of uBiome's enterprise value. (Ebemidayo 2020, Han-soo 2019).

March 2021

On the 18th March 2021 the U.S. Securities and Exchange Commission (SEC) charge Jessica Richman and Zac Apte with conspiracy to commit both securities and healthcare fraud as well as money laundering (Morse 2021). They are said to have defrauded "investors out of $60 million through misleading statements and false representations of the company's prospects" after valuing their company at $600 million (Gelman 2021, np). SEC are currently "seeking to bar Richman and Apte from serving in future officer and director positions" (ibid, np). "If convicted, they face severe financial penalties and potential jail time" (Wood et al. 2021, 12). However, as they have left the US, they are now legally fugitives (Mathews 2021). The uBiome websites all remain offline and customers' data was never recovered.

My experiences with microbiome testing companies exposes well the mode of extractivist dispossession common to the biocapitalist economy (Rajan 2006). Central in such forms of dispossession is the privatisation of biological and bodily material or data, also known as bioinformation (Parry and Greenhough 2017). There are growing concerns about the privatisation of bioinformation due to its increasing prevalence, with specific critical attention towards how bioinformation is being extracted, who is profiting from this extraction, and who is excluded in the process (Kent and Meacham 2019, Parry and Greenhough 2017, Spector-Bagdady 2016). Conversations regarding the privatisation of bioinformation have largely been focused on genetic information (Greenhough 2006, Parry and Greenhough 2017, Spector-Bagdady 2016) and the commercialisation of such genetic information, cells (Almeling 2011), and blood (Kent and Meacham 2019) with few references regarding the specificities of the microbiome.[92] While the engagement of the microbiome into the biocapitalist economy via the utilisation of DTC products brings up similar debates that are discussed regarding genetic testing, including informed consent (Bunnik et al. 2014, Hauskeller

[92] Some of which, written prior to uBiome's scandal refer positively to their research practice (cf. Lorimer et al. 2019).

2011, Niemiec et al. 2016, Niemiec and Howard 2016, Parry and Greenhough 2017), the marketing of DTC products (Hauskeller 2011, Magnus et al. 2009, Parry and Greenhough 2017, Schaper and Schicktanz 2018), and "the speculative re-invention of the future" (Cooper 2011, 11), there are some specific nuances that the microbiome poses to data privacy issues of bioinformation (Franzosa et al. 2015, Gligorov et al. 2013, Knoppers et al. 2021).

The distinctions between microbiome and genetic bioinformation, regarding data privacy, were brought to my attention in the aftermath of uBiome's liquidation. After finding out about the sale of uBiome's data and assets to Psomagen, I emailed Psomagen to find out what had happened to my data, how they were using it, and if it would be possible to withdraw. To which, they responded,

> *Hello Alice,*
>
> *Thank you for reaching out to us.*
>
> *Back in 2020, Psomagen, Inc. purchased the intellectual property of uBiome, yet all the data have been anonymised to protect the consumers' personal information, which is the regulation reinforced by the US Bankruptcy Court. All of the data from uBiome was de-identified, so, unfortunately, we are unable to locate/share personal data at all. Hope this helps.*
>
> *We do, however, offer an exclusive discount to previous uBiome customers who wish to try out our new Kean Gut or Gut+ kit. Please let us know if you have any other questions or would like to have the promo code for your future purchase of the Kean kit at www.keanhealth.com. Thank you.*
>
> *Best,*
> ***Customer Service Team***

After politely rejecting their offer for a discounted test, I then asked what the processes of anonymisation and de-identification were and how they differ; these details were not clearly stated on their website. Though subject to conflicting definitions, some have suggested that "anonymised data does not contain any identifiable information and

there is no way to link the information back to identifiable information" (Wilkins nd, 1 emphasis added, see also Chevrier et al. 2019). De-identified data, on the other hand, typically "does not contain any identifiable information, *but there is a way to link the information back to identifiable information*" (Wilkins nd, 1 emphasis added). To be told by the Psomagen customer service team that my data had been both anonymised and de-identified, was somewhat confusing. Unfortunately, nevertheless expectedly, none of my follow-up emails received a response. To find clarity, I reached out to the KEAN HEALTH support email asking if they would be able to tell me how the uBiome data was de-identified and/or anonymised, whether this process is the same process that KEAN Health customers' data undergoes, and how they use uBiome's users' data? They responded,

> *Hello Alice,*
>
> *Thank you for reaching out. All we know as a customer service team regarding uBiome data, it is not usable and we do not have any plan to use it at all. We are sorry that we cannot give you more information. Psomagen has its own pipeline keeping its own data and the customers who purchased the kits through our website will get their results under their accounts in the online portal and also can get the raw data (fastQ file) if they make the request.*
>
> *Hope this helps. Please let us know if you have any other questions. Thank you!*
>
> *Best,*
> ***Customer Service Team***

I replied asking if they could inform me as to how KEAN HEALTH members data is used; this enquiry was also not responded to. It remains unclear how my data is being used by Psomagen nor what their de-identification and/or anonymisation process entails.

The process of de-identification and/or anonymisation most probably includes the removal of "Personally Identifiable Information (PII)-- information that can identify an individual (e.g. first and last name, birth date, home address, phone numbers, etc.)"

(KEAN HEALTH 2021, np). However, as Psomagen do not clarify this, I cannot be sure. In Atlas Biomed's privacy policy they state that,

> Anonymised and aggregate raw data has been stripped of your name and other contact information and aggregated with other customers' raw data so that you *cannot reasonably be identified* as an individual from that information (Biomed 2022b, np emphasis added)

The vague language[93] used by Atlas Biomed, and unclear communication from Psomagen and KEAN HEALTH both bring to attention the fraught relationship that the consumer has with such companies and the murky privacy waters that one's data enters when engaging with privatised biocapitalist companies.

These dynamics are discussed at length by Greenhough in her work on public health records in Iceland (Greenhough 2006, Greenhough 2007, Parry and Greenhough 2017). The Health Sector Database, submitted by the Icelandic government, granted the exclusive rights to Iceland's medical records by the private biotechnology company deCODE (ibid). Controversy arose when deCODE later planned to repurpose the medical records for commercial use. In particular, deCODE was criticised for not seeking "explicit informed consent [from] each and every Icelander" (Parry and Greenhough 2017, 37). They had planned, rather, to presume consent. Greenhough draws attention to the lack of transparency that deCode offered to the Icelandic public and the powerful role that biotech companies have in shaping bioethics more broadly.

Similarly to genetic data, how microbiome data is de-identified exposes some extremely concerning implications for data privacy (Parry and Greenhough 2017). In genetic research, Parry and Greenhough explain that biodata can be

> 'Washed' so that key information on age, health history and medical referrals are retained, while data that could be used to trace the bioinformation back to the individual (name, address, etc) is removed from the bioinformatic data base (2017, 45).

Microbiome data, however, presents new challenges to the privacy of bioinformation. "Research on privacy-preserving techniques for microbiome data is less advanced"

[93] It is unclear what 'reasonable' identification looks like.

(Hittmeir et al. 2022, 3), and up until recently, it has been assumed that microbiome data is not as revealing as genomic data (Franzosa et al. 2015, Hittmeir et al. 2022, Niemiec and Howard 2016). As Franzosa et al discuss, it has been assumed that 'washing the data', via the removal of human DNA from microbiome samples, would avoid the identifiability of data (2015). While DNA is relatively stable, the microbiome changes over the course of one's life, and as such, certain microbes that can expose geographical location of the subject can remain in the microbiome for a long time, meaning that microbiome data may continue to have identifiable components even after it has been washed (ibid). As Hittmeir et al succinctly explain,

> The individual variations in the human microbiome reveal information about our diet, exercise habits and general well-being, and are useful for investigations on the prediction and therapy of diseases. On the other hand, these variations allow for microbiome based identification of individuals, thus posing privacy risks in microbiome studies (Hittmeir et al. 2022, 2).

The microbiome then, poses potential problems regarding direct identification of subjects via the ability to track subjects and individuals' life history from the microbiome (Franzosa et al. 2015). In light of this, some have suggested that DTC MT products,

> That…[intend to] keep consumers' data for indefinite periods of time or share it with third-parties provided that this data is anonymised [is problematic as,] in light of recent findings regarding the increased difficulty of anonymizing multi-omic data, such practices may prove harmful to consumer privacy (Joly et al. 2020, 22).

This highlights the importance in how Psomagen, Atlas Biomed, and other DTC MT companies choose to de-identify and/or anonymise their data. Such privacy questions also provoke concern when considering how microbiome data may be operationalised in a discriminatory way via medical insurance (Gligorov et al. 2013, Gürsoy et al. 2022, Knoppers et al. 2021). As Knoppers et al explain,

> While people are not responsible for their genetic profile, [as the microbiome is mutable] they may be perceived as responsible, at least to some extent, for their epigenetic and microbiomic profiles (2021, 549).

Because users are produced as responsible for their microbiome profiles, some have suggested this may enable insurance companies to discriminate to whom, and how, they offer their services (ibid).

However, if the microbiome data is 'washed' too much, then important traits about the microbiome could be distorted. As is well recognised,

> The human microbiome is contextually dependent, making it impossible to understand a microbiome community without information about its host... Therefore, participant and sample metadata (i.e., contextual information) are also an important consideration in participatory microbiome research (Debelius et al. 2016, 48).

If important contextual information is not included in the analysis of the data (such as gender, ethnicity, and age), this contributes to the universalisation of the microbiome as discussed earlier on in this chapter. In other words, fully 'anonymised' microbiome samples might not be very scientifically useful as vital microbiome characteristics and traits are left out. How microbiome data is treated, is of the upmost importance, both for the privacy of consumers as well as how the company uses the data in their research.

Furthermore, it is interesting to note differences in how genetic and microbiome data are understood in relation to the human, and the potential implication this may have for the privacy of such data. Here, similarly to the FDA deciding to regulate FMT as a drug, in conversations surrounding microbiome data privacy, we may see that the microbiome is presented as distinctly not human. This is demonstrated by Knopper et al as they suggest

> That, in contrast to human genomic or epigenomic information, microbiomic data is obtained by the analysis of the genomic composition of non-human cells, and as such, it may not be conceptualised as belonging to individuals (Knoppers et al. 2021, 556)

In the same way that genetic information goes through processes of dispossession (Greenhough 2006), this quote hints towards the potential modes by which, microbiome data is dispossessed from the original owner, via its nonhumanness. This quote exposes a humanistic approach to the body where the microbiome is understood via its nonhumanness rather than through the complex and deeply

dependant relationality that the human has with the microbiome. It represents a concerted effort to keep the nonhuman/human boundary firm and distinct. One might speculate that again; the microbiome is not treated with the same care and attention that the human genome is because of its nonhumanness.

While DTC products are often advertised as benefiting the consumer by enabling their ability to learn more about their body, it is often the company that are set to gain more from consumers' 'interactions' with DTC products via the production of valuable bioinformation (Parry and Greenhough 2017). In practice, and as Parry and Greenhough explain, DTC GT products offer companies as a means to attain a wealth of "highly characterised bioinformation creating the company's own private biobank that those in commercial biopharmaceutical research will later pay-to-view" (Parry and Greenhough 2017, 95-96). They go on to explain that this data is highly valuable as,

> Companies can then…use data to identify individuals at risk and genetic targets for drugs and other therapeutic interventions. In a commercial context, these bodies of information represent two significant opportunities: promising lines of inquiry for the development of new drugs or healthcare products, and an already-identified population of at-risk individuals who could form the market for such interventions (ibid, 96).

Similarly, Wiggins and Willbanks (2019) paper points out that DTC product companies including 23andme and uBiome, sell themselves as offering "consumer-friendly services, network effects, and data return" yet in practice they "inspire concerns about surveillance and obscure terms of service" (Wiggins and Wilbanks 2019, 3-4). Similarly, to DTC GT, DTC MT products are sold under the premise that it will offer the consumer novel information about their microbiomes and requires that consumers pay for their biological data to be given to private companies, enacting a privatising politics of the microbiome.

My interactions with uBiome also reveals the risks that customers are exposed to by engaging with such products. The story of a billion-dollar biotech company promising the world but later found to be engaging in fraudulent practices and misleading customers and investors is not new. Founders of other medical companies

such as Theranos[94] have similarly been arrested for conspiring to defraud private investors (Justice 2021, Palmer and Weiss 2021, Paul 2022, Wood et al. 2021). Others have critiqued the biotech system for encouraging high-risk 'fake it till you make it' behaviours as start-ups are required to "satisfy venture capitalists' high-risk, high-return appetites" (Palmer and Weiss 2021, 17). The distinctive capitalistic features of start-ups, including but not limited to high-risk funding methods, operating as private enterprises (with consequent lack of public scrutiny) and occupying legal grey zones have led to some to argue that "wrongdoing [by start-ups] is a normal phenomenon, in that it is prevalent and a product of organisational structures and processes" (Palmer and Weiss 2021, 2, see also The Consilience Project 2021). Although investors and founders' reputations and finances may suffer from the closure of start-ups, patients experience the worst consequences of high stakes investments and failures. By being misled by medical companies, patients' finances and, sometimes, health are put at risk, so much so that it has been argued that such rampant free-market capitalism is a public health risk (Brezis and Wiist 2011). While the closure of uBiome was not inherently a health risk as they were not offering medical intervention, FMT users who engaged in such products suffered financial and emotional hardship[95] by being mis-sold false promises that tracking one's microbiome would be able to help them with their conditions. The promise of such was overinflated both through uBiome's products being billed via medical insurance and as others have pointed out, the exaggerated medical relevance of their kits (Knoppers 2020).

I propose that the damaging role that DTC MT products produce, is not so much to users' health, but instead in the expectations placed on the subject using the products in and in how such products produce a human 'self'. To come back to the title of the chapter, I wish to reflect on the microbial self that has come to be known and to whom it has been made known. Though I have become informed of the taxonomic presence of my microbiome at certain points this has produced a very specific imagining of a microbial self. The unmarked, ungendered, and unsexed normal human body that is reproduced by the testing products works to individualise

[94] Theranos was a private health corporation founded via blood testing technology, which was later found to not work. The company's founder Elizabeth Holmes and former company president Sunny Balwani have recently, as of January 2022, been charged with fraud (Paul 2022, Tun 2022).

[95] Many FMT users posted on the Facebook advocacy pages relaying their frustration and despair at losing their data. One user particularly stood out to me after making a post asking if anyone could help them get their uBiome data back. They relayed their desperation, disappointment, and anger as they had invested a lot of their life savings into paying for the tests.

responsibility for one's health and erases the situated structures of power and oppression that are formative in the microbiome's development and emergence. The tests divert attention away from broader societal and political critiques on inequalities in food division and poverty, that determine access to food, and broader assessments on the agricultural industry, and its impact on soil health and hence food quality and production, that humans are subjected to and that have a formative role in the development and functioning of the microbiome (Ishaq et al. 2021). The tests place responsibility on individual behaviours while deflecting from the structures of economic power, and this speaks to broader critiques of how we understand health.

Here I take inspiration from decolonial thinker Candace Fujikane (2021) as she uses the example of Hawaiian indigenous politics to argue for indigenous modes of knowing and understanding biological life. I wish to apply Candice's critique of environmental health as she seeks to revisit individualistic understandings of environmental health and argues for an alternative understanding that takes seriously "the health of entire systems" (2021, 25). This involves situating the human in broader contexts that are sensitive to the power structures and systems that determine the wider social, political, and environmental circumstances of individuals. Considering the risks to data privacy and opaque communication around this, and the potential precarity of engaging in private biotech DTC products, the rest of the chapter considers alternative approaches to the microbiome that question the need to quantify the microbiome, via taxonomies, in order for it to be made known.

Encouraging alternative onto-ethico-epistemologies of the microbiome

I want to now return, if briefly, to critiques of taxonomic recording of microbial life to speculate on the work that taxonomies do for understanding the microbiome, including potential alternatives. While taxonomies record the presence of life, they also enclose life, thereby enabling the practice of governance (Foucault 2005, Haraway 1997). Taxonomy as a technology of ordering biologic life produces its governability (Foucault 2005, Haraway 2008). Foucault, influential in observing the power of taxonomy, noted the epistemic shift in the seventeenth and eighteenth centuries that was, in part, represented by Linnaeus' taxonomic ordering of organisms by the similarities in their DNA (1974,48). By doing so, life could be neatly ordered according to objective, universal, and rational principles (ibid, Haraway 1997, Haraway 2008). The practice of ordering and categorizing biologic life according to taxonomic rank, organises and

encloses life into specific categories. By determining what something *is* and how it is situated with the rest of the world, taxonomy has been powerful in determining how we understand and order the natural world (Foucault 2005, Haraway 1997, Haraway 2008). As Lorimer exemplifies in his work on the conservation of Asian elephants, the taxonomic classification of the elephants plays a determining role in what species' are prioritised as they decipher the elephants "potential for future adaptive differentiation" (2015, 187).

Further, microbial life problematises the ordered and rational taxonomic modes of classification as their evolution emerged through symbiotic exchange of DNA (Haraway 2008, Margulis 1971, Margulis 1981). As Haraway explains, "bacteria pass genes back and forth all the time and do not resolve into well-bounded species, giving the taxonomist either an ecstatic moment or a headache" (2008,31).

As I have suggested, becoming aware of the vast multitudes of microbial life that are present in the human body may encourage reflection on the human as more-than-human. The biocapitalist economy that DTC MT products circulate within restrict, however, the actualisation of this relational politics because they remove the user from the broader societal ecologies that recognise the determining role that broader structural forms of power have in microbiome development. Such structures include, of course, the exploitative, individualising, and privatising forces of neoliberalism (Sparke 2017). Considering the extensive critiques that I have put forward regarding microbiome testing alongside the damaging consequences of the privatising politics that biotechnological companies encourage, I want to consider alternative approaches that could be used in coming to know and relate to the microbiome.

Here, I wish to draw again from Fujikane as she lays out how gratitude towards, and commitment to, abundance and flourishing *with* nonhuman life acts as a threat to a settler-colonial biopolitics because it resists capitalist governance, accumulation, and enclosure (2021). Here I explore an onto-ethico-epistemic shift that alters "the purpose, identity and function" (Holloway 2019, 74) of a personal human-microbe relationality, a shift that moves away from the dominant modes of taxonomic recording, controlling, and privatising microbial life that occurs via the DTC MT companies. Instead, I propose an onto-ethico-epistemic shift that individuals may adopt to revise how one might situate the human self in wider microbiopolitics.

This shift was witnessed in some FMT users as they referred to a change in how they see microbial life and their relationship to it via notions of corporeal

communication.[96] While some FMT users engaged with microbiome testing kits, for others tuning into the corporeal sense was more useful for coming to know their microbiomes and understand what their microbiome was telling them. From my own experiences, engaging in bodily sensation provided me with more valuable bodily knowledge than looking at a list of microbes and the related suggestions that Atlas Biomed made. For example, some of the dietary suggestions that Atlas Biomed suggested I eat based off the microbiome data they had collected, such as white onions and chickpeas, I already avoid due to the undesired effects that they have on my digestion. Other foods recommended, such as whole grain rice, spinach and increasing the amount of fibre in my diet, did not appear to me as specialised recommendations, but foods that are generally beneficial to most people.

Some members in industry and academia also spoke about this shift in relating to their microbiomes. What emerged in interviews were themes of microbial autonomy and abundance that spoke to an appreciation of microbial life outside of taxonomy by engaging in the corporeal sensory as a mode of knowing the microbiome. Some industry and academic members spoke about reflecting on their relationality with their bodies and microbiome, such as Rhianna, an industry member

> I think it's [working with the microbiome] definitely made me a lot more okay with being grimy, haha, because there are so many bugs on you at all times, it's basically impossible to get away from them. And it's not clear that you would want to really, because there are good bugs that boost your immune response and improve your response to like external stimuli. Yeah, I think that definitely at times I sometimes have realisations of how sweat is related to the microbiome or how certain states that my body is in when dancing or while engaging in other types of physical activity and how integrated those responses are with what's happening with the microbiome on my body at that same time. Yeah, so I think that there is heightened awareness of me and my little bugs, haha.

Other members in industry such as Sam spoke to revaluating the autonomy and power that the microbiome has. As he explained,

[96] As discussed at length in Chapter Seven.

> It [working with the microbiome) has absolutely changed the way that I think about myself and health. Beyond changes to my routine and lifestyle, I eat more fermented food such as kombucha… More generally I'm very wary of antibiotics and anything potentially antimicrobial. It has generally given me a sense of two things. One, a sense of deeper connection to the world around us, the built environment, and the people that we choose to live with. When you're cohabiting with someone, you're sharing microbes, you start to shift to be more in line with theirs. You might pick up bits of their personality, but your microbes combine as well. It's a wild and beautiful biological mechanism sharing bits of yourself with another person. You're more like them than just mannerisms, but also in biophysical similarities! It [working with microbes] has also given me a more holistic perspective of my diet, also seeing my health as something that is continuous, that's susceptible to changes that are perhaps more permanent. I sort of focus on nutrition, you can eat all the sugar you want and burn it off, but what about the long-term effects on your microbiome? What about the non-reversible effects? It's also given me a lot of hope. I appreciate that I'm a lucky person I have a healthy diet and I really appreciate the micro-biodiversity around me… it's also given me a lot of hope that these are the kinds of things we can maybe treat and cure in our lifetimes… it's never been 2019 before and we are still discovering new parts of ourselves that determine our biochemistry and who we are.

For Sam, the microbiome's autonomous power over the human is appreciated as the agentive 'human' individual must conform to the demands of the microbiome as opposed to the microbiome conforming to the demands of the 'human'. These excerpts demonstrate personal understandings on the body's relationality with microbial life that stem from a respectful approach to their microbiomes, specifically appreciating their microbial multiplicity and autonomy. However, both Rhianna and Sam, while appreciating the expansiveness and autonomy of the human microbiome, do not speak to the limits of controlling or enclosing the microbiome. In fact, both are employed in private biotechnological firms that seek to master and enclose the microbiome into products or models for human-focused outcomes. Lacy, a microbiome artist, however, particularly stuck out to me as I asked her about the differences in using bacteria as opposed to the other in-organic materials she used to work with. She explained that,

> It's a challenge, I mean, to control, because you have to know a lot. I have been working with Mark for eight years and I'm starting to know how they act, and, you know, if I want something bacillus, bacillus grows very quickly, so it's a challenge to draw with them to try to control them, but then in another way it's like, I love when they do their own thing, but we are working together, bacteria and I. I try and do something and then they do whatever.

Notably, Lacy lays out how attempts to control her microbial colleagues proved to be less fruitful in creating bacterial art than allowing them to exist beyond human constraints.

If microbiome testing companies reduce, monitor, and privatise the microbiome, an onto-ethico-epistemic shift that is open to microbial life allows other personal modes of knowing the microbiome to be taken seriously. Though, of course, one's capability to enact this onto-ethico-epistemic shift is also subject to broader determining societal politics and power structures, my intention here is to encourage alternative modes of knowing the microbiome beyond taxonomic methods. A shift that informs a more relational mode of engaging with microbial life that does not require taxonomic recording for it to be legitimised. Such an approach opens up engaging with corporeal sense as an accessible mode of knowing the microbiome. While work that resists privatising forces by engaging publics into scientific microbiome research remains important and valuable for large scale discovery and understanding of the microbiome (Lorimer et al. 2019), not offering one's own data to biotechnological companies also emerges as significant in resisting the privatising politics of the microbiome that they encourage.

Conclusion

This chapter set out to explore how the microbiome becomes known to FMT users and the public through microbiome testing kits. The chapter has pointed out the very real limitations of the testing kits and the detrimental work that they do in individualizing and universalizing the microbiome by dissociating the individual user from broader societal and structural forces that dictate the microbiome. Hence, I argue that these factors combined, expose how the kits reproduce a false sense of embodied control while also individualising the microbiome.

While microbiome testing offers consumers the potential to quantify their microbiomes, they also expose attempts to govern and secure microbial life through recording the taxonomic presence of your microbiome. Furthermore, the chapter has demonstrated that such individualising also occurs in the marketing of the products, aligning the kits with Rose's theorisation of ethopolitics. However, as I have made clear, access to technologies of the biological citizen, such as DTC MT products, are restricted by broader structurally determining factors. Most prominently, due to the relative high price point, the kits are inaccessible to many especially FMT users that have been forced into insecure employment due to their conditions. This, I have posited, exposes the production of the sub- biological citizen as the oppressive forces, of for example, neoliberalism, restrict access to DTC MT products (Sparke 2017).

Lastly, drawing from my experiences of uBiome's closure, I have drawn attention to the risks to one's finances and personal and emotional wellbeing that engaging with private companies presents. Prominently these vulnerabilities emerge via entangling patients and consumers into the susceptibilities of high risk free-market capitalism via the privatisation and potential loss of personal biological information. I offered an onto epistemic shift that reconsiders the motivation to quantify the microbiome via taxonomy. Instead, such an onto-ethico-epistemic shift opens other, less quantifiable modes of coming to know the microbiome that takes seriously the corporeal bodily sensation.

Chapter Eight: Conclusion

This chapter concludes by first, providing a detailed summary of the chapters. I then come back to the research questions that shaped the thesis and summarise my

findings. Lastly, I draw out the significance of the thesis by meditating on the implications that this work has for both how we understand the body and health and the broad field of geography and indicate what research areas could build on my findings.

Summary

The microbiome complicates traditional humanist understandings of the human body as autonomous and superior to nonhuman life (Beck 2019, Greenhough 2012, Greenhough 2022, Lorimer 2016, Lorimer 2017c, Lorimer 2017a, Lorimer 2020). Instead, it encourages an ecological and relational view of the body (ibid). FMT, more specifically, as a medical intervention demonstrates this ecological approach to the body (Xiao et al. 2020). I have observed this procedure as a way of re-introducing microbial diversity into bodies in an industrialised western context that are microbially estranged (Blaser 2014, Velasquez-Manoff 2012a, Velasquez-Manoff 2012b). However, while the recent discovery of the mutable human microbiome in dominant medicine is highly promising (Camara-Lemarroy et al. 2018, Cho and Blaser 2012, Foster et al. 2017, Khanna et al. 2016, Knoop et al. 2018, Maltz et al. 2019, Nie et al. 2019, Rea et al. 2016, Wang and Kasper 2014), much remains unknown (Carlson et al. 2018, Clemente et al. 2012, Falony et al. 2016, Helmreich 2013, Valdes et al. 2018). Much like other novel areas of dominant science and medicine (Daston 2000, Jasanoff 2004, Latour 1988, Latour 2012, Mol 2002), how the microbiome emerges is political. How knowledge is made and what knowledge is seen as legitimate is determined by broader structural powers, which has political implications for how a human-microbiome relationality takes shape. Taking these into consideration, my research questions how the microbiome is becoming made known, the processes of legitimation that different understandings of the microbiome are exposed to, and the forms of relationality that stem from such understandings. To do so, the thesis draws from research with FMT users and microbiome-related industry and academic members to unpick the politics of the microbiome using FMT as an entry point.

Chapter Two set out the theoretical framework that I used to approach my research questions and develop my empirical analysis. I introduced my feminist decolonial approach that diffracts work from ANT (Latour 1990), and biopolitics (Foucault 2008) that I mobilise throughout the thesis to unpick the politics of the human

microbiome. I proposed this approach foremostly to both observe the myriad nonhuman actants involved in the politics of the microbiome while also remaining attentive to how structural power emerges and shapes networks.

Chapter Three provided an overview of the research methods and approaches that formed the foundation of my empirical analysis. By highlighting the methodological limitations of natural and medical sciences' (Haraway 1988, Harding 1991, Harding 2019, Herbert 2000, Jasanoff 2004, Latour 1988, Latour 2004, Latour 2013), the chapter argued for a broader onto-ethico-epistemological reflection within microbiome studies to decentre the favouring of the 'objective' and 'neutral' natural and medical sciences.

Throughout the subsequent empirical chapters, I address how the microbiome is being made known, the politics of its legitimation via different forms of knowledge production, and the kind of relationality that is informed from such an entanglement. Chapter Four, 'The making of 'real' and 'legitimate' microbiome science', addresses these research concerns by focusing on the knowledge politics that the microbiome is emerging through. I first examine how the notion of 'real' science and scientists (Stengers 2018) arose during my time in the field, and the exclusionary politics that this informs. I suggest that although there have been calls to incorporate the social sciences in the production of microbiome knowledge (Benezra 2020, Delgado and Baedke 2021, Greenhough et al. 2020, Rees et al. 2018), these are restricted by the onto-ethico-epistemology enacted in dominant science that requires a nature culture binary for knowledge to be legitimate. Although these hierarchical and exclusionary forms of knowledge production are not entirely new (Harding 1991, Harding 2019, Stehr 2015), they play an important role in shaping how the microbiome becomes known and in enabling the reproduction of violent politics of colonialism and racism. I expose how such a hierarchical politics of knowledge affects FMT users by pushing them to the peripheries of biomedical discourse, producing what I have referred to as the 'periphery patient'. While it is important to maintain academic standards in the production of microbiome knowledge, completely dismissing FMT users' experiences works to dissociate them from a medical system that they have already had negative experiences with. Hence, I argue that while the dominant modes of knowledge production have been incredibly valuable in providing insight into the mechanics and functions of the microbiome, they also enact a politics of exclusion and violence.

In Chapter Five, ‘Drug, Tissue, or organ? How do you solve a problem like the microbiome?’ I explore how such microbiome knowledge secures forms of epistemic and economic control via the regulation of FMT by the FDA. Performing a political ecology of the body and microbiome I exposed the diverse and complex networks involved in the regulation of FMT in America (Sachs and Edelstein 2015, Scheeler 2019). Prominently, the chapter highlights how the FDA’s decision to regulate the microbiome as a drug acts as an important moment in the agential cutting of the microbiome as distinctly *not human*. By regulating FMT as a drug, the microbiome consequently becomes entangled in networks of capitalist accumulation that work to distort the microbiome via the reductive processes of the drug development process. While an FMT drug may offer some patients easier access and, on the whole, a drug represents a much less invasive process (Ossorio and Zhou 2019), regulating FMT as a drug may restrict more varied application of the procedure in America (Sachs and Edelstein 2015, Scheeler 2019). I support others’ suggestions (Sachs and Edelstein 2015, Scheeler 2019) that FMT should not be regulated as a drug but instead via HCT/P as, first, it would primarily be available for a wider variety of conditions, and, second, it would inform a less exploitative and reductive relationality to the microbiome. As a drug, the microbiome is produced as a discrete, controllable object that services human health. Regulating FMT via HCT/P represents and onto-ethico-epistemological move as the microbiome would be understood as *part of* the human and would thereby complicate traditional humanist notions of human individuality and superiority.

Moving on from broad structural frameworks that dictate how microbiome knowledge is produced and then cemented in governance regimes, Chapter Six: ‘Bodily Identity: Exploring an FMT-induced hospitality’, goes on to explore how the microbiome becomes known to FMT users via personal practice. Recognising their microbiomes as autonomous life that can express agency, many FMT users came to revise their human selves as multispecies via the procedure of FMT. Through the process of undergoing FMT and working to maintain a newly acquired microbiome, some FMT users animated traits of Derridean hospitality (Derrida 1999, Derrida and Dufourmantelle 2000, Derrida 2002, Judith 2010). By adopting traits of unconditioned hospitality, I suggest that hospitality in the context of FMT revitalises Derrida’s hospitality into new multispecies terrains as the human host does not know exactly who, or what microbes, will show up (Derrida 1999). Importantly, the process of FMT

ultimately aims for the nonhuman guest *to become part of the host* (O'Gorman 2006). Inherent in such hospitality are practices of care that take seriously and pay close attention to how the microbiome impacts their health and wellbeing. I propose that corporeal communication is a mode by which FMT users enact such bodily microbial hospitality. This involves a heightened awareness of bodily sensation as a mode of microbial communication. I end the chapter by speaking to the politics of care, exploring how corporeal communication and bodily microbial hospitality are determined by broader societal structures of oppressive power. I assert that, although the potentialities of human-nonhuman entanglement are conceptually exciting, it is also vital that the external systemic and structural forces that shape such entanglements be taken seriously within posthuman and more-than-human discussions.

The last analysis chapter, Chapter Seven: 'Coming to know a microbial self via microbiome testing kits' explores microbiome emergence via publicly available microbiome testing kits. I argue that microbiome testing kits reproduce a false sense of embodied control by extracting the user from wider structural and systemic forces that work to dictate the microbiome. Though such tests speak to Rose's (2007) theorisation of ethopolitics, where individuals are responsible for maintaining their health, I suggest that they do not enable an improvement to one's health because of the very real limitations in what microbiome testing can tell someone about their health. Instead, I argue that such technologies demonstrate the emergence of the sub-biological citizen (Sparke 2017). Drawing from my ethnographic experiences of uBiome's closure, I demonstrate how microbiome testing companies expose consumers to the extractivist dispossessive dynamics of the biocapitalist economy (Rajan 2006).

While these dynamics have been in motion for many years and have been spoken about at length regarding genetic information (Gürsoy et al. 2022, Joly et al. 2020, Parry and Greenhough 2017), I show how the microbiome poses specific difficulties to the privacy of microbiome bioinformation by retaining geographically identifiable information even after it has been 'washed' (Franzosa et al. 2015, Hittmeir et al. 2022, Niemiec and Howard 2016). By taking account of the substantial critiques of what microbiome tests can tell you and how your data is mobilised by such private companies, I end the chapter by proposing an onto-ethico-epistemic shift that questions the need for the microbiome to become quantified, via taxonomic recording,

for it to become legitimate. Such an onto-ethico-epistemic shift, I suggest, may be used to revise how one situates oneself in a wider microbiopolitics.

Revisiting the research questions and aims

This thesis explores the politics of the microbiome's emergence. It first questions how the microbiome becomes known, through both dominant structural technologies of governance, regulation, and modernist onto-ethico-epistemologies that reinforce a nature/culture binary, as well as via FMT users who have personal and intimate experiences with their microbiomes in an everyday setting. Such a reproduction of the nature/culture binary exposes the answers to the second research question that the thesis intended to answer: how legitimacy is ascribed to different forms of knowledge production. A hierarchy of knowledge production about the microbiome is reproduced by positioning knowledge that does not follow strict modernist onto-ethico-epistemologies as unsubstantial or illegitimate because it exceeds and disrupts the nature culture binary.

Lastly, the thesis explores the differing kinds of politics and relationality that emerged from different productions of the microbiome. Though the microbiome and FMT both offer the potential to revise how humans relate to nonhuman life (Beck 2019, Greenhough 2012, Greenhough 2022, Lorimer 2016, Lorimer 2017a, Lorimer 2017c, Lorimer 2020), as this thesis has demonstrated, the dominant understanding (in a US context) of the microbiome via FMT as a drug, continues the same humanistic onto-ethico-epistemologies that this thesis seeks to critique. However, though this represents the 'dominant' understanding in the US, this is not the universal understanding of the human microbiome. Some FMT users develop and nurture a relationality with their microbiome that is less hierarchical and human focused. While, the microbiome is not to be understood as a drug everywhere, as Belgium's FMT regulation demonstrates (Scheeler 2019), the production of a *C. diff* drug will have far-reaching implications for the treatment of *rCDI* and other gut related conditions internationally via the production of a novel FMT drug.

Overall, this thesis shows how the dominant modes of knowledge production remain those that animate a modernist onto-ethico-epistemology, and gain legitimacy via the reproduction of a nature culture binary. The hierarchy that arises works to exclude other forms of knowledge, be they from the social sciences, or from those that

have personal and intimate experience with their microbiomes. Throughout the thesis I show how different forms of human microbiome knowledge production generate the microbiome differently and how these encourage vastly different relationalities and politics of the microbiome.

Implications of findings

Similar to other critical social scientists' work on the human microbiome, I demonstrate that human health is an interspecies relationship (Haraway 2008, Greenhough 2012, Greenhough 2022, Lorimer 2016, Lorimer 2017a, Lorimer 2017b, Lorimer 2017c, Lorimer 2020). This thesis emphasises the significance of questioning how the human body is understood and interacted with in dominant medical settings. Understanding the human as dependent on the multitudes of microbial ecologies that inhabit the nonhuman body, poses significant challenges to traditional understandings of bodily intervention and health. Recognising the human body as a more-than-human ecology encourages us to question how bodily and medical interventions impact the human microbiome, and how we might treat the body with the microbiome in mind. Though the microbiome poses significant problems to current understandings of the human body, the microbiome should not be seen as something to be coerced into current models, or worse, ignored. Rather, an ecological understanding of the human could provide more fruitful alternative methods of intervention, treatment, and understandings of health and wellness.

Importantly, and what sets this thesis apart from other work in microbial geographies, is that I have kept the wider structurally determining forces, that powerfully dictate the dynamics of a human-microbiome relationship, at the centre of my analysis. One's ability to enact a considered microbial bodily hospitality is determined by factors such as time availability, stress exposure, and financial resources. Although the complex relationship between broader structurally determining forces and personal wellness has been explored elsewhere (Herrick and Reubi 2017, Lupton 2012) there is particular importance in remaining sensitive and critical of it in human microbiome studies. First, how these emerge in health outcomes is crucially important in being attentive to the politics of health and in highlighting inequalities in dominant medicine. Second, as this thesis has emphasised, the role that wider structurally determining forces has in dictating a human-nonhuman

entanglement needs more attention in posthuman and more-than-human work. Human-nonhuman entanglement offers the potential for generative and fruitful engagements both materially and philosophically, however, these are restrained by very real and powerful structurally determining forces. Not everyone has equal access to human-nonhuman flourishing.

In this vein, the findings from this thesis specifically regarding the dynamic between vulnerable or 'periphery patients' and dominant medicine are productive for thinking about other kinds of chronic and poorly understood conditions and their related patient groups such as, for example, Myalgic encephalomyelitis or chronic fatigue syndrome (ME), endometriosis, or polycystic ovaries syndrome. Such an approach could be useful to consider the moments of conflict and/or synergies between patients' experiences of their conditions and their relationship with and trust in dominant medicine.

By exploring the complex dynamics between and within varying spatialities and scales, this work emphasises the importance of geographical enquiry to the microbiome and body more generally (Herbert 2000, Massey 1994, Stallins et al. 2018). I highlight microbiome onto-ethico-epistemologies, from macro forms of governance and regulation to the micro setting of FMT users' interactions with their microbiomes and the varying political impacts that stem from them. The microbiome as a drug distinguishes it as distinctly nonhuman; however, for many of the FMT users I spoke to, the microbiome is notably part of their human selves. Such onto-ethico-epistemologies of the microbiome are subject to hierarchical placement, where some are seen as more legitimate than others. I stress the importance of remaining sensitive to the political dimensions and interactions between and within these scales as they expose the reproduction of oppressive power. Yet, unpicking such political dimensions also exposes spaces of more hopeful and generative politics, such as those employed by some FMT users that I spoke with.

Beyond the specific focus of the human gut microbiome, and gut microbiome-related conditions, findings from this thesis have greater application elsewhere. How a relationality between humans and microbiomes emerges together with its political dimensions could offer fruitful insight into other microbial contexts. For example, such an approach could be used to explore the role that microbes play and the politics of relationality in spaces of conservation and/or farming in macro environments, for example, in rivers and or the ocean. The concept of corporeal communication, its

relevance to FMT users' ways of coming to know their microbiomes, and the politics of this, could also be applied to the complicated and corporeally sensitive modes by which people come to know and relate to obscure and invisible parts of the human body such as hormones, or even in mental health.

Finally, further research could explore how FMT relationalities vary between groups of people. All my research participants were white – thus, hearing from a more diverse set of FMT users, such as those from Black, Indigenous, and other racialised groups, and incorporating specific questions relating to, for example, gender or race and ethnicity, would provide more nuance in exploring the relationship between FMT users and dominant medicine. Exploring this relationship would also offer important insight into the dynamics of trust in a context where dominant medicine has historically reinforced structural forms of oppression and reproduced a politics of violence towards certain groups and communities.

Though I have encouraged exploring human-microbe relationalities outside of a disease setting, in the contemporary context of an ongoing global pandemic, exploring a human-microbe relationality in the time of Covid-19 could also be useful for uncovering how we understand, interact, and live with microbial life that is wildly different to ourselves. This is particularly important as the pandemic has encouraged greater fear of the microbial and human other. While quarantining and isolating a human self from dangerous viruses and contagious bodies is sometimes necessary, this ethos cannot continue to be upheld. As the microbiome exposes, humans are deeply entangled with nonhuman microbial others, independence from microbial life and others that are different from ourselves ignores the necessity and value that stems from microbial diversity. In a time where discourses that encourage borders and division are growing in popularity, deepening our understanding of human multiplicity and enmeshment with the nonhuman other could contribute to recognising these entanglements as valuable, rather than as risks. How a conducive relationship between humans and our microbial counterparts develops in precarious and unsettling times seems more important now than ever.

Appendix

Research Details

Interviews

FMT users

Email interviews

- 2017
  - Joe (AUS)
- 2019
  - Robin (US)

Virtual interviews.

- 2017
  - Mike (US)
- 2018-9
  - Sally (US)
  - Paul (UK)
  - Benny (AUS)
  - Earl (US)
  - Marley (Sweden)
  - Billy (US)
  - Eric (US)
  - Sam (Poland)

US microbiome researchers and laboratory groups

- Alz Lab 2018
  - Interviews
    - Ernie Senior Research student
    - Graham Postdoctoral Research Fellow
    - Samuru PhD
    - Lane Postdoctoral Research Fellow
- Betz University 2019
  - Interviews
    - Charles PI
    - Louise PI
- Cargo University 2019
  - Interview
    - Margret
- DC Lab 2019
  - Interviews
    - Emily
    - Simon
    - Mark and Lacy
- Callum Karn 2019
- George Felg 2019

Faecal bank employees.

- Two interviews with TJ (2018 and 2019)
- Carly
- Edwina
- Freya
- Ian
- Nadiya
- Timal
- Tobin

Industry members

- Emily
- Harry
- Rhianna
- Sam
- Jag

Participant observation using an ethnographic method.

Facebook FMT advocacy groups

- Fifteen pages between 2017- present

Paid attendance to conferences.

- International microbiome engineering conference, 4-6th November 2018, Boston MA.
- Translational microbiome conference, 16-18th April 2019, Boston, MA.

Laboratory tours

- Ernk lab 2019
- DC lab 2029
- Alz lab 2018

Free events, talks, and conferences.

- How international biotech companies support the Cambridge ecosystem, CIC Cambridge, 30th May 2019, Cambridge MA.
- Mass General Hospital walking tour, 29th May 2019, Boston MA.
- The future of medicine: biomedical innovation in Boston and Japan, Venture café, 27th May 2019.
- Bacterial bonanza at the MIT museum, 10th May 2018, Cambridge MA.
- Healthcare and Drug pricing debate with Roivant Sciences, Harvard Science Centre, 23rd April 2018, Cambridge MA.
- Bio connect 2019, Venture cafe Cambridge, 19th April 2019, Cambridge MA.
- Data Science in Medicine, BPS Wellness summit 2019, 15th April, Roxbury MA.
- Rethinking advocacy in medicine conference, Tufts University, 11th of May 2018, Boston MA.
- HMS screening: human nature documentary, 13th May 2019 Harvard Medical School, Boston MA.
- Larger than life science- the next wave, Amgen, 8th May 2019, Cambridge MA.

- Bioxchange at Mcdermott Will & Emery, including lab tour, 29th March 2019, Cambridge MA.
- Human Tissue Ethics in Anatomy, Past and Present: From Bodies to Tissues to Data, School, 4th April 2019, Harvard Medical School, Cambridge MA.
- Nova wonders exhibition, WGBH educational foundation, 9th April 2019, Boston, MA.
- Biomedical informatics entrepreneur's salon: Tom Knight, 10th of April 2018, Harvard Medical School, Cambridge MA.
- Day of learning with indigenous, authors and educators (indigenous medicine talk), Lesley University, 6th April 2019, Cambridge MA.
- Viruses the good the bad the ugly, Paul Turner, 28th March, 2019, Harvard Natural History Museum, Cambridge MA.

Multispecies auto-ethnography

- Microbiome testing kits from
    - Atlas Biomedical testing
    - uBiome

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