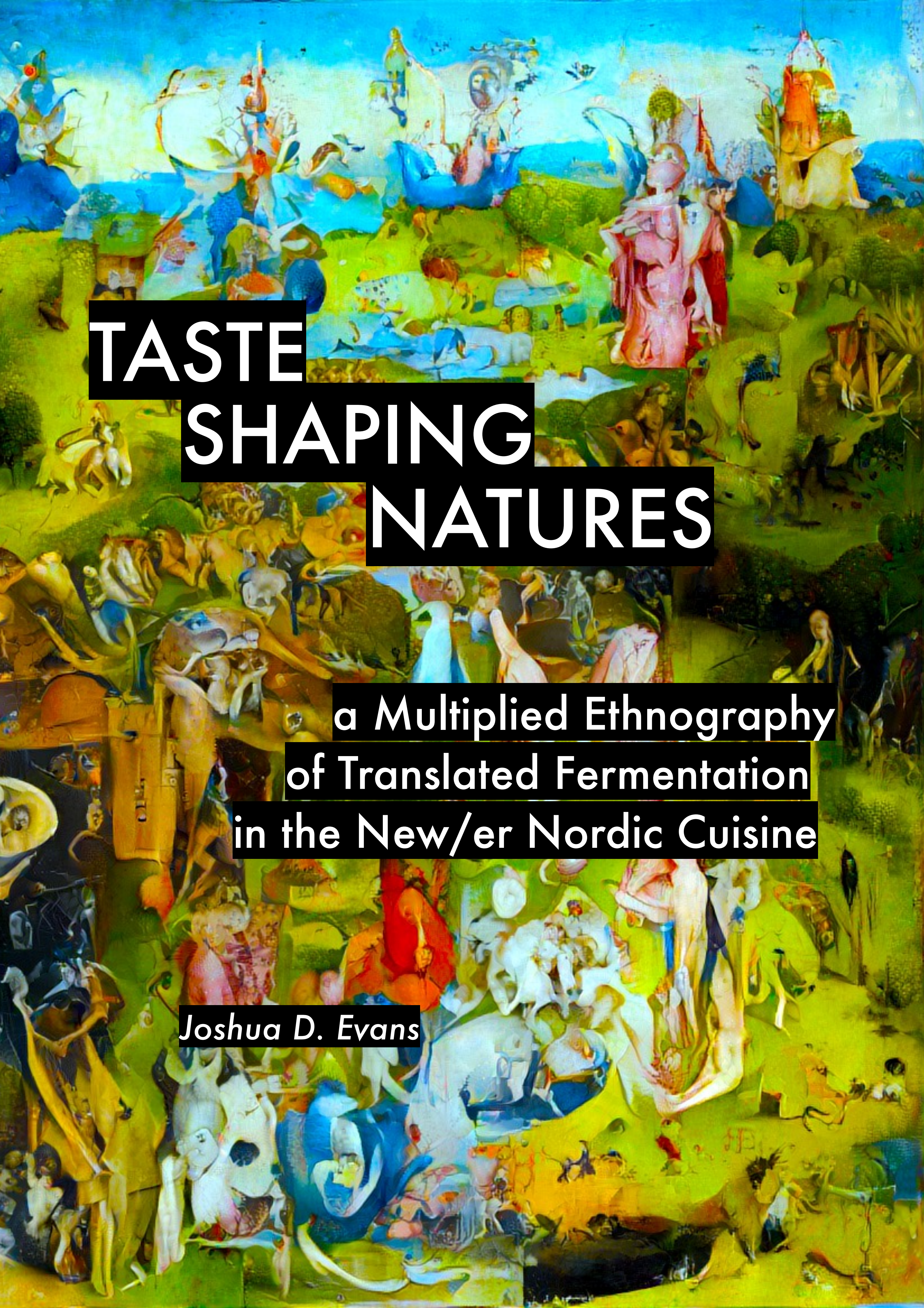

TASTE SHAPING NATURES

a Multiplied Ethnography of Translated Fermentation in the New/er Nordic Cuisine

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submitted Jan 2022 in fulfilment of the requirements for DPhil by

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ABSTRACT

Culinary innovators in Copenhagen are combining far-flung fermentation techniques with Nordic ingredients to yield products and flavours that have not existed before. This flavour-oriented 'translated' fermentation is also having broader cultural and material consequences, for these culinary practitioners as well as for their microbial partners' biogeography, ecology, and likely their evolution. To account for these novelties, I bring together critical scholarship on nature, more-than-human geographies and multispecies studies, theories of taste, and STS, to develop the concept of a 'taste shaping nature': a nature shaping and shaped by taste. Employing a novel combination of multispecies multisensory ethnography, collaborative microbiological experiments, and DNA sequencing—an approach I shorthand as 'multiplied ethnography'—I conducted fieldwork around two sites in Copenhagen, Restaurant Noma and Empirical Spirits, leaders in the culinary movement sometimes known as the 'New Nordic Cuisine' (NNC). Linking my fieldwork and the literature, I develop each part of 'taste shaping natures' across four analytic chapters: on 'Nature', 'Consipience', 'Experiment', and 'Interest'. 'Nature' investigates how the NNC has mixed 'wild' and 'postpastoral' natures, how these 'multinatures' have shifted over time, and how they have shaped and been shaped by different approaches to fermentation. 'Consipience' articulates how humans and microbes—or any creatures—come to know each other through taste and smell, within and across species, as a contribution to STS, multispecies studies, and sensory ethnography. 'Experiment' examines the role of technoscience in how humans and microbes know and shape each other in translated fermentation, and proposes a model of experiment as a contribution to STS. 'Interest' brings together the aesthetics, ethics, politics, and biological consequences of translated fermentation's taste shaping natures, and suggests the supporting concept of 'micro-governmentality' as a complement to 'microbiopolitics'. In conclusion I reflect on fermentation politics, and consider how fermentation contributes to ongoing debates around domestication.

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[1] See www.genekogan.com and www.genekogan.com/works/style-transfer, based on Gatys, Ecker, and Bethge (2016).

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LIST OF ABBREVIATIONS

AAB	Acetic Acid Bacteria
AFN	Alternative food network
ANT	Actor-Network Theory
ASV	Amplicon Sequencing Variant
BSA	Bovine Serum Albumin
EBT	Eriochrome Black T (indicator pigment)
EDTA	Ethylene-diamene-tetra-acetic acid
FOH	Front of House (restaurant service team)
FU	Fluorescence Units
HGT	Horizontal Gene Transfer
ITS	Internal Transcribed Spacer (fungal gene)
LAB	Lactic Acid Bacteria
LGT	Lateral Gene Transfer
meta/genomes	A shorthand I use for 'genomes and metagenomes'
NCSU	North Carolina State University
NFL	Nordic Food Lab
NGS	Next Generation Sequencing
NNC	New Nordic Cuisine
NND	New Nordic Diet
OED	Oxford English Dictionary
PCR	Polymerase Chain Reaction
PE	paired-end
PERMANOVA	Permutational Multivariate Analysis of Variance
pH	potential of hydrogen (measurement of acidity)
PI	Principal Investigator
RH	Relative Humidity
R&D	Research and Development
SCOBY	Symbiotic Culture of Bacteria and Yeasts (eg. a kombucha mother)
SNM	Statens Naturhistoriske Museum (Danish Natural History Museum)
SNP	Single Nucleotide Polymorphism
spp.	species (plural)
SPRI	Solid Phase Reversible Immobilization (beads)
SSK	Sociology of Scientific Knowledge
STS	Science & Technology Studies
TE	Tris-EDTA (buffer)
TET	Tris-EDTA-Tween (buffer)

NOTES ON THE TEXT

Portions of this text have been published in earlier forms: parts of 1.1, 4.4.1, 6.2, 8.0, 8.3.1, and G.1 in Evans and Lorimer (2021); and parts of 8.2 in Evans (2021).

Some parts of this work have been made by others: sequencing and analysis of the preliminary samples were performed by Jacob Agerbo Rasmussen and Sarah Mak; analyses of the miso samples were performed by Florent Mazel; labwork for the kōji samples was performed by Max Emil Ermter Ramsøe, under the guidance of Christian Carøe; and analyses of the kōji samples were performed by John Gibbons and Kimmo Sirén.

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Chapter cross-references in the main text appear in full (eg. 'Chapter 1'); parenthetical chapter cross-references are abbreviated (eg. 'Ch1'). Cross-references to specific sections are indicated by the section number (eg. '1.1.1').

[2] www.copyrightuser.org/understand/exceptions/quotation/

ACKNOWLEDGEMENTS

Though it sometimes felt like being a single cell in a petri dish, making this thesis, as many things do, involved an ecology. I am grateful to many people and institutions who have made the result both richer and possible at all. While I take full responsibility for any errors, I hope these people and institutions will accept my thanks.

First and foremost, thanks to my supervisor, Jamie Lorimer. Since the summer of 2015 when we first met and sat in Hertford's Quad while I shared some basic, barely formed ideas, Jamie has been supportive, reliable, generous but not indulgent. Not anyone would be willing to supervise such a methodologically 'eclectic' project, but Jamie has been from the start. He has given me considerable reign to shape the project as I've seen fit, while gently and patiently guiding (and re-guiding) it, and me, in the necessary directions. He has shared opportunities to join him in making presentations, papers, and workshop trips, and visited Copenhagen to become acquainted with my fieldwork sites. He has supported my own research trips and workshop organising, and was instrumental in obtaining my funding. He's shown me what academic work is about and for, and reminded me when I've forgotten (or tried to). His even guidance suffuses the thesis, and has shaped it for the better.

My collaborators from the Copenhagen culinary world must also be front and center. Huge thanks to the teams at Noma and Empirical for letting me be in the way, ask lots of questions, use their infrastructure and resources, and unfailingly support my work, especially when they knew it wouldn't yield results for a couple years; and an extra thanks to Empirical for sponsoring my 'Guest Researcher' visa in 2020-2021 once my two-year

'Visiting PhD' visa through University of Copenhagen ended. This culinary world's 'ja tak' / 'can do' attitude is exceptional, and my gratitude to all involved runs deep. Especially to David and Jason in the Noma fermentation lab for facilitating my day-to-day work, René for letting me conduct my research at Noma, and Lars and Mark for hosting me at Empirical. Also to Kim at Restaurant Amass and Thomas at Restaurant Inua in Tokyo (while it was open) for sharing samples of some of their fermentations for sequencing, as well as previous members of Nordic Food Lab for making it so inspiring a place, where the seed of this project, as many others, was planted.

At and around these places, I had the pleasure of meeting such generous, curious, talented and fun participants throughout my ethnography, and I have to thank each of them for their time, knowledge, palates, samples, and interest: Kim Wejendorp, Jia Hao Choo, Priyanca Patel, Yu Ting Lin, Hiro Takeda, Chris Stewart, Jason White, Sam Hunt, Ni Lenette, Louise Beck Brønnum, Junichi Takahashi, Dylan Watson-Brawn, Spencer Christenson, Johannes Bay, Andrew Lê, Daniel de Haas, Mathias Skovmand-Larsen, Jonas Astrup Pedersen, Henry Stevens, Edith Salminen, Tamara Vega, Rodrigo Nincao, Lisa Abend, Kamilla Seidler, Anna Loraine Hartmann, Luke Kolpin, Torsten Vilgaard, Réka Almási, Marika Groen, Eric Heilig, and David Zilber. Y'all're legends.

Then there is Team DNA. I feel a specific, almost urgent gratitude for these collaborators, because they enabled a crucial part of my project I simply could not have done alone. Thanks to Tom Gilbert at the University of Copenhagen, first at the Section for Evolutionary Genomics at the Natural History Museum, then at the Center for Evolutionary Hologenomics at the GLOBE Institute, for hosting me in his group, sponsoring my visa, giving me lab space, funding my sequencing, and providing feedback

on my experimental designs and analyses; to Jacob Agerbo Rasmussen and Sarah Mak for conducting the labwork and analysis on my preliminary samples; to Christian Carøe for patiently guiding me step-by-step in the labwork for the metabarcoding of the miso samples; to Max Emil Ermter Ramsøe for doing the labwork for the kōji metagenomics; to Florent Mazel at Université de Lausanne for conducting many rounds of analyses of the miso samples, helping me interpret them, fulfilling any request for amendments, and always responding to my questions, no matter how basic; to John Gibbons at the University of Massachusetts Amherst and Kimmo Sirén in Tom's group at the University of Copenhagen for conducting analyses of the kōji samples; to Aviaja Lyberth Hauptmann at Ilisimatusarfik / University of Greenland and Tiffany Mak at the Danish Technical University for reading and offering feedback on the sequencing analyses and discussion of the results; and to Michael Bom Frøst for providing petri dishes for the laboratory kōji experiment. I'd also like to thank Greger Larson at Oxford for his feedback on my experimental designs and productive early conversations about domestication, and Rob Dunn at North Carolina State University (NCSU) and the University of Copenhagen for his feedback on my experimental designs, my DNA results and discussion, for his ongoing support of my work in general, and for including me in invariably enriching conversations about flavour, microbes, ecology & evolution, and interdisciplinarity.

Though I conducted my fieldwork, experiments, and labwork in Copenhagen and stayed to analyse my data and write up, I am grateful to the UK-based institutions and people that have supported my development as a researcher, both during and leading up to my DPhil. Thanks to the Department of Zoology at Cambridge, and my host and collaborator there Charlotte Payne, for welcoming me as a visiting researcher in 2016, where I first had the chance to start thinking more deeply about domestication. Also at Cambridge I'm grateful

to the Department of History and Philosophy of Science, where I did my MPhil in 2016-2017, and in particular to Helen Curry for supervising my work on histories of experimental evolution, laboratory domestication, and indigenous agricultures, and to Tim Lewens for supervising my work on philosophy of biological individuality and microbes. In many ways that year served as a scholarly foundation for my DPhil. At Oxford I'm similarly grateful to my department, the School of Geography and the Environment, for its breadth of perspective; to the More-than-Human Geographies and Indigenous Epistemologies reading groups for enriching talks and discussions; and to the Oxford University Blind Wine Tasting Society, particularly Janice Wang and Domen Prešern, for offering both palate boot camp and, incidentally, an activity of direct consequence for my research—in thinking through taste and figuring out consipience, experiences with OUBWTS often came to mind. Great thanks to Hertford College, for being a warm collegial home; to Alice Roques, the college librarian, for her perennial help in locating sources; and especially to the Mortimer May fund for generously funding my research through their DPhil Scholarship in Human Geography. A note of thanks as well to the Codrington Library at All Souls, for reading access and archival assistance.

Beyond these home institutions, I have had the pleasure to share my work a few other places, all of which have helped make it better. Thanks to Roskilde Festival, the Oxford Symposium on Food and Cookery, ArktiskMat, the Royal Danish Academy of Art, the Medical Museion, Fermenting Feminism, Laboratory for Aesthetics and Ecology, the Oxford Natural History Museum, Philly Chef Conference, Aarhus Food Festival, MIT Media Lab, Fermentology @ NCSU, and Food on the Edge—and, through Jamie, to INRA, the Wenner-Gren Foundation, and 4S—for the opportunity to share in presentation; to Fermenting Feminism, Laboratory for Aesthetics and Ecology, the MIT Journal for Design and Science, Fermentology @ NCSU, Hypercomf artist collective, and food feminism fermentation—and, through Jamie, to Current Anthropology—for the opportunity to share in writing; to the Royal Geographical Society Conference 2018 for the chance to organise a panel with colleagues on 'Mapping microbial multiplicity'; and to the Synbio futures workshop at the Science, Technology, and Innovation Studies department at the University of Edinburgh in 2017, the Kilpisjärvi Collective for *With Microbes* in 2020, and the More-than-Human Collaborations workshop in 2021 organised through Oxford, Cambridge, and Queen's University Belfast for the chance to participate. These opportunities to share work have invariably improved it, especially in the company of such diverse, sensitive, and charitable colleagues and elders.

A few close colleagues have given me the gift of reading and offering feedback on chapter drafts. They have suggested improvements, identified new directions, and provided more help than they might know. Warm thanks to Erika Szymanski (Chapters 4–7), Emma Pask (Chapters 5–7), Anna Sigrithur (Chapters 4, 6, and 7), and Aviaja Lyberth Hauptmann (Chapter 7) for their generous reading. A special thanks as well to my secondary supervisor, Beth Greenhough at Oxford, for reading and offering feedback on drafts of all the analytic chapters and the whole thesis prior to submission, and for offering useful and empathetic guidance at critical points along the way. Similarly, thanks to my Transfer of Status (first year), Confirmation of Status (third year), and Viva assessors—Javier Lezaun and Richard Grenyer, Marion Ernwein and Alexandra Sexton, and Heather Paxson and Javier Lezaun—for their helpful comments and engagement with my work at each stage.

A few further thanks for individual collaborators and colleagues. To Erika Szymanski, Anna Krzywoszynska, Carmen McLeod, and Alexandra Sexton, for the productive conversations and joint writing to think through microbial ontologies and microbial multiplicity. To Maggie Coblentz, my collaborator at MIT Media Lab's Space Exploration Initiative, for figuring out together how to launch some miso to ferment on the International Space Station and in doing so providing the opportunity to think with it. And to Anna Tsing, Rob Dunn, Eben Kirksey, Bill Adams, Thom van Dooren, Shawn Wilson, Hannah Landecker, Paul Freedman, Sandor Katz, and Harold McGee, for their helpful correspondence.

Finally, and not least, some personal notes of thanks. To scattered friends I've eaten with, thought with, and whose thinking is there in mine: Andrew M, Charlotte McC, Josh P, Kelly D, Andreas J, Guillemette B, Edith S, Mathias S-L, Charlotte P, Anna S, Stephen H, Emma P, and Erika S. To Guillemette in Biarritz, everyone at Maos Lyst, Casper, Gitte, Ask & Sejer at Bøgedal, Roddie, Lindis, William, Johnny, & Eric in the Arctic, and Tonje and Frimand at Lönnebacken for sharing with me some wonderful places to stay, play, think and work. To Locana, Duncan A, Mike R, Sue B, Alex F, Jenny D, Sean & Carl, Mattie F and crew, Lunch Klub, Blanch & Shock, and Kate & Hugo, for helping make the UK home for a couple years. To my radiant Copenhagen friends, who bring the vibe, have kept me sane, and somehow are still there: Maria RS, Sara M, Ebba M, and all the lovely rest. To my parents for having showered me with opportunities and my siblings for being weird. And to M, for having the unfathomable patience to put up with it, and with grace.

And, of course, to the microbes, without whom not. I feel now somehow I understand you even less.

PROLOGUE: IN THE FERMENTATION LAB

Steaming barley has a specific smell. It's something like bread, something like beer, something like bao, and something else altogether. It's a nice smell. That's what I'm thinking when the oven timer goes off. Jason swings the door open, engulfing us in steam. 'Here,' he says, unloading stainless steel trays onto the stainless steel countertop. 'Start breaking up.'

With my plastic dough cutter I start prising the pearled barley gently out of the perforated tray. The trays are filled to the brim, and the barley, steamed for forty minutes after an overnight soak, cakes together in one enormous mass. Jason and I loosen large chunks into empty, ethanol-sterilised, non-perforated trays. When all the grains are out of the (very hot) steaming trays, we use our hands to break up the (still very hot) barley, rubbing the chunks between our palms into individual grains. Our hands are double-covered with laboratory latex gloves, which make the heat just tolerable. A chef with seasoned hands, like Jason, might mind it less.

We continue stirring the grains in the trays with our hands, making sure all clumps are broken and helping them to cool. When they reach around 37˚C, we use sugar shakers to

Figure 1—David Zilber, then director of the Noma fermentation lab, inoculating a 'sheet' of flattened steamed barley.

dust the grains with spores of a special Japanese fungus, and mix them to coat evenly (Figure 1). This is why we use gloves, and are so careful with sterilising our trays and implements: cleanliness is of paramount importance to minimise the chance of unwanted colonisation by other faster-growing or more opportunistic microbes. We transfer the inoculated grains into new perforated trays lined with damp wrung linen cloths, fold the cloths overtop of the grains, slide the trays into a tall wheeled rack, and wheel the rack into

Figure 2—The Noma fermentation lab.

one of three small closets outfitted with temperature and humidity control and sensors. We nestle the temperature probe into one of the trays of grains, close the door, and set the room to 32˚C and 75% relative humidity. 'What's next,' Jason asks aloud, as we return to the fermentation lab's main central room, morning light pouring through a large overhead window (Figure 2). As deputy head of fermentation at a renowned Copenhagen restaurant called Noma, Jason has multiple tasks to keep track of at a given time, thinking simultaneously across hours to years ahead.

First thing the following morning, we check our barley. We pull back the linen cloth. Tiny white filaments have begun to sprout and hold the grains together. We wheel the rack into the main lab, unload the trays, and mix the grains to redistribute the growing mycelia and dissipate the heat produced by the fungus' metabolism. It's important not to let the grains get too hot, Jason tells me, otherwise the fungus can heat itself to death. If we give it a glut of nourishment all at once, we need to help pace its growth.

Yesterday's steamed barley smells gives way to new ones—the small kitchen space grows fragrant with flowers, ripe tropical fruits, raw mushrooms. We return the grains to the trays, wrapped in freshly wrung linen cloths, and wheel the rack back into the closet. We lower the temperature to 28˚C to keep the grains from overheating. The fungus continues growing. At the end of the day, myriad tasks and tastes later and with service coming to a close, we leave a large bucket of dried yellow peas to soak overnight in the refrigerator, and head into the night—this time of year, in early July, the midnight sky has still a bit of light.

The next morning, after just less than two full days, the fungus is finished fermenting our barley. The fluffy white mycelia have bound the grains into a spongy cake (Figures 3 & 4).

Figure 3—The finished fermented barley.

Figure 4—The finished fermented barley.

The result is fragrant, lightly sweet and umami. This is called 'kōji'—the Japanese word for the filamentous fungus *Aspergillus oryzae*.[3] Kōji describes these organisms and the ecology formed when they are grown on rice, barley, soybeans, or other starchy or proteinous substrates for use in fermentation.[4] Kōji fungi produce enzymes that break down larger molecules—starches into simple sugars, proteins into amino acids, and fats into fatty acid chains—facilitating microbial metabolisms that enhance the flavour, healthfulness, and preservation of many foodstuffs. This power has led to kōji becoming a cornerstone of Japanese cuisine, used to produce sake, soy sauce, miso, and many other products (Shurtleff and Aoyagi 2012).

Humans have a history with kōji that goes back thousands of years. The benign *A. oryzae* was likely domesticated from the more dangerous wild *A. flavus* by intoxication-fixated humans selecting for the saccharification of rice as a necessary step for the subsequent production of ethanol by yeasts (J. Gibbons and Rokas 2013; J. Gibbons et al. 2012; Kurtzman et al. 1986; Machida et al. 2005; Machida, Yamada, and Gomi 2008).[5] In other words, kōji emerged because it helped our recent human ancestors enjoy the pleasures and powers of inebriation. These selections for enzyme production and atoxigenicity were also shaped by preferences for the production of desirable secondary metabolites, including its

[3] Kōji may also refer to other Aspergilli, such as *A. sojae*, *A. awamori*, and *A. luchuensis*, and even a non-Aspergillus fungus such as *Monascus purpureus*, or 'red rice kōji'.

[4] Japanese distinguishes between different states of the fungus: 'kōji' refers to the fungus with substrate before sporulation (while it is white and fluffy and ready to ferment with); 'tane-koji' refers to the sporulated fungus with or without substrate (as with pure spore powder or spores on whole dried rice grains); and 'koji-kin' refers to the fungus itself, without substrate. Thanks to Shinya Shoda for this clarity. Most non-Japanese fermenters nowadays seem to use 'kōji'—or 'koji', without the long 'ō' vowel, as it is most often spelled in English—to refer both to the fungus itself and the fungus grown on substrate.

[5] The estimated timing of the domestication of *A. oryzae* ranges from around 9000 years ago (McGovern et al. 2004) to between 3000 and 700 years ago (Watarai et al. 2019). Lee (2019) has shown how the taxonomic distinction between *A. oryzae* and *A. flavus* itself was driven by the twentieth-century discovery of aflatoxin as a carcinogen, and the subsequent desire to show *A. oryzae* to be safe for culinary use.

pleasing aromas (Galagan et al. 2005; J. Gibbons et al. 2012; K. Ito et al. 1990; Yoshizaki et al. 2010).

Kōji is not just a delicious microbe but a powerful social actor. Its industries have structured Japanese society for centuries, and as a central feature of late nineteenth-century Japanese technoscience it helped drive the country's modernisation and industrialisation (Lee 2021). For its culinary importance and profound social significance in Japan, in 2006 the Brewing Society of Japan designated kōji the country's 'national fungus' (Lee 2019).

Kōji's exceptional 'charisma' (Lorimer 2007) has by now captivated many beyond Japan. Contemporary chefs and fermenters like Jason and David are far from the first here; kōji has been circulating the world since at least the late nineteenth century. In the 1890s, for example, Dr. Jōkichi Takamine, a Japanese chemist and entrepreneur, saw it as a promising biotechnology for industrial whisky production, and worked to commercially translocate it from Japan to the USA and Europe (Shurtleff and Aoyagi 2012). Over the twentieth century the *Aspergillus* genus became one of the best-characterised fungal genera. Many of its species became model organisms for laboratory research, workhorses for the production of enzymes, acids, and aromas (Goffeau 2005) and other industrial biotechnologies (Cairns, Nai, and Meyer 2018), or intensively studied for their pathogenicity (J. Gibbons and Rokas 2013), strain diversity (Zhao et al. 2013), functional genomics (He et al. 2019), and reproduction (Wada et al. 2012). The spores of *Aspergillus oryzae* and other Aspergilli used for fermentation can now be bought online and are posted worldwide. The genus has developed a global anthropogenic biogeography, beyond that of its own mobilities (Tsing 2014), by virtue of its mutualistic utility and gustatory allure.

Aspergillus oryzae is closely associated with the rice plant (*Oryza sativa*). As rice does not grow in Scandinavia, autochthonous populations of *A. oryzae* are unlikely to be here. Yet in recent years this fungus has found a home in restaurant kitchens across Copenhagen, and the world. At Noma, David, Jason, and their team in the fermentation lab grow multiple kinds of kōji, around 75 to 100 kilos per week in total, for use in various fermentations—both in large quantities with established recipes for production, and in smaller amounts for trials in R&D. The kind we have used here is an albino strain, purchased from the Japanese commercial producer Bio'c.[6] The finished kōji can be used immediately, refrigerated to halt fermentation before it sporulates, or frozen for later use.

The kōji finished, we turn to the peas. Yellow peas are a classic Danish ingredient, traditionally cooked until soft, often with a bit of pork. These ones we drain from the soaking water and boil in new water in a large pot. This is the easiest way to monitor their progress, Jason tells me. We must cook them to a specific texture: just cooked through, but still firm. Jason bites into one, showing me how to feel with my front teeth when the peas have reached the perfect point.

When the cooked peas are drained and spread in a tray to cool, we use a meat grinder to crush up the barley kōji, then the cooled peas. We combine three parts cooked peas with two parts kōji, add 4% of the total weight in salt, and mix everything together thoroughly with gloved hands. When everything is mixed evenly, Jason tests the consistency by squeezing a handful in his fist. 'It should hold together and squeeze out smoothly, neither

[6] Albino kōji was purified from a mutation in older black-sporulating kōji around the start of the twentieth century. It became popular because it did not leave black marks on the clothing of kōji growers and sake producers. Black kōji has since made a resurgence due to its distinctive flavours.

too runny nor too crumbly.' If the texture needs adjusting, he adds either a bit of pea cooking water or a bit of 'kōji flour', dehydrated kōji that he's blended into a powder.

When the texture is approved, we take large handfuls of the mixture and tamp it down into ethanol-sterilised, white plastic buckets or large glass jars, as firmly as possible to avoid air pockets (Figure 5). This creates an anaerobic environment that selects for desired bacteria and yeasts, and against unwanted moulds.

Figure 5—The cooked pea and barley kōji mixture, pressed into a bucket.

We cover the surface with a layer of plastic cling film, and weigh it down with ceramic weights. We place a dry cloth over the top of the bucket, secure it with a rubber band, and load the buckets and jars onto shelves in another room off the main kitchen (Figure 6)—this one larger than the kōji room, set to 30˚C and ambient humidity.

Figure 6—Full shelves in one of the lab's fermentation rooms.

From here, Jason will monitor them to ensure they are fermenting as desired, developing umami taste and fruitiness, and not going too sour too quickly. After three months, if all goes well, they will reach the desired balance of sweetness, sourness, and umami. The result: a yellow pea miso, or, as it's known colloquially at Noma, 'peaso'.[7] Peaso has become a staple of the Noma pantry, elaborated into many further forms. There is always some stored in the freezer, kept at the desired balance of tastes.

Noma did not invent miso, of course. It's a traditional product of Japan, a fermented paste usually consisting of soybeans, kōji grown on rice or barley, and salt. The simplicity of this formula belies the immense diversity of miso varieties across Japan—depending on the raw materials, their proportions, the method of assembly, the arc of fermentation, and the microbiomes of the space and the producer themself, misos can vary greatly in colour, texture, flavour, and use (Shurtleff and Aoyagi 1983). Many misos are rich in umami, and have been used for centuries in Japanese cuisine as a savoury element for soups, sauces, glazes, and other applications.

Even seemingly small details—like the exact degree of cooking the legume, or the exact level of moisture in the starting mixture—can matter greatly for the final result. As Jason explained to me, too much cooking can make the peas too mushy, introducing too much water to the miso such that it will quickly sour from increased bacterial activity; too little cooking will not cook the peas through, limiting the nutrients available to the microbes and yielding a dry, crumbly texture. David, a physics buff, framed it as a fermentative instance of nonlinear dynamics, in which slight variations in starting conditions can yield

[7] More than just a joke, I suspect this neologism serves an important function: giving credit to Japanese tradition while distinguishing peaso and miso as not quite equivalent, both to preclude charges of appropriation and to signal the former's newness.

dramatic downstream differences. 'It's all chaos theory!' he'd tell me, referring to Edward Lorenz (eg. 1963).

David, Jason, and their predecessors at Noma have developed all kinds of miso with many Nordic varieties of protein-rich, leguminous substrates. This represents a quite novel approach to fermentation—deliberately combining microbes and techniques from different parts of the world with raw materials from the Nordic region, in the pursuit of new flavours. This approach—what I will call 'translated' fermentation—has emerged within a larger culinary movement known as the New Nordic Cuisine (NNC), which has aimed to explore the biodiversity and cultural identity of the Nordic region through cooking.

Back in the miso room, Jason shapes the microbial ecology of the fermentation as it goes, adjusting temperature, humidity, surface weight and oxygen exposure to steer the miso's taste towards Noma's desired balance. Similarly, Jason is steered by the microbes, whose metabolisms shape his sensory and bodily responses through pleasure, interest, and disgust, and structure his time and labour, ordering his tasks and often forcing him to stay extra hours or come in on weekends. No one is in full control, nor is this a symmetrical 'collaboration'; but, through these intimate, taste-based relations, humans and microbes come to shape each other's lives and livelihoods, in more profound ways than they might suspect.

1 TRANSLATED FERMENTATION IN THE NEW/ER NORDIC CUISINE

The time I spent at Noma in 2018 and 2019 wasn't my first encounter with such 'translated' fermentation experiments. Part of the reason why they let me be there at all, let alone get in the way and ask lots of questions, was because we had known each other for a few years. In 2012, I moved to Copenhagen to work at Nordic Food Lab (NFL)—a non-profit open-source research space established by Noma in 2008 to investigate the edible diversity of the Nordic region and share the results with the restaurant industry, academia, and other publics.

I arrived on summer solstice; those first high summer days passed in a flurry of new flavours (new, at least, to me). Lars Williams, then NFL's head of research and development (R&D) and for some years prior an R&D chef at Noma, and Arielle Johnson, then doing her PhD in flavour chemistry, led me through tastings of the lab's inventory: kombuchas made from carrot juice or lemon verbena; vinegars made from celery, or quince in a balsamic style; lacto-fermented dryad saddle mushroom, which tasted like peaches; garum, an ancient Roman fish sauce, made with grasshoppers. I tasted kōji for the first time, fresh, roasted, and fried; and of course, there was the peaso. They taught me how to grow kōji for use and for spore, make miso, create the various fermentations we had on board (the lab was on a houseboat), and experiment with new ones.

Over the following months, I also learned some of the basic microbiology involved in these different fermentations—why some wanted air and others did not, who liked which temperatures most, which signs were promising and which to look out for. Like many others before and since, I became fascinated by microbial reproduction, ecology, and evolution—the rapidity, the horizontal/lateral gene transfer, the promiscuous, 'rhizomatic' messiness (Deleuze and Guattari [1980] 1987). The more I learned how quickly some of these microbial communities change, reorganise, and adapt to new environments, the more I came to suspect it was possible, if not probable, that these experiments for flavour could also be bringing new ecologies and even perhaps new organisms into being. Without willing or realising it, these chefs and fermenters might be doing much more than merely making 'new', rarified flavours for a relatively small and exclusive audience to taste, and broader publics to be inspired by—they might also be facilitating inadvertent changes to microbial life, with implications far beyond their kitchens.

This project emerged from my curiosity and desire to figure out whether this inadvertent change was happening. It quickly grew into something much larger. If it was happening, what particular social relations, among humans and between humans and microbes, were enabling it? How should these relations be described and understood? And what would this 'taste shaping nature'—a nature shaping and shaped by taste—imply for other fields?

If these chefs were indeed fermenting 'new life' into being—as Noma's head chef René Redzepi describes the 'magic' result of that carrot kombucha's 'transformational power' (Redzepi 2014a: 12)—this would constitute a story quite different from what one commonly hears. It is not the dominant story of global loss of biodiversity (Montenegro de Wit 2016), microbial included (Flandroy et al. 2018; Hanski et al. 2012; Nabhan 2010), both 'out there' and in our bodies, in which 'missing microbes' (Blaser 2014) are leading to 'epidemics of absence' (Velasquez-Manoff 2013). Rather, this 'new life' would position cooks and fermenters, professional and lay, as inadvertent breeders, population managers, progressive conservationists, ecological-evolutionary 'variers' and 'selectors' (Darwin [1859] 1982). They would be participating in ongoing processes of domestication—not only symbolically, as the assignation to nonhumans of new metaphorical roles, and materially, as the spatial relocation of these organisms into the domus, but evolutionarily, as the hereditary reorganisation of these organisms into new forms. This domestication question—what it is, how we know, who decides, and why it matters—is the thesis' central concern, which I introduce in this chapter, and return to in the final chapter.

Bringing together taste, cooking, fermentation, and microbes within the rubric of domestication promises contributions to multispecies studies, domestication studies, and science and technology studies (STS). While microbes and fermentation have recently become popular in multispecies studies and STS (Paxson 2012; Paxson and Helmreich 2014; Lorimer 2016a), they are largely absent from studies of domestication; taste and cooking are generally understudied in all three fields. Understanding domestication through taste shaping natures and fermentation might also offer contributions to broader debates, for example around agriculture, rewilding, and genome editing, about how humans and non-humans make and remake each other in loopy, never-ending ways.

To address these themes, I first need to set the scene. I begin the chapter by describing the project's broader social context—the New/er Nordic Cuisine, the Copenhagen culinary world, and the culture and political economy of fine dining, as well as some of the scholarship on cooking. Against this background I then discuss the rise of fermentation and a particular 'translated' approach to it, and situate these movements within the larger 'microbial moment' (Paxson and Helmreich 2014) sweeping the sciences and broader publics. Finally, I introduce the domestication question, which I return to in the final chapter. I conclude the chapter by looking ahead, providing an overview of the thesis' aims, research questions, main contributions, and chapter structure.

1.1 COOKING IN THE NEW/ER NORDIC

To understand the proliferation of kōji, miso, and other fermentations, and why they have been translated into Scandinavia as they have, we need to know a little more about the evolving cultural economy of the NNC, and its interest in microbial 'deliciousness'.[8] In this section, I offer some background on Noma and the NNC, its historical and geographical context, critiques of it and its subsequent shifts, and the culture and political economy of contemporary fine dining, and how these discussions inform scholarly work on cooking.

1.1.1 ORIGINS OF NOMA AND THE NNC

In 2003, Claus Meyer, a well-known Danish gastronomic entrepreneur, and René Redzepi, a rising star chef, opened a restaurant in Copenhagen, aiming to develop a cuisine based on what they saw as the undervalued products and traditions of the Nordic region.[9] They

[8] A term frequently used by Redzepi and other Noma affiliates. Beneath its cute, earnest tone is the implication of an objectively discoverable, or at least inevitably perceptible property inhering in food itself. Of course, it is probably more complex. Noma's 'deliciousness', rarified and challenging for many, is a highly specified set of taste norms, developed by Redzepi, his teams in R&D and Front-of-House, and a network of sympathetic experts (chefs, journalists, etc.) that helped assemble and validate it. On the other hand, while deliciousness is always socially shaped, it is not shaped equally easily to anything at all (Ch2).
[9] The area stretching from Greenland to Finland, with Iceland, the Faroe Islands, Norway, Denmark, and Sweden in between.

called the restaurant 'Noma'—a conjunction of 'Nordisk mad', or 'Nordic food'. The following year, Meyer and the Nordic Council of Ministers, an intergovernmental body for regional cooperation, gathered a cohort of chefs, writers, and other stakeholders from across the region to draft a manifesto for the 'New Nordic Cuisine' (Table 1). This culinary movement, they hoped, would bring together restaurants, non-profits, researchers and government agencies to develop the region's culinary identity, industry, and tourism, and 'express the purity, freshness, simplicity and ethics' they wished to associate with the region (Risvik et al. 2008).

The New Nordic Cuisine Manifesto (2004)

1. To express the purity, freshness, simplicity and ethics that we would like to associate with our region.
2. To reflect the changing of the seasons in the meals we make.
3. To base our cooking on ingredients and produce whose characteristics are especially excellent in our climates, landscapes and waters.
4. To combine the demand for good taste with modern knowledge of health and well-being.
5. To promote Nordic products and the variety of Nordic producers - and to spread the word about their underlying cultures.
6. To promote animal welfare and a sound production process in our seas, on our farmland and in the wild.
7. To develop potentially new applications of traditional Nordic food products.
8. To combine the best in Nordic cookery and culinary traditions with impulses from abroad.
9. To combine local self-sufficiency with regional sharing of high-quality products.
10. To join forces with consumer representatives, other cooking craftsmen, agriculture, fishing, food, retail and wholesales industries, researchers, teachers, politicians and authorities on this project for the benefit and advantage of everyone in the Nordic countries.

Table 1—The New Nordic Cuisine Manifesto (Risvik et al. 2008).

The ethos promulgated by the NNC, and Noma's particular aesthetic interpretation of it, have since suffused the culinary world, elite and beyond. Gaining growing recognition throughout the 2000s, Noma tipped into global renown in 2010, when they were voted 'Best Restaurant in the World' by the World's 50 Best Restaurants List, an authoritative industry voice.[10] This was also around when fermentation began to play a key role in Noma's culinary style.

The NNC grew alongside and in part thanks to 'alternative' food movements of the late 1990s and early 2000s: locavorism, organics, 'farm-to-table' and 'nose-to-tail' eating. Noma's rise was related to these, but not quite coincident with them; the restaurant has often incidentally used 'sustainable' foods but it is not their agenda. Rather, Noma's key project initially, as with the NNC, was the construction of a regional culinary identity, and one so alluring it would draw attention from across the globe (and, they hoped, from actual Nordic people too).

Noma and the NNC tapped into a deep hunger among consumers for 'a connection to time and place' (Redzepi 2010: 12), which Redzepi aimed to build by imposing deliberate constraints on the products he could use: 'The seed of our creativity had to be limitation' (Redzepi 2014a: 15). This move towards regional distinction was one example of the well-documented reaction to the perceived homogenising effects of placeless globalisation and the rapid extinction of many locally-specific ways of life (Appadurai 1996; Petrini 2003). Nature—or rather, an idealised naturalism (Paxson 2012)—featured heavily in this reaction. This naturalism saw New Nordic chefs assemble a wide range of rare and forgotten breeds, ancient techniques, local, seasonal, organic and biodynamic products,

[10] www.theworlds50best.com. They retained the title in 2011 and 2012, regained it in 2014, and garnered it a fifth time in October 2021.

and lots of 'wildness' to produce a highly wrought experience of a diverse, bountiful world to which humans might be restored in timeless balance.

One will notice that the manifesto's principles are not specific to the Nordic region. Indeed they are principles that manifest in many cuisines around the world.[11] Here we might introduce a distinction between 'cuisine', a particular historical-cultural-biogeographical-practical expression of a set of culinary values and beliefs, and 'culinary ideology', the set of values and beliefs that animate a particular cuisine (Evans 2015). What was new for the NNC was not that it discovered or constructed an entirely new culinary ideology, but that it applied a well-established one to, as one of my participants suggested, 'a relatively obscure part of the western world' with a different culinary ideology and history.[12]

1.1.2 Historical & geographical context of the NNC

The New Nordic was new because it valorised freshness, lightness, 'healthfulness' and flavour in comparison with 'old' Nordic food: heavy, stodgy, Protestant fare for eking out a life in a cold, difficult climate. The implied 'old' Nordic food and its patterns of production, preparation, and consumption have of course also shifted over time—particularly the rise in meat and dairy consumption since the mid-nineteenth-century industrial revolution, increasing urbanisation and centralisation in the twentieth century, and post-WWII valorisation of abundance and cheapness at the expense of flavour and nourishment (Boyhus 1996, 1998, 2000; Bergflødt, Amilien, and Skuland 2012; Hyldtoft 2010; Skougaard 1984).

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[11] The NNC pamphlet notes the principles are transferrable (Risvik et al. 2008: 7), but not that they already exist the world over.
[12] Spencer Christenson, a Canadian chef at a Berlin restaurant called Ernst.

This regional history contributed to the New Nordic's turn to flavour, health, ethics, diversity, and 'nature'. Yet as a self-conscious culinary intervention it was responding more to the longstanding gastronomic hegemony of larger European powers—'to create a culinary tradition capable of matching the great, established cuisines of the world' (Risvik et al. 2008: 6). While today, Redzepi's express desire 'to cook without reference to other cultures' (Redzepi 2014a: 42) may strike one as haughty and insular, even xenophobic, at the time the desire to develop a regional approach distinct from established cuisines was a form of resistance, a declaration of independence from French and Spanish dominance.

Of course, complete independence isn't possible. The NNC inherited much from the French Nouvelle Cuisine of the 1960s and 70s, which called for a lightening of classic dishes and heavy sauces, introducing fresher, more delicate preparations (Leer 2016; Rao, Monin, and Durand 2005). It was then shaped at least as much by the then-dominant ideology of culinary modernism, sometimes dubbed 'molecular gastronomy' (Roosth 2013). This movement, whose epicentre from the 1990s through to the late 2000s was a celebrated restaurant named El Bulli in Catalonia, emphasised technique and unfettered human creativity. It aimed to surprise and misdirect the diner through the abstraction of raw materials, notably through radical transformations of texture into gels, foams, and exploding spheres of liquid. This cuisine could implicitly be practised anywhere in the world, with ingredient provenance a lesser concern. It often involved deliberately bringing together ingredients unrelated to each other by ecology or region, in contrast to the emerging Nordic style. It was also premised on the chef's genius over and above nonhuman agency like that of tasty microbes.

In their public self-presentation through cookbooks, interviews, and the dining experience, Noma found in culinary modernism a useful counterpoint for the naturalistic methods they were developing; but under the hood, in the kitchen and the fermentation lab, Noma and the NNC have always retained certain key principles of this scientism.[13] In practice, we must understand the shift to Nordic naturalism and the celebration of microbial agency in fermentation not as a simple reactionary move against culinary modernism, but as a subtle 'post-Pasteurian' (Paxson 2012) reworking of its neophilic, high tech identity. For example, Lars, David, Jason, and many other fermenters described how the technologies for monitoring and conditioning their fermentations were vital, not only for achieving consistently optimal results, but sometimes, as with kōji, for achieving successful results at all. While the NNC employs many techniques of the modernist canon, it has co-opted them into a new model, narrating the role of technoscience in its ideology in quite different terms: less as a means of uncovering universal culinary principles and physical and chemical techniques, and more for developing specific regional microbiological articulations of flavour impossible to reproduce elsewhere (4.4.1)—even if one followed the same recipe exactly.

Since the NNC's rise, similar turns to 'naturalism' have swept the elite culinary world, including in France and Spain.[14] While 'who influenced whom' is a question for another thesis,[15] and both directions are probably the case, what is worth noting here is the NNC's uneven geography of circulation—it has by now spread to many places in some form,

[13] As a younger cook, Redzepi also spent a season working at El Bulli, and Noma's early style was heavily inflected by modernist techniques (Redzepi and Meyer 2006).
[14] Other culinary traditions, such as the French, might claim their own histories for similar principles (eg. Sarran and Pellé 2017).
[15] Renowned French chef Michel Bras had, for example, been leading a comparable turn toward vegetables, lightness, and foraging since the 1990s (Bras 2002).

though not equally. It has been particularly predominant across the anglophone world, though also present across northern, central, and parts of eastern Europe, and Central and South America. The places where it seems to have had greatest influence are, perhaps not coincidentally, colonial nations, where indigenous connections to and knowledge and appreciation of the edible landscape have been systematically extirpated. It might have been that the NNC promised to settlers anxious about their relationship with the land they occupied a way to develop, they hoped, a deeper connection to it, without necessarily having to confront their colonial heritage.[16] The NNC's general absence of Sámi people, the indigenous peoples of Scandinavia, facilitated this promise (Ch4). In this example we begin to see some of the NNC's problems.

1.1.3 Critiques of the NNC & subsequent shifts

The NNC was not without its critics. Beyond the derision lobbed by French and Danish chefs alike, some also questioned the insular history and exclusionary politics it suggested. The Nordic Council seems to have anticipated such critiques, when they acknowledge the historical introductions of 'exotic spices' and 'the potato' (Risvik et al. 2008: 6). Viking trade had also circulated goods from the Mediterranean, Eastern Europe, and the Near East since at least the eighth century (Jankuhn 1982; Mitchiner 1987; Noonan 1992). Yet these acknowledgements did not obviate the overarching priority: establishing Nordic uniqueness rather than interdependence. Aware of treading ground frequented by xenophobes, the Council reassures us that 'being for Nordic food doesn't mean being against the food from other countries. It's about valuing your traditions and your situation, wherever in the world you find yourself.' (Risvik et al. 2008: 29) While it seems reasonable

[16] There is a lot more to say here; see eg. Gora (2021).

to suggest that culinary appreciations needn't be zero-sum, the NNC nonetheless came to be seen by some as a form of culinary fascism (Holm 2011), as such laissez-vivre public statements were hard to reconcile with its interest in naturalising the relation between Nordic nature and Nordic people to yield a timeless culinary identity (Ch4).

In the scholarly literature, the NNC has also been subject to critical discussion with respect to gender (Leer 2019; Neuman and Fjellström 2014), class (Micheelsen, Holm, and O'Doherty Jensen 2013, 2014), race and colonialism (Andreassen 2014), nationalism (Neuman and Leer 2018), identity formation (Hermansen 2012), social distinction, scaling (Riel Müller and Leer 2018), and historicity (Leer 2016).[17] Contra Munk and Bøcher Ellern (2016), the politics of the NNC are not only 'ontological' in that they inhere in actors' practices; these multiple dimensions of social critique show that these politics are also discursive and sometimes explicit. Still, 'very limited critical research has been done on the phenomenon' (Andreassen 2014: 438), then and since. Much of this critical literature has also tended to reify the NNC as a discrete, transcendental entity. One exception that aims

[17] Leer (2019) investigates different 'constructions and negotiations of masculine identity in the NNC', comparing Meyer in the domestic kitchen and Redzepi in the professional one, and noting how they each work to distance themselves both from 'traditional understanding of women's everyday cooking' and from 'food and gender practices of hypermasculine chefs': a 'precarious balance' (ibid.: 316). Neuman and Fjellström (2014) observe the increase in Swedish men cooking since the advent of the NNC, which they ascribe to cooking's 'enhanced status' due to 'greater incorporation of gastronomy', and food and cooking practices recently becoming 'not associated with emasculation in contemporary Western society' (ibid.: 269). They conclude that 'Sweden's gender-egalitarian ideology may have a particularly strong legitimising impact on Swedish men's food and cooking practices.' (ibid.) In relation to the closely linked 'New Nordic Diet' (NND), a large-scale social experiment to codify and democratise the NNC into an analogue of the so-called 'Mediterranean Diet', Micheelsen, Holm, and O'Doherty Jensen (2013, 2014) observe that while 'most participants… are positive towards the ideas underlying the development of this new diet and enjoy the taste and appearance of NND meals,' women and urban residents are particularly receptive (2013: 14). While their findings indicate that 'the taste of the NND is likely to appeal to wider groups of consumers,' (2014: 1247), they also identify multiple 'barriers to acceptance', including the 'untraditional formats of NND meals, the time needed to prepare them, the unfamiliarity of ingredients, perceived problems regarding product availability, [and] reservations about the [project's] elitist character,' all of which suggest class-based differences in the diffusion and adoption of the NNC and NND (2013: 14). Critiques concerning race and colonialism (Andreassen 2014) and nationalism (Neuman and Leer 2018) I discuss further in the analysis in Chapter 4.

to account for its change over time proposes a simple narrative of 'rise and fall' (Leer 2016). I suspect its history is slightly more complex, dialectical, and sedimentary, which I detail in Chapter 4.[18]

While the innovation imperative of vanguard restaurants like Noma explains that the New Nordic changed in general (Tan 2020), innovation alone does not explain why the NNC changed in the particular way it did. I propose that shifts in Nordic cookery from regionalism to what some might call a 'glocalism' (Robertson 1995) from around 2014 occurred alongside larger social and political shifts in Scandinavia and beyond. The European refugee crisis and the rise of the political Right led to the amplification of historic but previously marginal discourses that construct exclusive regional identities by naturalising ethnic or national connections with landscape (Biehl and Staudenmaier 1996; Campion 2021; Lorimer and Driessen 2016; Moore and Roberts 2022; M. Zimmerman 1995). The uncomfortable political charge of a natural and native Nordic cuisine became obvious (Holm 2011). For a fine-dining restaurant like Noma, in the business of selling narrative just as much as food to affluent, generally cosmopolitan consumers, the story of Nordic purity rapidly became untenable.

This was likely one reason why Noma began to look for 'new' culinary horizons overseas. While Redzepi has frequently explained that Noma's three 'pop-ups' in Japan (2015), Australia (2016), and Mexico (2017) were all part of the 'pursuit of deliciousness', keeping the team on its toes and constantly learning about different cultures and flavours, these endeavours also helped rebrand Noma as outward-looking, cosmopolitan and global in perspective. Projects like these gesture to an evolving agenda that is now definitively more

[18] A project that aligns with efforts to conceptualise the ideological shifts of recent culinary history; see A. Johnson (2020) on 'fuzzy legibility' and 'the recent dialectical emergence of post-modernity in cuisine'.

than regional (Evans 2015; Leer 2016), even while their success remains predicated on their skill in packaging the 'Nordic' for a global audience. Empirical Spirits, a 'free-form' distillery and flavour company founded in Copenhagen in 2017 by two Noma alumni, Lars Williams and Mark Emil Hermansen, is exemplary of this more recent 'glocal' chapter. They use ingredients and techniques from around the world, while still animated by the NNC ethos.[19]

This shift to glocalism I call the 'Newer Nordic' (Ch4).[20] This history could be narrated with more phases and transitions—but this shift, I argue, is the most significant one, so I begin here. Many of my participants would baulk at the term 'Newer Nordic', as those on the vanguard have in recent years moved away from reference to being 'Nordic' of any kind.[21] For analytic purposes, however, the term is useful, and offers a critical contribution to the scholarly literature.

1.1.4 FINE DINING CULTURE

Professional cookery involves specific practices, spaces, culture, and political economy (Fine 1996), different from those of domestic cookery. René, Lars, David and Jason work at the cutting edge of this industry, in a global and competitive fine dining scene. This is an economic world marked by high capital costs, thin margins, and a dependence on reading and shaping consumer trends and preferences, contributing to these chefs' all-consuming drive to generate new, consistently executed dishes (Tan 2020). While dishes and the dining experience remain the core of the craft, success is increasingly contingent upon a

[19] Noma and Empirical were the two sites for my ethnography, which I describe further in Chapter 3.
[20] While such shifts have been overlooked in the scholarly literature, they have recently been acknowledged in journalism (Morris 2020). I use 'New/er Nordic' to refer to their shared history.
[21] Comparable to a study by Slavich et al. (2019) on 'molecular gastronomy', New Nordic chefs 'advanced' the NNC precisely 'by resisting the label'. What is notable in the New/er Nordic is that, contra Slavich et al., the NNC's main players have not developed new labels as their practices have changed (Ch4).

prominent public image, constructed through the strategic and intensive use of media. Noma's success, for example, is based not only on their style of cooking and hospitality, but also on their extensive and proactive participation in book publishing, filmmaking, photography, journalism, social media, and other forms and outlets of publicity.

Though Noma's food is regionally focussed, their team is highly international, and many of their guests travel from abroad. Access to dine is limited by price and demand. At the time of writing (October 2021), the cost of a meal was 2800 Danish kroner (~320GBP/435USD), with 1800 (~205GBP/280USD) for paired wine.[22] Waiting lists run into the thousands. While prices may be high, fine dining work is not a lucrative profession. Chefs and front-of-house generally enter the profession for other reasons, including a love of gastronomy and hospitality, and in fine dining, the pursuit of excellence and sometimes renown. Noma's pre-eminence has made it a top destination for ambitious cooks, some just starting out and some already with their own restaurants, who apply for three-month unpaid internships known as *stages*.[23] *Stagiaires* comprise most of the production kitchen workforce where prep is completed, while the salaried chefs run the service kitchen. Completing a stage at a restaurant such as Noma can prove invaluable in building one's culinary career, for the affiliation, network, and knowledge of products and techniques acquired. These benefits are often used to justify the lack of remuneration.

The stagiaire debate has been growing in recent years, as it is an existential matter for restaurants of a certain level. On the one hand, while still legal, stagiaire's unpaid labor appears increasingly unjust, however much non-monetary capital they might gain (Danish

[22] The price has increased over time; in 2012, for example, it was about half the price. For a period around 2018, they offered a reduced rate of 1500 kroner (~170GBP/230USD) for the menu with wine for students, a rather rare offer for such restaurants.
[23] The term is French.

stagiaires, if studying to become a chef, are paid by the state). On the other hand, in an industry with already notoriously thin margins, stagiaires make fine dining economically possible. Like public fine-arts institutions in Denmark, Noma cannot survive without 'subsidy'; yet unlike these other institutions, Noma does not receive public or private funding. Until a structural solution is found for the industry generally, especially at the upper end, having stages seems to be difficult for ambitious restaurants to avoid. This difficulty, of course, does not make the practice just.

Many such restaurants have also been driving an emerging discourse in the industry that casts cooking as a socially engaged practice, and chefs as more than mere technicians but activists and leaders in the progressive transformation of food systems and society. Top chefs have founded their own non-profits to address various social issues. One of Redzepi's, an annual/biennial symposium and educational institute called 'MAD', has facilitated conversations about the industry's problems around gender inequality, racial discrimination, abuse, and mental health (MAD 2016, 2018). Other equally important dimensions of intersectional justice, such as sexuality and class, and deeply seated problems of exploitation and capitalism, are still rarely mentioned. Tensions persist between public aspirations for a new working culture and the lived reality, among stages for example, of the actual work experience.

1.1.5 Cooking in scholarship

Over the same period of the NNC's rise, how and what we eat has also become a key question for many leading theorists. Though interest in the connections between taste, pleasure, and ethics is ancient (see eg. Lucretius and the Epicureans, Hippocrates, and Galen), contemporary scholars are rediscovering these links (Carolan 2015; Mol 2009, 2021), and recognising eating, both well and at all, as a world-making activity (Satsuka 2011: 134) and necessarily multispecies endeavour (Bertoni 2013: 62; Derrida, in Nancy 1991; Donati 2016; Haraway 2003, 2008: 295, 2010: 54; Hird 2009: 142–3). One recent and exemplary work is Annemarie Mol's *Eating in Theory* (2021). Mol uses eating and its empirical multiplicity to interfere in persistent hierarchies of humans, species, senses, and activities (like 'thinking and talking' over 'eating and nurturing'; ibid.: 1). As for many scholars, one of Mol's aims is to reimagine 'what it is to be human' (ibid.: 3) beyond human exceptionalism, re-entangling humans within the metabolic cycles and dependencies of earthly life.[24]

Yet, amidst all this discussion of eating and living and dying together, few if any of these scholars focus on cooking—that which orchestrates and makes it all possible. This omission suggests one of the ways in which studying the NNC can contribute to scholarly discourse—for example in food geographies. Over the past couple decades, food geographies have critiqued the global industrial food system and its environmental degradations (Sage 2011) and charted the rise of 'alternative' food networks (AFNs) and economies (Goodman, DuPuis, and Goodman 2012).[25] They have addressed questions of 'nature', embodiment, relationality, and materiality (Evans and Miele 2012; Goodman 1999, 2016; Miele 2011; Murdoch, Marsden, and Banks 2000; Murdoch and Miele 2004).[26]

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[24] Mol is clear that the ethnographic stories of eating she uses to do 'empirical philosophy' here 'do not [and are not meant to] lead to theoretical conclusions about eating itself; rather, they are meant to rekindle our understanding of being, knowing, doing, and relating,' which form the central chapters of her book (ibid.: 5) In this way, the book 'takes its cues from eating' but is not 'about eating.' While this orientation makes sense given her ultimate interest in philosophy rather than, say, gastronomy or food studies, I have the sense this priority ends up reinforcing rather than interfering with the hierarchy of activities she identifies. In using eating to 'provide lessons for theory', eating is still merely instrumentalised, rather than taken as an activity of interest in itself. In the end, eating remains subordinate to thinking, and the hierarchy of activities remains.

[25] For related work in the environmental humanities on agriculture as a form of (re-)enchantment and care, see Curry (2002); Herman (2015).

[26] For a recent review of food geographies, see Sexton, Garnett, and Lorimer (2021).

And they have identified ongoing histories of 'food biopolitics': the formation of patterns of 'personal consumption as a means to optimise societal well-being.' (Sexton 2018: 588)[27] Yet cooking has received little attention in these debates (cf. Roe 2006b).

The little work on cookery across anthropology, geography, and food studies is scattered.[28] Some early ethnographies attend to cooking practices, though anthropological commentary generally marginalises their significance. Mintz' and Du Bois' review of the anthropology of food and eating (2002), for example, lists 'cooking' as a keyword, though only discuss it once (ibid.: 100): in relation to 'Franz Boas's exhaustive treatment of Kwakiutl salmon recipes (1921).' It is salient that Mintz and Du Bois defend Boas' close interest in these recipes as more than 'mere fact collecting', valuable for what they reveal 'about social organization and hierarchy' (2002: 100)—even though these revelations were only later ascribed to Boas' text (Codere 1957). This treatment of cooking, even by Mintz as a founder of food anthropology, is representative of its status across these cognate fields.

In more recent work on cooking, a predominant theme is gender,[29] often linked with work and domesticity, and interrelated social categories of class, race, and nationality (eg. Deutsch 2019; Inness 2001; Swinbank 2002; Williams 2014). Emerging out of these studies' attention to gender norms, many geographical works have focussed, justifiedly, on domestic more than professional cooking (Dyck and Dossa 2007; Longhurst, Johnston, and Ho 2009; Roe 2006b; Roe and Buser 2016). These works tend either to place themselves self-evidently within the 'consumption' side of the predominant production/consumption distinction (eg. Jackson 2017)—a key organising principle in

[27] See also Bobrow-Strain (2008); Paxson (2008); Mansfield (2012); Sexton, Garnett, and Lorimer (2019).
[28] There is a lot more to say about this literature, but a systematic review of it must wait.
[29] As Mintz and Du Bois note, 'so swiftly has the literature on food and gender grown that it could properly merit an [Annual Review of Anthropology] article of its own.' (2002: 109).

much food scholarship—or don't concern themselves with this rubric at all (eg. Meah and Jackson 2013, 2016). Other disciplines, such as sociology and food studies, feature a few studies of professional kitchens and restaurant culture (Fine 1996; C. Lane 2014; Leschziner 2015; Pearlman 2013; Tan 2020), but then not always with the link to broader systems of food production.[30]

This distinction between 'production' and 'consumption' structures much of the scholarly work on food. Some scholars, noting the binary's analytic limits, have endeavoured to show how these categories are not separable or linear (Goodman 2002; Goodman and DuPuis 2002; Jackson 2004; Mol 2009: 13; Spackman and Lahne 2019; Whatmore 2002), but the categories themselves, and their relation, are rarely questioned. That cooking remains strangely marginal throughout this work, as if it were an afterthought or exception rather than ubiquitous and essential, may be partly because it does not fit easily into the production/consumption binary. Yet, as a consequential assemblage of knowledge practices most people in the world engage in multiple times a day, cooking mediates production and consumption and their feedbacks. It could thus help subvert this binary, offering more complexity in analysing how these domains co-constitute each other.[31]

Given scholarship's general underestimation of cooking, it isn't surprising how little attention kitchens have received as sites of knowledge production. Sociologist Thomas Gieryn's 'truth spots' are key here: the notion 'that place matters mightily for what people believe to be true' (Gieryn 2018: 2–3).[32] Like other truth spots (eg. university lecterns,

[30] Journalistic work might be somewhat 'ahead' in linking cooking to larger food systems debates and the production/consumption binary (eg. Pollan 2013).
[31] A task I cannot take up further here, but may elsewhere.
[32] See also Guggenheim's notion of the 'locatory' (2012), and Livingstone (1995) and Shapin (1998) on the role of place in scientific knowledge production and circulation.

pilgrimage destinations, courthouses, or laboratories; ibid.: 2), kitchens have certain features that shape knowledge production in certain ways (Ch6). In studying fermentation in particular, kitchens emerge as a key but overlooked site of mutual multispecies transformations—the heart and hearth of the domus (Ch8).

It is in this context—of the NNC as a response to Nordic food history, the dominance of France and Spain, critiques and subsequent shifts toward 'glocalism', more recent discourses around cooking and progressivism, and growing recognition of the significance of food and eating (though less so cooking) in scholarly and wider worlds—that New/er Nordic fermentation has emerged. Many of these circumstances are also linked to the rise of fermentation and the widespread and growing interest in microbes.

1.2 MICROBES & FERMENTATION

Forces shaping the NNC—especially the desire for more ecologically sensitive, healthful, flavourful, diverse, and place-based foods in response to the catastrophic consequences of postwar industrial agriculture (Katz 2002, 2003, 2012; Kingsolver, Kingsolver, and Hopp 2009; Paxson 2012: 77; Pollan 2006, 2013)—have also driven fermentation's recent popularity. In this section I characterise Noma's 'translated' approach to fermentation; discuss some of fermentation's definitions, politics, and metaphors; and situate the rise of fermentation within the larger 'microbial moment' (Paxson and Helmreich 2014).

1.2.1 'TRANSLATED' FERMENTATION

Noma's practice of fermentation began as a way of reconnecting with Nordic culinary traditions and expanding their repertoire of regional flavours (Redzepi 2014a), comparable to their use of salting, smoking, drying, pickling, and other ancient preservation methods.

Their approach to fermentation, as described, has mixed techniques from around the world—such as ancient Roman garum (a salty, savoury, fermented fish sauce), Italian balsamic vinegar, and East Asian kombucha—with products that can grow in the Nordic region. This combination has yielded flavours, such as hare garum, quince balsamic vinegar, and blackcurrant leaf kombucha, that are unlikely to have existed before (Johnson and Williams 2016; I describe the difference between New and Newer Nordic approaches to fermentation in Chapter 4.).[33]

Following this model, chefs and fermenters around the world are adapting existing techniques and recipes to new biogeographies and ingredients, as if they were translating a text into a new lexicon—an approach we might call 'translated' fermentation.[34] The use of 'translated' here draws on literary translation theory.[35] Different approaches to translated fermentation, as with literary translation, are possible here: 'fidelity' to the original, or 'freedom' to render it new (Benjamin [1923] 1996); a 'foreignizing' approach that retains a sense of the original's difference, or a 'domesticating' approach that favours accessibility in its new context (Venuti 2004). These categories can also help make sense of how fermentation traditions change as they move (Chiaro and Rossato 2015; Smith 2009) without resorting to rudimentary notions of 'authenticity' (Appadurai 1988).[36]

While such mobilities and mixings have also shaped the development of fermentation traditions over centuries and millennia, these developments would have been largely slow

[33] For further examples, see Redzepi and Zilber (2018). To ensure the safety of these novel fermentations, all products made for service have HACCP plans, approved and controlled by the Danish Health Authority. HACCP stands for 'Hazard Analysis and Critical Control Points', a systematic preventive approach to food safety.
[34] This is not to say that food and taste are 'languages' (Ch5).
[35] It draws less on the sense of translation in the Sociology of Scientific Knowledge (SSK) and Actor-Network Theory (ANT; eg. Callon 1984; Latour 1990; Law 1992), 'articulating or forging alliances between different actants' (Giraldo Herrera 2018: 13), but it could be worthwhile plumbing this connection further.
[36] Though see Strohl (2019) for a defense of the concept's qualified use.

and gradual compared with the rapidly combinatorial, geographically discontinuous, deliberate, and flavour-oriented experiments being undertaken by chefs and fermenters at Noma and elsewhere. And while pockets of DIY fermenters have been practising such translations for decades (Katz 2003, 2012; Shurtleff and Aoyagi 1983), Noma's global influence, its focus on flavour and culinary application, and its concurrence with the contemporary 'microbial moment' (Paxson and Helmreich 2014) have contributed to its authoritative position in popular translated fermentation culture (Redzepi and Zilber 2018).

Japanese culinary traditions have been especially formative for Noma's approach, particularly in their pursuit of umami taste. Umami (旨味) means 'delicious taste' in Japanese, coined at the start of the twentieth century to refer to the savouriness triggered by glutamic acid (the receptor was only more recently discovered). Developing new, regionally appropriate sources of umami—such as in misos, shoyus, and garums—was one of Noma's main goals for their early experiments with fermentation. Kōji became a key collaborator in this pursuit, because of its enzymatic power: breaking down proteins yields amino acids, some of which stimulate umami taste.[37]

Some might see in this 'translated' approach to fermentation a form of cultural and economic appropriation: commodifying microbes and culinary practices sourced from other parts of the world with unjust distributional consequences (eg. Chan 2021). I am sympathetic with this concern; though in this case, the data did not suggest such a categorical critique but a more nuanced situation. Noma chefs use commercially available

[37] For further discussion of the imaginaries that have shaped Japan's prominence as a source of inspiration, see Evans and Lorimer (2021).

cultures or commonly available 'wild' ones,[38] credit their sources of inspiration and knowledge, and work to distribute their intellectual property through their cookbooks and social media—of course to their own benefit and profit, but also to that of many others. In my ethnography, I found them attentive to negotiating the tricky line of appreciating their sources of inspiration while not claiming to be replicating or owning them. Inasmuch as cultural production and exchange involve some degree of 'making appropriate', my participants were sensitive to the problems at hand, and assiduous in addressing them.[39]

1.2.2 FERMENTATION: DEFINITIONS, POLITICS, METAPHORS

Translated fermentation is but one recent iteration of fermentation's ancient and staggeringly diverse practices and products. Most every human society past and present has some fermentation tradition (Steinkraus 1995, 2004; Tamang, Watanabe, and Holzapfel 2016), and many cultures' most valued foods undergo some microbial transformation (familiar Western examples include bread, beer, cheese, pickles, chocolate, coffee, and wine). Even long before the emergence of *Homo sapiens*, fermentation as pre-digestion may have conferred evolutionary advantage on our primate ancestors (Amato, Mallott, et al. 2021), in addition to the pleasures of inebriation (Amato, Chaves, et al. 2021; Carrigan et al. 2015). Subsequently, alongside other preservation methods such as salting, smoking, drying, and more recently, pasteurisation, fermentation has played a key role in making food safe, long-lasting and nourishing (Katz 2012). Fermentation also frequently plays a role in the formation of cultural identities (Jasarevic 2015; Yamin-Pasternak et al.

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[38] Their kōji spores, for example, were commercially produced in Japan by a company called Bio'c, and legally imported with respect to the Nagoya protocol.
[39] Further discussion could be worthwhile here, particularly around the ethics and politics of their pop-ups, but it will have to wait for future work.

2014), their often particular and pungent flavours making them potent culinary shibboleths (Brumberg-Kraus and Dyer 2011).

Just as different people prefer different fermentations, ‘fermentation’ also means different things to different people. One definition is more narrow: biochemistry’s ‘anaerobic respiration’. Popular fermentation tends to use a broader conception: the human-guided microbial transformations of edible substrates into culturally appropriate food products (Evans 2021; Katz 2012; Reade, Valicourt, and Evans 2015). This cultural and disciplinary multiplicity is amplified by historical and geographical multiplicity. As Latour suggests, ‘fermentation has experienced other lives [under other names] before 1858 and elsewhere, [beyond the] unique, dated localized life offered by Pasteur’ (1988: 153) that both definitions above inherit. This multiplicity also means that, as any fermenter who has interacted with a strict biochemist will know, even the seemingly simple act of defining fermentation is an enactment of power: it has ‘onto-politics’ (Law 1998; Mol 1999). These onto-politics also involve a more-than-human/multispecies dimension (Ch2). If understood as microbial transformation of foodstuffs guided by any actor, human or otherwise, fermentation is easily seen to be practised by nonhumans (Ch7): honeybees ferment pollen, also known as ‘bee bread’ (Anderson et al. 2014); certain ants and termites cultivate fungi (Mueller et al. 2005); some primates ferment fruits for later enjoyment (Amato, Chaves, et al. 2021). Some even go so far as to frame any microbial metabolism as ‘fermentation’ (Katz 2020; cf. Ch7). In Chapter 8 I return to this key question of what fermentation is, how expansive its definition should be, and why its definition matters.

Alongside fermentation’s expanding definitions, recent years have seen an increasing number of scholars excited by fermentation’s metaphorical resonances and political suggestiveness. Artist, curator, and academic Lauren Fournier is exemplary here, when she offers

> ten ways in which fermentation is a ripe conceptual framework for articulating transinclusive, anti-racist feminisms. These include the following: fermentation is political; fermentation is vitalism; fermentation is accessibility; fermentation is preservation and transformation; fermentation is inter-species symbiosis and coevolution; fermentation is survival and futurity; fermentation is care of the self and care of others; fermentation is harm reduction; fermentation is queer time; and fermentation is collaboration. Fermentation is a way to tap into the fizzy currents within transnational feminist practices (2020: 89).

These are some important and desirable aims. Such a list also asks microbes and fermentation to do quite a lot. Though defining fermentation always involves onto-politics, I am less sure that fermentation, of any definition, can offer an essential politics as much of the current literature suggests (Ch8). This is for both empirical and theoretical reasons: the dizzying diversity of modes, scales, and aims with which fermentation is practised makes it difficult to have a singular, categorical politics (Evans 2021); and the scientism that such new materialist approaches often rely upon takes certain scientific accounts of the microbial world—and, importantly, not others—at face value in order to undergird a socially desirable theoretical position (Paxson and Helmreich 2014). I develop this argument against fermentation politics throughout the thesis and return to it in Chapter 8.

1.2.3 THE 'MICROBIAL MOMENT'

Popular, professional, and scholarly fascination with fermentation have emerged alongside an explosion of scientific and public interest in microbiomes over the past two decades. This growing microbial obsession is driven not only by practical implications for health and well-being—of which there are many—but also because its revelations unravel neat notions of human individuality and autonomy. Humans are, in this new micro-paradigm, recast as more-than-human becomings all the way down and all the way back (Gilbert, Sapp, and Tauber 2012; Haraway 2016). Here I review the contours of this 'microbial moment' (Paxson and Helmreich 2014), its effects on recent social science, and its implications for my study.

The development and falling price of DNA sequencing technology have spurred a revolution in microbial sciences. These culture-independent techniques have changed how we know microbial worlds, revealing multitudes of hitherto unknown-because-unculturable lifeforms. The rise of microbiome science has begun to illuminate the integral role of microbes in human health, affecting allergies, immune systems, nutrition, appetite and eating behaviour, even mood, cognition, and possibly mental health (Alcock, Maley, and Aktipis 2014; Sivamaruthi, Kesika, and Chaiyasut 2018; Yong 2016; Yu and Hsiao 2021). This science reveals 'the human' as always already an ecology, a teeming multispecies happening rather than an autonomous, a priori subject. We learn that our bodies consist of more 'non-human' cells than 'human' ones;[40] that the human genome contains crucial genes of microbial origin (Horie et al. 2010); that microbiomes have been involved in human adaptation since before the emergence of our species (Amato et al. 2019; Foster et al. 2017). Such findings have led to new, holistic conceptualisations of humans—and indeed all animals and plants—as 'superorganisms': 'holobionts' of many species with shared, nested 'hologenomes' (Bordenstein and Theis 2015; Theis et al. 2016).

This microbiome science is reordering many basic concepts in biology such as 'organism', 'species', and 'evolution' (Goldenfeld and Woese 2007). Yet microbiology has always had uncertain conceptual foundations, which microbiologists acknowledge—for example, that

[40] While earlier estimates proposed astounding figures like ten times more of the former than the latter, the most recent ratio is roughly 5 microbe : 4 human (Sender, Fuchs, and Milo 2016). Of course, this is at least as much a conceptual question as an empirical one.

'microbe' or 'microorganism', the discipline's organising concept, is an inherently anthropocentric term, simply referring to organisms generally smaller than are visible to the naked human eye (Ogunseitan 2005; O'Malley 2014; Stanier and van Niel 1962). And while 'species' is already multiple (Dupré 1992, 2001), and 'none of the traditional species concepts encompasses all groups of organisms,' this may be especially true of microbes, specifically bacteria, as these concepts have been developed with little consideration for prokaryotic systematics (Ogunseitan 2005: 9).

These conceptual issues are just some of the many that have spurred social scientists to think with microbes (Brives, Rest, and Sariola 2021; Greenhough et al. 2020).[41] Scholars have studied human–microbe relations in food production (Paxson 2012), identifying a 'post-Pasteurian' discernment in contrast to a 'Pasteurian' categorical antagonism (Paxson 2008).[42] They have followed what happens when these relations go awry (Dunn 2008; Spackman 2017). They have attended to reproductions of inequalities in microbiome science (Benezra 2016, 2020; Hobart and Maroney 2019; Lorimer 2017), and considered whether microbes should be extended rights (Cockell 2004, 2005). They have used microbes as models for thinking with in STS (Helmreich, Roosth, and Friedner 2015; Latour 1988), history of science (Lee 2021), and participatory science (Lorimer et al. 2019). Beyond the human body, they have located frontiers of microbiome science in seas and soils (Helmreich 2009; Krzywoszynska 2019, 2020; Krzywoszynska and Marchesi 2020), identified microbes as indicators of the Anthropocene (Clark and Hird 2014; Landecker

[41] As well as to propose microbes as promising partners in trying to integrate natural and social sciences (eg. Benezra, DeStefano, and Gordon 2012).
[42] Lee (2015) describes what could be recognised as an early example of post-Pasteurianism in her study of early twentieth-century Japanese microbiologists, many of whom 'regretted that only Dutch and Japanese researchers were interested in useful rather than pathogenic tropical bacteria.' (ibid.: 246)

2015), and found in changing human relations with them larger shifts of 'going probiotic', 'using life to manage life' across domains and scales (Lorimer 2020).

Much of this social science work on microbes, particularly in social theory (Haraway 2016; Hird 2009), is indebted to Lynn Margulis' work on symbiogenesis: that multicellular life arose from one bacterium ingesting another without digesting it, what Margulis calls 'endosymbiosis' (Margulis and Sagan 1995, 2002). At first derided by scientists, Margulis' theory has since been supported by evolutionary and experimental evidence, and has helped usher in a new paradigm in biology that, in contrast to neo-Darwinism, sees symbiosis as not the exception but the rule (Gilbert et al. 2010; Gilbert, Sapp, and Tauber 2012; Gilbert 2014; Mcfall-Ngai et al. 2013).[43] Some refer to this paradigm as the 'post-modern synthesis' (Koonin 2009; McFall-Ngai 2017).[44] This development has even prompted some scientists to propose renaming organelles as 'bacteria' (Oborník 2019; cf. Gruber 2019) which, among other far-reaching consequences, would result in seeing endosymbiosis as one kind of—indeed the original—domestication (Oborník 2019).

Symbiogenesis involves not only endosymbiosis, but also ongoing processes in which organisms continually and reciprocally shape each other within and across species lines. One such process is horizontal or lateral gene transfer (HGT/LGT), in which organisms, particularly microbes, exchange genetic information horizontally, body to body, not only passing it on vertically through descent. Many scholars have proposed that such processes

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[43] Among many fields, this new focus on symbiosis has also found its way into food and fermentation sciences (Quintero-Galvis et al. 2018; Günther and Goddard 2019).

[44] After the twentieth century's so-called 'modern synthesis' that integrated Mendelian genetics, population genetics, and Darwinian evolution (see Huxley [1942] 2010). Symbiogenesis, superorganisms, holobionts and microbes have spurred similar relational approaches in the philosophy of biology—for example to questions of individuality (Ereshefsky and Pedroso 2013; 2015; Gilbert and Tauber 2016), and to developing a biological ontology based on processes rather than entities (Dupré and O'Malley 2007; 2009; Bapteste and Dupré 2013; O'Malley 2014; 2015; Dupré and Guttinger 2016).

invite new metaphors for speciation (O'Malley, Martin, and Dupré 2010)—trees are no longer cleanly branching but 'reticulated' (Doolittle 1999) and 'rhizomatic' (Deleuze and Guattari [1980] 1987), 'seas of information' (Helmreich 2003). Symbiogenesis as a form of 'involution' (Hustak and Myers 2012), a rolling-in, complements evolution as a rolling-out, the latter driven by and in turn shaping how organisms become 'involved' in each other's lives and lineages (ibid.; Ch7). Animal–microbe relations are exemplary here, in which microbes, surface/interface mediators in the gut and on the skin, shape us inside-out and outside-in: the body is a torus (Ch7) whose gut is both within and without.

These developments in the biological sciences, and around microbes in particular, have lent themselves to some social scientists' theories of relationality (Haraway 2008: 3–4; 2016; Hird 2008; 2009).[45] Other scholars have critiqued this new-materialist approach and its turn to microbiome science for social theory as a form of scientism, uncritically celebrating scientific findings simply because they are theoretically convenient (Paxson and Helmreich 2014). As Stefan Helmreich suggests, 'Biology does not speak for itself.' (2014: 59) I also am wary of this tendency, and resist scientifically reifying microbes as a source of new social theory. I do, however, justify DNA as one of multiple approaches for enacting microbial identity (Ch3), however partial, however situated (Haraway 1988).

These tools reshaping microbiology and giving rise to microbiome sciences have also shaped adjacent fields like microbiogeography (Kaufman et al. 2020), and opened up new terrain in studies of fermentation microbes (Bokulich and Mills 2012; Bokulich et al. 2016): in wine (Bokulich et al. 2014; Bokulich et al. 2016; Gilbert, van der Lelie, and Zarraonaindia 2014; Knight et al. 2015; Vontrobová et al. 2019), fermented vegetables

[45] Even as human–microbe relationships are ultimately asymmetrical, as we need them much more than most of them need us (Hird 2010).

(Jung et al. 2018), meats (Van Reckem et al. 2019), and other products (Capozzi and Spano 2011). More and more DNA data are being generated, but more data does not necessarily mean more knowledge. Basic questions persist: where do the different microbes come from? Do they change, and if so, how and why? And especially, do specific places have unique microbiomes, or is 'everything everywhere' and the environment selects (O'Malley 2008)?

These questions are often framed in terms of 'microbial terroir' (Felder, Burns, and Chang 2012)—an extension of the French concept of terroir that ties specific organoleptic qualities of foodstuffs to specific conditions of their cultivation and production (Trubek 2004; 2008; Trubek and Bowen 2008).[46] Microbes have only recently been conceptualised as part of terroir, and both natural and social scientists have begun studying how terroir shapes and is shaped through fermentation (Bokulich et al. 2014; Eriksson and Bull 2017; Gilbert, van der Lelie, and Zarraonaindia 2014; Knight et al. 2015; Myles 2020; Paxson 2010). Yet few scholars have noted how the meaning of 'microbial terroir' has shifted over the last decade or so: at first suggesting a place's unique environmental microbiome that, it was assumed, would give a unique flavour to products fermented there (as described by Paxson and Helmreich 2014), to a more recent idea emphasising how human agencies shape the microbial ecology and resulting product (eg. Goddard 2016). I explore this shift further in Chapter 4, in the context of the New/er Nordic Cuisine.

[46] In her investigation of synthetic yeast, Erika Szymanski argues that terroir can be understood not only descriptively but also performatively—as 'a world-building tool', an invitation to consider multiple possible futures (Szymanski 2018: 40).

1.3 DOMESTICATION

New/er Nordic translated fermentation in the 'microbial moment' is just one instance of older, broader processes of how humans and nonhumans shape each other. Domestication is a central idea here, and a promising way to frame my initial curiosity about the potential biological consequences of New/er Nordic translated fermentation experiments. In this section I briefly review some of the voluminous literature on domestication, to prepare my analysis of it in Chapter 8.

Already in classical antiquity were philosophers and other thinkers considering the status of domesticated organisms (Harris 1996; O'Connor 1997). It was first in the nineteenth century that domestication as a process and concept gained sustained scrutiny by scientists like Galton and Darwin. The latter used domestication (as 'unconscious' then 'artificial' selections) as an analogical starting point to argue for natural selection (Darwin [1859] 1982, [1883] 1896). Many classic studies of domestication have since approached the topic in the context of agricultural history (Haudricourt 1969; Hodder 1991; Sauer 1956), considering when, where, how and why people did and did not transition between nomadism and sedentism (Bettinger, Barton, and Morgan 2010; Bharucha and Pretty 2010; Mysterud 2010; Scott 2011; 2017). Much of this work has come to figure domestication, agriculture, and sedentism as coinciding, complementary strategies in constantly shifting assemblages (Conklin 1959, 1961; Smith 2001b; Terrell et al. 2003). Earlier instances of this work on domestication and agriculture were also concerned with why people came to domesticate in the first place. The debate often split along established material vs. symbolic lines, with some arguing for scarcity and environmental determinism driving domestication (Davis 2005; Zeder 2009) and others for domestication resulting from surplus, leisure, and/or for social status (Hayden 2003; Isaac 1970; Sauer 1969).

Much of this literature focusses on animals, as our most charismatic and 'useful' companion species (Armitage 1986; Clutton-Brock 1989; 1992; 1994; 1999; 2012; Digard 1992; Hecker 1982; Hemmer 1990; Isaac 1962; Jarman and Wilkinson 1972; Zeder 2012b; 2012a), though plants, particularly cereal crops, have also received extensive attention (Allaby et al. 2017; Fuller, Allaby, and Stevens 2010; Larson 2015a; Smith 2001a). Most of these scholars, often in archaeology, anthropology, and related disciplines, agree that domestication involves intertwined biological and socio-cultural dimensions, though tend to favour one or the other 'side' according to their disciplinary and methodological position (Anderson 1997; Russell 2002). A common biological approach, favoured by zooarchaeologists, has focussed on morphological change in skeletal structure, resulting from human control (Clutton-Brock 1992; Zeuner 1963) and intentional selection (Clutton-Brock 1994), though occasionally also arguing for symbiosis (O'Connor 1997). A common sociocultural approach, favoured by anthropologists, has focussed on how humans have brought animals into the human domus as property, associated relations of captivity, and resulting changes in social structure (Digard 1990; Ducos 1978; 1989; Ingold 1980). This methodological split is understandable, but it can end up entrenching the nature–culture dichotomy which many scholars have thoroughly critiqued and aim to move beyond (Ch2).

While the dominant position across disciplines now sees domestication as a gradual process rather than a discrete event (Lien, Swanson, and Ween 2020: 17), many of the classic works above helped establish and perpetuate the dominant narrative of domestication as a process always driven by humans, with intention and teleology (eg. Diamond 1997; 2002). This dominant narrative has been increasingly called into question (Anderson 1997; Cassidy and Mullin 2007; Lien 2015; Swanson, Lien, and Ween 2018; Russell 2002), for its political implications as much as mounting evidence against it. The concept of domestication has long been used to order hierarchies of cultivation and land use practices, and the knowledges and societies that go with them—implicitly or explicitly justifying colonialism, neocolonialism, and other forms of structural inequality perpetuated through the organisation and governance of land and landscape (Beckwith 2004; Deur and Turner 2005; Evans 2017; Gammage 2011; Pascoe 2014; Spence 1999; Turner 1999). Furthermore, public attitudes towards technoscientific modes of shaping non-human life—such as synthetic biology, genetic modification, and genome-editing technologies such as CRISPR—hinge greatly on whether these approaches are seen as continuous with or rupturing from longer histories of humans intervening in the reproduction and evolution of other organisms (Cassidy and Mullin 2007; Davis 1987; Szymanski and Calvert 2018). The framing of domestication is politically consequential.

Related literatures document how agriculture, food, and cooking have shaped human history (Laland, Odling-Smee, and Myles 2010; Russell 2011; Scott 2017; Wrangham et al. 1999). But taste as a driver of domestication figures only on the margins of these discussions, found in pioneering writings by figures like Gary Nabhan (2006) and Michael Pollan (2002; 2018) on the selection and dispersal of, for example, apples, potatoes, chilli peppers, and certain fungi.[47] More recent work aims to bring taste and flavour into eco-evolutionary biology (Dunn and Sanchez 2021), but here the focus is on taste as a driver of

[47] Related work on the more recent political ecology of food has shown how consumer tastes come to shape organisms, breeds, and ecologies (Guthman 2019), but only the hereditary shapings here might be considered 'domestications'.

evolution generally, not domestication specifically. In this modest literature on taste shaping natures, moreover, most examples focus on familiar plants and animals. To date there is very little work on tasty microbes as agents of historical and domesticatory change.[48] This is surprising, as hominids have been shaping and shaped by microbes for millions of years (1.2.2). These ancient, taste-driven entanglements indicate a significant gap in most accounts of domestication, and suggest a 'microbiology of desire', akin to Pollan's 'botany of desire' (2002), in which many co-evolutionary stories between humans and fermenting microbes remain to be told.

One such story is that of 'hand taste'. The original Korean phrase, *son mat*, describes how a cook's hands (and by extension their habits and tacit knowledges) shape the taste of a dish. In contemporary fermentation, the phrase has taken on a further meaning: that one's microbiome, introduced to the food as it is prepared, shapes the fermentation in a unique way, such that even different people making the same product with the same ingredients in the same place by the same recipe will still end up with different results (Katz 2012; Redzepi and Zilber 2018). The idea is also recently gaining scientific support (Dunn et al. 2020; Park et al. 2019; Reese et al. 2020). Reflecting on domestication, how it might be thought anew through fermentation, and what such insights might suggest for taste shaping natures like hand taste is one of the overarching aims of the thesis, which I touch on throughout and draw together in Chapter 8.

[48] For a few exceptions see Dunn and Sanchez (2021); Flachs and Orkin (2019); J. Gibbons et al. (2012); J. Gibbons and Rinker (2015); Money (2018); Nabhan (2010).

1.4 THESIS OVERVIEW

In this chapter I have described the project's origins, outlined the New Nordic Cuisine and its history and proposed the 'Newer Nordic' to denote its recent shifts, discussed Noma's context in fine dining culture, and reviewed scholarly work on cooking and what studying the New/er Nordic might contribute to it. Turning to fermentation, I identified 'translated fermentation' as a particular approach in contemporary fermentation practice, discussed fermentation definitions and onto-politics, outlined an argument against fermentation essentialism and fermentation as metaphor that I return to in Chapter 8, and situated fermentation's rise within the larger 'microbial moment'. I then introduced domestication as the thesis' overarching theme, to help make sense of and perhaps in turn be informed by New/er Nordic translated fermentation's novelties. I now suggest my aims, frame my research questions, offer main contributions, and outline the thesis' chapter structure.

1.4.1 AIMS

The thesis has five aims: (i) to develop a conceptual framework for 'taste shaping natures'; (ii) to assemble a methodology for integrating multiple sites, senses, species, and methods into ethnography; (iii) to provide a critical account of the New/er Nordic Cuisine that places it in social and political context and assesses how and why it has changed over time; (iv) to develop concepts that account for the enmeshed aesthetics, ethics, 'epistemics',[49] and politics of how humans and microbes know and shape each other in New/er Nordic translated fermentation, with applicability to STS, more-than-human, and multispecies

[49] We might conveniently use the adjective also as a noun, homologous to 'aesthetics', 'ethics', 'politics', and the more recent 'ontics' (Tsing 2017; Verran 2001).

scholarship; and (v) to consider the implications of these microbial taste shaping natures for current debates about domestication.

1.4.2 RESEARCH QUESTIONS

Having introduced my investigation of the relationships between taste, microbes, and domestication in New/er Nordic translated fermentation, I arrive at my main research question:

> How do taste and natures shape each other in New/er Nordic translated fermentation?

Taste shaping natures have three main components: natures, taste, and modes of shaping. Each suggests a subsidiary research question:

> On natures: Why have the New and Newer Nordic each enacted different natures for different ends, and how have these natures shaped the practice and taste of translated fermentation?
>
> On taste: How does taste structure how human fermenters know their microbial partners, and how do these knowledge practices enact taste?
>
> On modes of shaping: Through what modes do human fermenters and their microbial partners shape each other in New/er Nordic translated fermentation, and with what consequences?

1.4.3 CONTRIBUTIONS

My three main contributions—'tasting shaping natures', 'multiplied ethnography', and 'domestication revisited'—align to aims (i), (ii), and (v). 'Taste shaping natures' describe how taste, in the broad sense, shapes and is shaped by multispecies relationships and environments. 'Multiplied ethnography' is shorthand for a methodology that integrates multiple sites, senses, species, and methods—in this case, analysis of culinary aesthetics, biological experiments, and DNA sequencing—into ethnography. 'Domestication revisited' analyses the concept's multiplicity, weighs more expansive and more critical approaches to conceptualising it, proposes an intermediate approach, and identifies insights from thinking domestication microbially.[50] The remaining supplementary contributions I outline in Chapter 8.

1.4.4 Chapter structure

To fulfil my aims, address my research questions, and develop my contributions, the chapters proceed as follows.

Bringing together critical studies of nature, more-than-human geographies and multispecies studies, theories of taste, and STS, in Chapter 2 I develop a conceptual framework for 'taste shaping natures'. Here I introduce the literatures I will use to address each of my subsidiary research questions—on natures, taste, and modes of shaping—which inform the four analytic chapters on 'Nature', 'Consipience', 'Experiment', and 'Interest' respectively.

Just as taste shaping natures bring together multiple literatures, studying them requires combining multiple methods. In Chapter 3 I discuss the multiple sites, species, senses, and methods I need for investigating the specific taste shaping natures of New/er Nordic translated fermentation, and justify my methodological assemblage of multispecies ethnography, sensory ethnography, sensory science, microbiological experiment, and DNA sequencing.

From here, I develop my four analytic chapters. In Chapter 4, mobilising the critical literatures on nature I introduce in Chapter 2, I trace how and why New/er Nordic natures, as imaginaries and materialities, have shifted over time. I frame these shifts in terms of

[50] In the thesis, I am able to share the first three of these contributions only as a précis (8.3).

different approaches to 'wild' and cultivated natures, identify the conjunction of ethics and aesthetics in culinary practice, and analyse these natures' differing implications for translated fermentation.

Having examined natures, I turn to taste. In Chapter 5, engaging the account of taste I develop in Chapter 2, I introduce the novel concept of 'consipience' to account for how humans and microbes, and any nonhumans, co-produce knowledge within and across species by tasting and smelling together. Linking STS literatures on attunement and intersubjectivity, I describe 'interspecies consipience' as a crucial multispecies relation in fermentation, identify two kinds of 'intraspecies consipience' among humans in which it is valuable to taste both similarly and differently, and discuss consipience's epistemological relations with technoscience and with language.

With nature and taste developed, in the remaining two analytic chapters I investigate modes of shaping. In Chapter 6, drawing on the literature on experiment I outline in Chapter 2, I develop the concept of a 'culinary experiment' as a particular mode of shaping in avant-garde culinary practice, and in New/er Nordic translated fermentation specifically. I draw out its key knowledge practices around the senses, science, and surprise, discuss its contributions to studies of experiment generally, and propose a model for 'qualifying' experiments by situating them along three dimensions: 'openness of goal', 'unprecedentedness of outcome', and 'degree of trial'.

If experiment focusses on epistemics as a mode of shaping, Chapter 7 brings aesthetics, ethics, and politics back into the mix. Drawing on the STS literature on interest I mobilise in Chapter 2, I develop 'interest' as a mode of shaping that promises new relational terrain, different from control and domination but not more innocent, for understanding translated fermentation practices, their more-than-human politics, and their material implications. I link the ‘interesting’ as an aesthetic category to how fermenters ‘become interested’ in their microbes across four main stages of the fermentation process. This ‘ethics of involvement’ and its biological consequences prompts me to consider interest as the co-constitution of involution and evolution, a broader discussion that prepares our return to the domestication question.

Drawing together these chapters, in Chapter 8 I summarise my contributions from across the thesis, and use them to answer my research question and fulfil my aims. I then return to the thesis’ central themes of fermentation and domestication. I further discuss why fermentation cannot have an essential politics, and use fermentation to consider the insights that thinking domestication microbially offers domestication studies. In closing, I offer broader reflections from my thesis for theory, for society, and on method, and indicate directions for further research.

2 TASTE SHAPING NATURES

Taste shapes ecology and evolution, microbes make tasty food, and humans and microbes have been shaping each other as long as both have lived. Yet for all the growing interest in food, taste, microbes, and fermentation, little scholarly work has explored these connections. To do so, in this chapter I develop the concept of a 'taste shaping nature': a nature shaping and shaped by taste. I bring together critical studies of nature, more-than-human geographies and multispecies studies, theories of taste, and STS into a framework to address the thesis' first aim (1.4.1), and to help answer my main research question. I use the three subsidiary research questions—on natures, taste, and modes of shaping—to structure this framework.

The New/er Nordic emerged and changed through shifting natures—as imaginaries, materialities, and sources of value. These natures were multiple, comprising wild, 'wilder', and postpastoral dimensions in different proportions. I use these literatures on nature to address the first subsidiary research question in Chapter 4. Human fermenters know their microbial partners primarily through their senses, especially smell and taste. Drawing together literatures on taste from the natural and social sciences, I present taste as a multisensory, multispecies, and productively multivalent phenomenon, which I use to address the second subsidiary research question in Chapter 5. Through taste, human fermenters and fermenting microbes know and shape each other across species lines. These shapings take many forms. In my ethnography I investigate three: experiment, interest, and 'micro-governmentality'. I use these modes of shaping to address the third subsidiary research question in Chapters 6 and 7, where I also outline their consequences for microbial biogeography, ecology, evolution, and implications for more-than-human politics. Finally, I reflect on other practices and domains where the concept of taste shaping natures might be useful.

2.1 ON NATURES

To frame the emergence and shifts of the New/er Nordic's natures, I briefly review nature's analytic status, before discussing the multiple kinds of nature the New/er Nordic assembles.

2.1.1 NATURE IN THEORY

Since the 'cultural turn' of the 1970s and 80s, it is a truism that nature is not given but constructed, by different actors for different purposes (Braun 2002; Castree 2003; 2005; 2014b; 2017; Castree and Braun 2001; 2006; Latour 2004c; Swanson, Law, and Lien 2018).[51] Some scholars have subsequently argued there is no such thing as nature (Latour 1993; 1998), and political ecology need make no reference to it (Latour 1998; 2004c). Others, emerging from the 'ontological turn' of the 1990s, have argued in the other direction: that nature is multiple rather than singular (Lorimer 2012; Viveiros de Castro 1998),

[51] It is by now similarly commonplace to note how science has played a central role in the construction of Nature as singular and transcendental (Goldman, Nadasdy, and Turner 2011; Haraway 1989; 1991; 1997).

fundamentally reordering anthropology and related disciplines (Latour 2009; 2011). The related 'nature–culture binary' has been similarly critiqued as a historical rather than transcendental distinction (Braun 2004), whose referents not only shift over time but whose categories are entangled 'all the way down' (Anderson 1995; Descola 2013; Goodman, Heath, and Lindee 2003; Haraway 2008; Ingold 1986b; 1986a; 2011; Latimer and Miele 2013).

The most recent chapter in this history of 'nature' may be the emergence of Anthropocene discourse since the term's coinage in 2000 (Crutzen and Stoermer 2000). While the mainstream discourse takes the Anthropocene as a self-evident call for eco-modernism, the techno-utopian 'decoupling' of humans from 'nature' (Asafu-Adjaye et al. 2015), social scientists have elucidated multiple possible trajectories this new epoch offers, and the different histories these futures mobilise (Bonneuil and Fressoz 2016; Castree 2014c; 2014a; 2014d; Clark and Szerszynski 2020; Latour 2014b; 2014a; 2018; Lorimer 2012; 2015; 2016b; Purdy 2015; Yusoff 2016). Many scholars have also critiqued the Anthropocene concept for its implied anthropocentrism and tendency to flatten human difference (Crist 2013; Haraway 2015; 2016; Haraway et al. 2016; Johnson et al. 2014; Swanson, Bubandt, and Tsing 2015). While the Anthropocene has made human agency a planetary force, it can also help pull humans away from the centre of the picture, offering ways to move beyond the anthropocentrism that gave rise to it—an approach guiding much work in geography, anthropology, and environmental humanities (Kirksey 2015a; Tsing 2015; Tsing et al. 2017). This relationality—that the Earth is made up of relationships, in which humans are present but never central—is not a new idea, but has long precedents in many indigenous cosmologies (Kimmerer 2013; Smithers 2015; Todd 2016; Tuck and Yang 2012; Viveiros de Castro 1998).

Despite its fraught analytic status, ‘nature’ was constantly invoked in my ethnography, by chefs, fermenters, and other culinary practitioners, as it is throughout New/er Nordic, contemporary cooking, and fermentation worlds. For these practitioners, ‘nature’ denotes an ontology (which varies), invites a mixture of epistemologies (science, the senses, and modes of food procurement and preparation), suggests certain ethical and political norms, and functions as a source of cultural and economic value. Rather than explain away my participants’ use of ‘nature’ as mistaken, I suspect it more fruitful to take this ethnographic cue seriously and try to account for it in its own terms. I thus use ‘nature’ as an actors’ category that signifies a totality of agencies, sometimes excluding and sometimes including humans—what Castree calls ‘external’ and ‘universal’ natures respectively (Castree 2014b). I develop these links between a given nature’s ontology, norms and values further in Chapter 4.

2.1.2 Multinatures: wild, wilder, and post-pastoral

To analyse the New/er Nordic’s multiple natures I draw together wilderness/wildness and pastoral/post-pastoral distinctions into an analytic framework (Chapman 2006; Cronon 1996; Gifford 2012; 2014; Paxson 2012). These pairs are comparable: in each, the latter term rearticulates the former in response to increasing awareness of the world’s entanglement. The pairs differ in where they locate nature’s ultimate value: for itself or for humans (Table 2). Bringing these pairs together helps analyse how and why New/er Nordic natures have changed over time, and how these natures have shaped the practice and taste of translated fermentation.

		nature's value	
		for itself	for humans
nature–culture relation	distinct	wilder	pastoral
	entangled	wild	post-pastoral

Table 2—Comparison of the wilder/wild and pastoral/post-pastoral.

While the wilderness/wildness pair is normally possible only in nouns, it is useful for analysis to have corresponding adjectives. I use ‘wilder’ (ˈwɪl.də[r] as in ‘wilderness’, rather than ˈwʌɪl.də[r], the comparative of ‘wild’) as an adjective for wilderness, in contrast to ‘wild’ for wildness. ‘Wilder’ is fitting as an adjective: as a heteronym of ‘wild’’s comparative it connotes wilderness’ impossible excess; and its own pronunciation links it to the archaic verb ‘to wilder’, meaning ‘to cause to lose one’s way; lead or drive astray’ from which ‘bewilder’ derives (OED 2021c).

Each of these categories describes imaginaries and materialities. They never completely coincide but are related and shape each other. Changing materialities can change the imaginary, as with the wild; conversely, an imaginary, like wilderness, can be so powerful that it enacts the world it imagines (even if it is impossible fully to achieve).

Environmental historian William Cronon makes an influential critique of wilderness, as a dualistic and paradoxical imaginary of a nature untrammeled by yet available to humans (1996). On the other hand, ‘*wild*ness (as opposed to wilderness) can be found anywhere…if we acknowledge the autonomy and otherness of the things and creatures around us.’ (ibid.: 24, original emphasis) Environmental philosopher Robert Chapman formalises this distinction in debates about ecological restoration, ‘to separate wilderness from wildness both conceptually and ontologically by enlarging the domain of wildness to include certain human activities.' (2006: 463) We can think about this distinction in absolute and relative terms: wilderness represents a kind of absolute wildness where humans are (imagined to be) totally absent, while wildness can feature greater or lesser degrees of human activity. This wildness aligns with geographer Rosemary-Claire Collard and others' more recent call for 'wildness [to be] understood relationally, not as the absence of humans but as interrelations within which animals [and other creatures] have autonomy' (Collard, Dempsey, and Sundberg 2014: 328; see also Rose 2004).

The wild is an imaginary with corresponding materialities; the wilder, on the other hand, is probably bound to the realm of the imaginary. This is not to say that the wilder imaginary is materially inconsequential. Emerging in the nineteenth century as a response to industrialisation and the growth of visible human impacts on nature, wilderness envisions a nature that is pure, timeless, and untouched by human activity, inflected by a Romantic fascination with the sublime. The result naturalises social purity, ignores past and present human landshaping activity, and justifies emptying land of people (Plumwood 2006; Smithers 2015; Spence 1999). Wildness, on the other hand, responds to pervasive human agency, describing and valorising nonhuman persistence despite histories of human domination. Wild natures are messy, historical, in feedback with people, and increasingly shaped by active and passive rewilding (Gammon 2018; Jørgensen 2015; Lorimer et al. 2015; Marris 2011). This wildness cannot be pure, reflects long histories of more-than-human translocations, and acknowledges past and present human landshaping activity.

While the wilder and wild describe natures that exceed human agency, whether absolutely or relatively, and that are ultimately valuable in themselves, the pastoral and post-pastoral describe natures in which humans are central, as receivers of value and sometimes, in the latter's case, as yielders of that value through work.[52] Literary scholar Terry Gifford traces the pastoral from classical antiquity, as a literary genre that depicts an idealised nature with a nostalgic, easy air (Gifford 2012, 2014). These pastoral natures are painted as a source of effortless bounty, which urban dwellers can retreat to for relaxation and return from with revelation. Such pastoral valorisation of rural living has long served to naturalise urban/rural geographies and corresponding class structures, and became a key part of nineteenth-century Romanticisms and emerging nationalisms (Grand, Pennington, and Thomsen 2013; Møller 2019; Oelsner 2012). Against this history, Gifford proposes the 'post-pastoral' to describe newer literatures emerging in the 1990s that depict natures as irreversibly changed, if not destroyed, by human activity. The post-pastoral is not what comes 'after' the pastoral but what aims to move 'beyond' it (Gifford 2014: 6). It recognises the 'collapse of the human/nature divide' and 'is more about connection than the disconnections essential to the pastoral.' (ibid.: 7)

Anthropologist Heather Paxson adapts Gifford's literary post-pastoral to explain how and why American artisan cheesemakers pursue their craft (Paxson 2012). Paxson's post-pastoral cheesemakers head 'back to the land' (ibid.: 8), but without the countercultural resonance of the 1970s. This movement is part of a larger 'post-industrial reconfiguration and reimagination of the American landscape' (ibid.). It retains the distinction between city and country but proposes a new, optimistic relationship between them: where largely urban markets can bring new life to run-down farms, new jobs to rural residents, and new tastes to consumers. This post-pastoral 'rejects industrial capitalism's wholesale

[52] Strictly speaking, the pastoral involves relations with livestock, and the 'agrarian' describes relations with plants. Here, following Gifford and Paxson, I use the 'pastoral' and 'post-pastoral' to describe cultivation involving any nonhumans, as my main concern is how land is used and imagined, less by which actor. But the specific actor likely does make a difference—a promising avenue for further work.

exploitation of nature and culture' (ibid.: 17), as well as the distinction between them. It is thus, with Paxson citing Marilyn Strathern (1992), 'after nature': 'at once post-nature, recognizing that there is no pristine natural world outside human cultural activity, and also ever in pursuit of some kind of remade nature as a ground for appropriate human action.' (Paxson 2012: 18) This 'nature' is neither wilderness nor country estate but what Paxson calls a 'working landscape'—a 'synthesis of land (resource extraction through labour) and landscape (bucolic vista)' (ibid.: 17).

Paxson's post-pastoral, like Gifford's, is still animated by pastoral values, but differs from it in questioning them. Paxson's post-pastoral inherits the pastoral's aesthetic values and appeal of 'rural goodness', and romanticises nature as a source of personal potentiality—but sees these as realised through labour, not idyll. Here urban elites celebrate rural life by living it (or trying to), embodying the ambiguous class status of the 'artisan' while articulating a new urban/rural geography. Technology is welcomed in this cause, but only to help build a flourishing working landscape based on 'collaboration with' rather than 'domination of' nonhumans (ibid.: 8). This post-pastoral agrarianism is thus optimistic but aware of the work and difficulty it involves, is future-oriented rather than nostalgic, and is sensitive to the troubled status of 'nature' while nonetheless interested in its preservation through working landscapes.

These two pairs—the wilder and wild, the pastoral and post-pastoral—help tease out the complexities and paradoxes in how the New/er Nordic has mobilised different natures for different ends. The main difference between them is what kind of nature they idealise: a nature ultimately for itself, or for humans. Does one desire confrontation or comfort, encounter or shelter? If the pastoral promise is that nature is there to provide for us, without our work or, as with the post-pastoral, with it, the promise of the wild is the possibility of encountering something about and in the world that is beyond us, beside us, around us, indifferent to us, even if not untouched by us as the wilder might hope for: something with its own interests (Ch7) and precisely therein its worth. Chapter 4 illustrates these contrasts, and how different mixtures of these natures have given rise to different tastes for and of different organisms—including different microbes and fermentations.

The New Nordic generally valorised wilder, 'external' natures separate from humans, while the Newer Nordic valorises wild, 'universal' ones including them (Ch4). The pastoral is difficult to locate in the New/er Nordic in part because the Nordic lands have rarely been idealised as bearing fruits without labour; rather the predominant cultural history, shaped both by the difficult climate and Protestantism, is of work as survival and salvation. The post-pastoral is more apparent, particularly in the Newer Nordic. While in principle these different natures—wilder and wild, pastoral and post-pastoral—are incompatible, Chapter 4 shows how in practice they can coincide. Drawing on 'multinaturalism', I call these assemblages of different natures 'multinatures'.

The New/er Nordic's shifting notions of nature highlight the role of taste in the politics of nature, shaping the imaginaries, materialities, and cultural politics through which nature is made and negotiated. They also suggest general features of taste shaping natures: that their natures are contingent (not necessary), constructed (not essential), and multiple (not singular); that they nonetheless take nonhumans and nonhuman agencies seriously, across scales; and that their imaginaries and materialities in turn shape human tastes.

2.2 ON TASTE

Taste is an important material-semiotic phenomenon conjoining physiology and sociality. It mediates sustenance and satiety, pleasure and survival, and has world-shaping powers. It lies at the heart of how human fermenters and fermenting microbes know and shape each other in New/er Nordic translated fermentation—a key theme throughout the thesis, and which I give close treatment in Chapter 5. Taste also means many things. Here I specify the particular sense in which these fermenters' knowledge practices enact taste, and how it draws together and departs from other common accounts.

Any critical discussion of taste in the social sciences is indebted to Bourdieu (1984)—he showed that taste is not merely idiosyncratic, but that as a robust index of class it is available to social analysis. Yet taste here is not that of Bourdieu, in at least two important ways: where Bourdieu is concerned with what cultural consumers like or prefer,[53] the taste I am concerned with here also involves how cultural producers sense their work. Noma and Empirical team members' motivation to make their dishes, fermentations, and spirits to the highest degree of precision is about what we could call 'expressibility': to be as specific and deliberate as they can in the products, flavours, and experiences they craft, and in how they sense them. This is not to say that distinction through sociocultural capital nowhere enters the process; but the capital that matters is not the cultural capital of performing discerning taste-as-preference, but the social capital of demonstrating consummate gastronomic craftsmanship based on taste-as-perception.[54] Distinction here is not about what one likes, but about what one can sense and articulate (Latour 2004b)—and more

[53] See also Teil and Hennion (2002).
[54] This social capital can also be lost by mis-tasting (Redzepi 2014a: 151).

importantly, it is a by-product of the main motivation of 'expressibility' described above.[55] We can thus contrast Bourdieusian consumers' taste-as-preference for social distinction with the idea I develop here of producers' taste-as-perception for sensory distinctiveness.[56]

Many classic anthropological texts on taste similarly focus on the implications of certain taste preferences (Mintz 1986; Mintz and Du Bois 2002) rather than the perception of how things taste. The recent 'sensory turn' is revising this tradition (Pink 2010; Sutton 2010), approaching taste also as perception (Ingold 2000: 283).[57] Along these lines, I understand taste and smell as made in practice (Besky 2020; Counihan and Højlund 2018; Hennion 2005; Mol 2011, 2012; Teil and Hennion 2002), trainable (Majid et al. 2017; Mol 2009), and possible to articulate (however partially).[58]

Nonetheless, some scholars have been reluctant to theorise taste and smell as specific modes of perception because they 'raise a whole gamut of problems of their own.' (Ingold 2000: 254). One immediate 'problem' may be simply characterising taste and smell and their relation. The predominant scientific approach is to distinguish between gustation (taste), sensation via chemoreceptors on the tongue, and olfaction (smell), sensation of airborne molecules via olfactory receptors in the nose (Dunn and Sanchez 2021; Shepherd 2013). Taste and smell together are often referred to as 'flavour'. While some social scientists have recently advocated for distinguishing taste and smell in this way (Watson and Cooper 2019), I wish to maintain taste's multivalence, as not only 'gustation' but what

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[55] See Chapter 7 for this 'expressibility''s aesthetic values in Noma's culinary R&D.
[56] For similar efforts to move beyond Bourdieusian taste—and the importance of doing so—see Spackman and Burlingame (2018); Spackman and Lahne (2019). For a critique of Bourdieu with respect to immigrant taste see Ray (2018).
[57] For recent work in STS see Lahne and Spackman (2018), Spackman and DeLaet (2017b); for an early geographical example see Roe (2006a).
[58] Some scholars think that taste and smell are ultimately beyond articulation (eg. Thrift 2003). While this position fits well with the non-representational agenda, I propose a slightly more nuanced relation between taste and language in Chapter 5.

we might denote as 'degustation': the multisensory, considered apprehension of substances ingested by mouth, including, for example, the haptic (and sometimes chemical) experience of texture or mouthfeel.[59] Doing so helps retain its dual sense of perception and preference, resists the reification of taste and smell as categorically distinct from the other senses, and remains faithful to its common usage whose multivalence is socially significant.

Retaining taste's multivalence is further supported by even the strict scientific sense of gustation being already multisensory. An assemblage of different physiological pathways possible to assemble otherwise, it does not provide the indisputable precision it suggests. Chemoreceptors for sweetness, sourness, saltiness, umami, and bitterness of course differ.[60] Bitterness in particular is associated with a range of receptors—twenty-five in humans (Lundström, Boesveldt, and Albrecht 2011; Shi and Zhang 2006). What binds them together is not physiological but phenomenological identity. Similarly, what binds chemoreceptors for the five 'basic' tastes together is simply that they are all present on the tongue. If anatomical placement were sufficient for a chemical-sensory modality to be included in gustation, it should also include the chemesthetic senses—'chemical touch' involved with pain and temperature (Green 2012; McDonald et al. 2016; Viana 2011). These receptors sense heat from chilies and coolness from mint, the pungency of fresh alliums and very green olive oil, the stinging of certain aged cheeses, the tingling of carbonation, and the numbing of Sichuan pepper, among many other important gustatory sensations. In general, there is no simple one-to-one correspondence between compounds,

[59] While the perception of flavour is multimodal, shaped by sight and sound (Spence 2017; Spence, Piqueras-Fiszman, and Blumenthal 2014), focussing on the historically maligned 'proximal' or 'lower' senses, including touch (Mann et al. 2011; Paterson 2009), might help overturn this sensory hierarchy—a key point of feminist epistemologies (Korsmeyer 1999; Pink 2010).
[60] This account does not even involve 'newer' tastes still being researched, such as kokumi (Maruyama et al. 2012; Ohsu et al. 2010; Yang et al. 2019).

taste receptors, and percepts. The same is even more true of smell, which is the most combinatorially complex of the human senses (Hoover 2010). This is all to say that chemistry and physiology alone are insufficient to explain the standard scientific account. Phenomenology is equally necessary.

This phenomenology, of course, varies—and not only because of physiological and genetic variation. How different bodies attune differently to taste-able substances is also shaped by social and political differences[61]—a key point illustrated by work in visceral geographies, critical race studies, and other fields (Carolan 2015; Harper 2009; 2010; A. Hayes-Conroy 2010; J. Hayes-Conroy 2009; A. Hayes-Conroy and Hayes-Conroy 2008; 2010; J. Hayes-Conroy and Hayes-Conroy 2010). Attending to how subjects taste difference must also always attend to how they taste differently. In the New/er Nordic, who can participate in these rarified culinary fermentation worlds is shaped by one's actual and potential tasting capacities.

In navigating taste's multivalence, tired yet still-pervasive debates of whether taste is 'subjective' or 'objective' are unhelpful. It is both, and neither—as historian and sociologist of science Steven Shapin writes, it is 'intersubjective' (Shapin 2012a, 2012b, 2016). For all the social-science work on taste, vanishingly little (Shapin cites, as an exception, Hennion 2007) actually investigates how 'taste communities coalesce around practices… that refer to mutually accessible external properties as the causes of internal states.' (Shapin 2012a: 178) Shapin calls for

> ethnographies – contemporary and historical – of how taste judgments come to be formed, discussed, and sometimes shared. Such ethnographies would look a lot like those produced by laboratory studies

[61] A process of differentiation that begins already in the womb (Dias and Ressler 2014).

> of science, concerned with how fact and theory judgments come to be formed, discussed, and sometimes shared. (ibid.: 177)

I hope to offer such an ethnography here. I also aim to offer a further contribution, by bringing nonhumans into the intersubjective mix of subjects who taste and are tasted in turn—humans and nonhumans learning to affect and be affected by each other (Despret 2004, 2013, 2014), becoming 'attuned' to each other's 'articulations' (Latour 2004b). This is a logical extension of Shapin's proposal. If we understand taste in its key sense—contact-based chemical sensation of the environment—then microbes have been tasting for billions of years.[62] While the specific mechanisms of humans and various microbes tasting all differ, understanding taste as a general capacity helps make sense of how humans and microbes in fermentation sense each other through 'chemical signatures' (Paxson and Helmreich 2014). This multispecies conceptualisation of taste adds further complexity to the notion of 'hand taste' (Ch1, Ch8). It also suggests how subjects know together by tasting together more generally, within and across species—what I call *consipience* (Ch5).

Though taste and pleasure have long been neglected by scholars across disciplines (Dunn and Sanchez 2021: x-xi), they are and always have been world-making forces. Taste shaping natures acknowledge and help account for this power. The specific sense of taste New/er Nordic fermenters enact—one that is multisensory and productively multivalent—reveals further general features of taste shaping natures: that their taste involves both perception and preference, gustation and degustation, physiology and phenomenology; that this taste is intersubjective, within and across species; and, as we will see in the next section, that different organisms and ecologies shape human tastes through their charisma.

[62] Donati (2016) has followed the logic of more-than-human taste even further, arguing, based on her concept of 'multispecies gastronomy', that if nonhumans can taste, and display clear eating preferences (see eg. Amato et al. 2021), then they must also be extended the courtesy of having not mere hunger but appetite.

2.3 ON MODES OF SHAPING

When human fermenters taste their fermenting microbes (and in theory vice versa) they don't just get to know them at a distance—they become involved, embroiled, implicated. In New/er Nordic translated fermentation, as for taste shaping natures generally, to know through tasting soon means to shape and be shaped, across species. Multispecies epistemics imply multispecies ethics. These shapings take many forms. Here I introduce three—experiment, interest, and micro-governmentality—which I develop further in Chapters 6 and 7 through analysing how New/er Nordic fermenters and their fermenting microbes shape each other, and with what consequences.

2.3.1 ACROSS SPECIES

Multiple allied streams of scholarship have asked how different species shape, 'become-with' (Haraway 2008), and ultimately might live well with each other. One is more-than-human geography (Greenhough 2010; Whatmore 2002, 2006). In contrast with post-humanism, which tends to dissolve the human figure entirely into its composite relations, the more-than-human retains the human as constituted through nonhuman others (Castree and Nash 2006; Lorimer 2015; Wolfe 2009). Another, emerging from anthropology, is the cognate approach of multispecies studies (Kirksey 2014; Locke and Münster 2015; van Dooren, Kirksey, and Münster 2016)—aiming to extend the methods of anthropology to study nonhumans (Kirksey and Helmreich 2010), and to situate the 'anthropos' among its many 'companion species' (Haraway 2003; 2008; Tsing 2010; 2012). Because of 'species'' multiplicity (Ch1), multispecies studies does not take the category as self-evident, but ethnographically as an actors' category and analytically as a performative heuristic for 'moving beyond human exceptionalism' (Tsing 2015: 162; see also Kirksey 2015b).

These literatures' pursuit of relationality among humans and nonhumans gives rise to an ethics of 'flourishing' (Cuomo 1998; Ginn, Beisel, and Barua 2014) and a politics 'against purity' (Shotwell 2016). Through these ethics and politics, related themes of 'conviviality' (Donati 2014; 2016; 2019; Hinchliffe and Whatmore 2006; Illich 1973; Stengers [1997] 2010), 'collaboration' (Fournier 2020; Haraway 2008; Paxson 2008), and 'togetherness' (Abrahamsson and Bertoni 2014; Ginn, Beisel, and Barua 2014) emerge. But togetherness does not imply symmetry, and a simple celebration of multispecies, more-than-human relationality can gloss over crucial dimensions of difference: that 'practices of care are always shot through with asymmetrical power relations' (Martin, Myers, and Viseu 2015; see also Puig de la Bellacasa 2011; 2017); that instead of 'everything is connected', 'everything is connected to something, which is connected to something else' (van Dooren 2014: 60); that 'detachment' is of equal importance as 'engagement' in navigating more-than-human entanglements (Brice 2014; Candea 2010; Ginn 2013).[63] Though many scholars acknowledge this need for differentiability, it is forgotten sufficiently often to prompt some to ask 'what comes after entanglement' (Giraud 2019). Much recent social-science work on fermentation tends to be so culpable, perpetuating a flat ontology of mere, celebratory togetherness, emphasising a 'nonhierarchical, relational ontology' of 'necessarily interdependent' beings, and glossing over specific relations of difference and asymmetry among microbes and between microbes and people (Hey and Ketchum 2018a; see also 2018b; Ch1).

[63] 'Collaboration' might be best understood in more narrow, symmetrical terms (Evans 2021).

The challenge of balancing more-than-human similarity and difference relates to tensions between anthropocentrism and anthropomorphism (Hall 2011; Marder 2012; Plumwood 1993). These are commonly framed as a trade-off, in which it is seen as ethically preferable to err towards the latter (Bennett 2010; Ginn 2013), employing a knowing anthropomorphism as a deliberate strategy to counteract anthropocentrism (Szymanski 2018). Scholars have also critiqued this framing, its assumptions and shortcomings: for example, that 'we [also] apprehend the feelings of other humans only by similar projections' (Langford 2017: 97); that the charge of 'anthropomorphism' is usually levelled to obscure more specific 'indefensible' human-exceptionalisms, such as that '"only humans can have minds, or the capacity to love,"' (Plumwood 2009: 11) or pleasure, or appetite (Donati 2016); or that 'egomorphism', the 'perception that [others] are "like me" rather than "humanlike,"' (Milton 2005: 259) might be more appropriate (Candea 2010). This literature ultimately aims to constitute nonhumans as individuated subjects, beyond mere instances of a species (Derrida 2008). Yet this process does not work the same way for every nonhuman, and it becomes particularly complicated when even the individual in question is not always clear—as discussed, for example, with microbes (Ch1).

More-than-human and multispecies scholars have developed and repurposed a variety of conceptual tools to undertake this differentiated subjectification of nonhumans (Ch5). Many draw on von Uexküll's concept of *umwelt* (von Uexküll [1934] 2010)—the experienced world as delimited by the contingencies of a given subject's embodied sensory-perception—to help imagine what it might be like to inhabit a given nonhuman subject's world as well as to recognise the inevitable limitations of trying (Buchanan 2009; Bull 2014; Deleuze and Guattari [1980] 1987; Ingold 2011; Lorimer 2007; Thrift 2004; 2006). Drawing on umwelt, Lorimer develops the concept of 'nonhuman charisma' to describe the different physiological and aesthetic properties that configure how nonhumans differently capture human attention, and with what consequences (Lorimer 2007; 2013; 2014). Though most work on nonhuman charisma has attended to animals 'big like us' (Hird 2010) known mainly through visual and haptic senses, fermentation microbes' nonhuman charisma, while multisensory, engages smell and taste prominently. Different microbes also have divergent kinds of charisma (Ch5), further outweighing the 'microscopicity' that ostensibly unites them as a group.

Taste shaping natures involve multiple species. Making sense of these multispecies relations requires acknowledging the interplay of engagement and detachment, similarity and difference, and symmetry and asymmetry in discussions of conviviality, collaboration, and togetherness.

2.3.2 EXPERIMENT

New/er Nordic translated fermentation engages experiment as a key knowledge practice and multispecies relation. As an analytic in geography and STS, however, experiment has become difficult to gain purchase on. Postwar philosophers of science developed ahistorical, universal theories of science that tended to take the idealised, positivistic account of experiment at face value—if they attended to it at all (Hacking 1983: 149). With the rise of science studies in the 1970s and 80s, scholarly focus shifted toward historical and ethnographic investigations of experiment in practice (eg. Rheinberger 1997; Shapin and Schaffer 1985).[64] More recently, in the last ten to fifteen years, interest in studying experiment in action has spilled over into an imperative to 'be' experimental, or at least to frame one's work as such (Jellis 2012: 1). As experiment's 'cachet' grew in the social

[64] See Jellis (2012) for a more detailed history.

sciences, and the meaning of experiment extended beyond science or avant-garde art, there was concern that 'its currency [was] in danger of being devalued' (ibid.: 1; 3).

Scholars responded to this proliferation in different ways. Some sought to limit the inflation by seeking 'the *nature* of experimental enquiry' (Powell and Vasudevan 2007: 1791; original italics), positing a set of necessary and sufficient conditions 'that links the recondite behaviors of lab culture to drug experimentation, experimental theater, thought experiments, [and] political acts' (Ronell 2003: 657). Many others resisted 'suggest[ing] some essential unchanging activity which might be called experimentation', instead accepting whatever called itself experiment (Jellis 2012: 21). Each approach has a complementary logical problem: it is just as impossible to identify experiment's 'nature' without generalising from existing instances of it as it is to identify exemplary instances of experiment without relying upon an existing general notion of what it is. The tension between these jointly necessary approaches pervades the literature.[65] This circularity has paralysed studies of experiment. Around 2012 or 2013, experiment seemed to peak—exhausting itself as an analytic once anything and everything could be fashioned experimental. Some scholars came to see this proliferation as mere 'strategic rebranding' of existing agendas and methods (Last 2012: 708; see also Jellis 2012; Kullman 2013). Even scholars committed to experiment's 'manyness' have sought a way to adjudicate between more or less 'productive' invocations of it, but to little avail (Jellis 2012: 220; 213).

Building on Jellis' efforts to 'reclaim' experiment, and supported by the experimental fermentation practices I studied, engaged in, and built on at Noma and Empirical, Chapter

[65] Of course, the problem is not specific to experiment, but a general philosophical one—comparable to prescriptivism vs. descriptivism in linguistics, nomothetic vs. idiographic approaches to knowledge production, Platonic vs. Aristotlean epistemology (Ch8).

6 makes the rather modest argument that, if experiment is worth retaining, this can be achieved by qualifying its kinds; its bagginess can be, if not solved, at least modified by sewing pouches and compartments into its lining. Qualifying experiment allows us to remain agnostic about the term's proliferation, while distributing its load such that it can avoid meaning little at all. It also shifts focus to new questions: assessing whether something is an experiment—for Latour, for example, everything now is (Latour 1998, 2004a, 2011)—becomes less interesting or important than assessing what kind of experiment it is, and how it relates to others.

Beyond the conventional understanding of a scientific experiment (also multiple), the literatures that qualify experiment have tended to do so by discipline, as 'extra-scientific' (Jellis 2012), 'social'/'societal' (Gieryn 2006; Guggenheim 2012), 'artistic' (Last 2012), 'art–science' (Born and Barry 2010; Gabrys and Yusoff 2012), or 'geographical' (Davies 2010; Kullman 2013; Last 2012), or by site, as 'laboratory' or 'field' (Kohler 2002). Yet these approaches can easily reinforce received disciplinary distinctions and spatial hierarchies. A more productive way to qualify experiments might be according to their goal or mode—'collective' (Latour 1998b, 2004a, 2011), 'cosmopolitical' (Hinchliffe et al. 2005), 'collaborative' (Gross 2009), 'wild' (Lorimer and Driessen 2014).

Based on the New/er Nordic fermenters' practices I studied, in Chapter 6 I develop the concept of a 'culinary experiment' as a particular kind employed by culinary innovators in their pursuit of novel flavours. Throughout the literature on cooking (Ch1), culinary knowledge practices are generally framed as craft[66]: tacit, traditional, embodied folk

[66] As Lorimer (2020: 262) writes, '"Craft" is a loaded term. Its definition and relationships with science and with labor have been the subject of much analysis in science studies and philosophy. Compare with Sennett [1997] 2009; Arendt 1958; Ingold 2013.'

knowledge, often contrasted, implicitly or explicitly, with the systematic, controlled, principle-based knowledge of scientific practice. Only a few studies have investigated how science in general, and experiment in particular, have shaped and been shaped by cooking.[67] 'Culinary experiment' aims to bring these scattered studies into dialogue, and use them to further theorise relationships between science, cooking, and taste.[68]

Paxson, in her study of American artisanal cheesemakers, notes how 'scientific knowing-why might successfully guide in the place of lost traditions of knowing-how.' (2012: 146) Here food production is framed as a craft which technoscience may come to shape, or, after her participants, as 'a balance between art and science' (ibid.: 129). Following her actors' categories so attentively in the analysis yields a rich ethnographic texture. These same categories can also occasionally reinforce somewhat crude dichotomous analytics, such as 'subjective' vs. 'objective', sensory/tactile/bodily vs. rational knowing, and 'art' vs. 'science', as transcendental rather than historically contingent and performatively reproduced. Here, cheesemaking is compared with running 'laboratory-based scientific experiments' (ibid.: 149), but without much elaboration of what this comparison entails or why it matters.

Molecular gastronomy has proven a popular case for studying this relationship (Borkenhagen 2017; Roosth 2013), in which chefs often develop dishes through controlled experiment. Here too analyses tend to reify distinctions between science and cooking and

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[67] In the social sciences. In the natural sciences, where 'molecular gastronomy' and culinary modernism (Ch1) have grown since the 1980s, coming to inform culinary practice and training, this link is not only recognised but actively pursued. See, for example, classics like McGee (2007) and This (2006), and more recent anthologies such as Vega, Ubbink, and van der Linden (2012) and Brenner, Sörensen, and Weitz (2020).

[68] Some scholars have attended to how 'scientific knowledge, methods, and rationales' shape 'moments in which people taste' in sensory science laboratories (Mann 2018: 23), and the use of 'experiments' in sensory training in a vanguard restaurant (Ulloa et al. 2017). In both these cases, however, cooking is absent.

between 'science' and 'art'—in Borkenhagen's case to serve his thesis concerning 'the challenges to incorporating science into creative fields' (2017: 630). He also notes the history, at least since Escoffier's late nineteenth-century formalisation of professional kitchens, of recognising the kitchen (analogically) as a kind of laboratory.[69] Roosth documents the metaphor's other direction, showing how many leading STS scholars have analogised laboratory work as a form of cooking (2013: 13, note 8).[70] I take seriously these longstanding metaphors that depict kitchens as laboratories and laboratory work as a form of cooking, and pursue their implications: that cooking involves not only habitual, tacit, repetitive craft, but can also make systematic, explicit, cumulative forays into the unknown; that experiments can mobilise primary sensory logics other than vision; and that kitchens function as a vastly understudied 'truth spot' (Gieryn 2018; Ch1).

These arguments can be taken still further. While much of the work outlined above tends to take science and cooking, and kitchens and laboratories, as distinct, pre-existing activities and spaces that then come to interact,[71] my ethnography suggests a different model. The practices of New/er Nordic chefs and fermenters unfold in and constitute amphibious, reconfigurable culinary spaces that straddle these distinctions, able to function as more kitchen or more lab according to the task.[72] Such kitchen-lab spaces are not entirely novel; rather, I situate them as the most recent chapter in the longer history of the co-constitution of science and cooking, and of laboratories and kitchens.[73] I develop

[69] Another form of experiment was perhaps even more prevalent in nineteenth-century kitchens: testing for contamination/adulteration of foodstuffs (Goodman 2013).
[70] Several scientist and STS colleagues of mine have commented, based on anecdote and research data, how often laboratory scientists talk about their work as 'cooking'.
[71] See also Hey (2020) for a microbial example.
[72] Suggesting a more-than-bijective relation between space and episteme (Foucault [1966] 2005, 1980).
[73] Kitchens have long contained multiple functions, particularly medical and apothecarial ones, from Hippocrates' famous edict of 'let food be thy medicine' until at least the seventeenth century (Guerrini 2016). Butchery and surgery, for example, have a long entangled history (ibid.), becoming distinguished only in the nineteenth century (Fitzharris 2017, its Whiggishness notwithstanding).

this argument further in Chapter 6, where I discuss how technoscience and experiment, in the pursuit of novel knowledges, techniques, and flavours, are key modes of shaping in culinary taste shaping natures.

2.3.3 INTEREST

This co-constitution and in-betweenness of culinary experiments and kitchen-labs calls to the second mode of shaping I develop: interest. The term 'interest' has two etymological strands. Both are relevant. The word comes from Latin, the third-person singular present indicative of the verb *interesse*, meaning 'to be between, to differ, to make a difference, to concern, to be of importance, to matter' (OED 2021a, 2021b). In medieval Latin, it took on legal and pecuniary meaning, as compensation for loss or compensatory payment (ibid.). Entering Middle English from medieval French, each aspect of the term—one of concern, curiosity, betweenness, mattering; the other of legal right, stake, investment, power—has shaped the concept's use in STS, in different ways.[74]

Early-1980s debates in SSK turned around the second sense, for example on using a theoretical construct such as 'interests' to explain an actor's behaviour (Barnes 1981; MacKenzie 1981; Woolgar 1981b, 1981a). In this context Callon and Law affirmed interests as internal to science (1982: 615) and suggested that, rather than interests compromising scientific validity and credibility (ibid.: 616), scientists acknowledged and negotiated them as part of working together (ibid.: 617). This position led to Callon's related concept of 'interessement': the process of intervening in other actors' attempts to establish the definition of a scientific problem—the actors, their identities and relations—

[74] The concept of interest has been an even older, persistent concern of moral philosophy, emerging in Plato's Republic and receiving extensive subsequent attention (Bloomfield 2007).

so as to make one's own definition dominant (Callon 1984: 208; 211).[75] Callon's interessement affirmed interests as integral to science, but only in one sense: that of investment, influence, competition for advantage.

STS's early focus on this sense of interest fuelled the 1990s' so-called 'Science Wars'. However, the other aspect of interest—that of concerning, mattering, relating—was also always there, if neglected. Much of Stengers' late-1980s work (only entering anglophone scholarship in the late 1990s) recoups this other, older meaning: an epistemology shaped by curiosity and situating oneself in relation, in between. For Stengers, interest—which she links explicitly to *interesse*, 'to be situated between' (1997: 83)[76]—is what ties scientists together, rather than 'the object' of objectivity (ibid.: 82). Contrary to certain popular accounts of scientific epistemology, here scientists cannot be 'disinterested'; for science to work, they must be 'interested': that which interests must 'concern the person, intervene in his or her life, and eventually transform it.' (ibid.: 83-4) For Stengers, interest is a necessary condition for truth value even to become possible, let alone be ascertained (ibid.).[77]

In subsequent work, Stengers identifies these two simultaneous aspects of interest, arguing that it 'not only means to stand in the way of [faire écran], but first of all to make a link between [faire lien].'[78] (Stengers [1993] 2000: 95) Here 'interessement', to stand in the way of, is invoked, acknowledged, and delimited. For Stengers, 'the sciences [do not] break with

[75] Interessement came to shape many later studies in STS, such as Star & Griesemer's work on 'boundary objects' (1989).
[76] This use of 'situated' calls up Haraway's contemporaneous and influential theory of 'situated knowledges' and 'partial perspectivism', in which being positioned, and articulating this position, is part of what makes objectivity possible (Haraway 1988; Stengers' original essay was published in 1989).
[77] This is not quite the same as saying that, as Jellis glosses Stengers here, 'it is more important that a proposition be interesting than true.' (2012: 44) It is more that, before a proposition can be true or false, it must first be interesting: worth attending to, worth gathering around, worth inserting oneself in into, worth calibrating between oneself and others.
[78] Both positions involve thinking interest spatially (Ch7).

this notion of interest as an obstacle [but] transform it into a stake.' (ibid.) Interests, and what we might call 'interestibility', are crucial to science—science does not need 'impartial' readers, for whom any proposition is equally interesting (ibid.), but 'interested', or rather, 'interestible' ones. In Chapter 7, I use Callon's 'interessement' and Stengers' *interesse* to characterise different fermenters' approaches to shaping their microbes.

Stengers' work heralded a shift in how STS scholars invoked interest. Rather than the 1980s' fixation on interests as moves for power in shaping knowledge, scholars began discussing interest as a matter of relation, an affective, almost aesthetic value guiding knowledge production. Despret, following Stengers, began showing empirically how interest matters, how it makes a difference, in the production of scientific knowledge in ethology and laboratory studies with animals (Despret 2004). She showed how this interest works mutually across species—it mattered to the resulting knowledge not only how horses or rats interested human scientists, but also how humans managed or failed to interest their nonhuman partners. In Despret's tellings, pursuing what was 'more interesting' or 'most interesting' emerges as the main epistemological principle guiding how these ethological and laboratory knowledges were produced: 'raising more interesting questions… enable[s] more articulated answers, and therefore more articulated identities. It is an epistemological question.' (ibid.: 125) Latour codified being interesting and interested as key conditions of what he termed 'the Stengers–Despret shibboleth' or 'The Stengers–Despret Falsification Principle', which he argues is more discerning and therefore epistemologically superior to Popper's original proposition in assessing the quality of scientific knowledge productions (Latour 2004b).[79]

[79] For other instances of being 'interesting' as an epistemic value, see eg. Teil and Hennion (2002), Hinchliffe et al. (2005).

This epistemology of discernment echoes the sensory discernment exercised by culinary fermenters in tasting their fermenting microbes (2.2; Ch5). It also implies interest as an aesthetic and affective value as much as an epistemic one—but does not explicitly say so, or how. To account for this aesthetic dimension, which is clear in translated fermentation, we must turn to literary theory and cultural studies. Literary theorist Sianne Ngai has identified the interesting as a key aesthetic category under capitalism (Ngai 2008, 2010, 2012). Ngai traces the emergence of the interesting to the early nineteenth-century German Romantics, particularly Schlegel (Ngai 2008: 781). For Schlegel, if classical Greek poetry was 'objectively rule-bound, universal, and disinterested',[80] 'das Interessante' of the new, modern novel was 'restlessly subjective and idiosyncratic' (ibid.: 782), in endless pursuit of novelty (ibid.: 780).[81] Ngai thus analyses the interesting as 'an aesthetic without content' (ibid.: 781) and, based on examples of 1960s conceptual art and the postmodern novel, as an ambivalent, low-intensity wavering between aesthetic and nonaesthetic judgment, interest and boredom (ibid.: 788). The aesthetic judgments involved in New/er Nordic culinary experiments and translated fermentations have some affinity with Ngai's interesting, but also depart from it in important ways, which I discuss in Chapter 7.

Meanwhile, in STS, interest was giving way to other terms. Puig de la Bellacasa extended Latour's exhortation to move from contesting 'matters of fact' to articulating 'matters of concern' (Latour 2004d; 2005) toward describing 'matters of care' (Puig de la Bellacasa 2011). These shifts were part of a larger 'critique of critique', acknowledging the limitations of a solely critical approach and aiming to recuperate more sensitive engagement with the sociality of science after the polarising 'Science Wars'. To this end, Puig de la Bellacasa

[80] Cue Kant's disinterestedness as a condition of aesthetic judgment (Ngai 2008: 787).
[81] The genre's name, then, no coincidence.

relegates interest and its 'excessively suspicious critiques of agonistic interests and power strategies' (ibid.: 89) to a past mode of STS, and reorients toward a more 'respectful', 'constructive' form of STS 'at its best' (ibid.: 89) in which concern and care form the new agenda (ibid.: 87-88).

Puig de la Bellacasa's notion of care in fact comes close to Stengers et al.'s reading of *interesse*: to concern, to affect, to relate, to matter, to have one's curiosity awakened. Glimmers of this other, older sense of interest appear throughout Puig de la Bellacasa's discussion, as that which attaches and holds together 'the concerns [which themselves] attach and hold together matters of fact' (ibid.: 89). To be interested is to want to know more, to care about other perspectives, to move into the spaces between entrenched positions. As much as she disavows interest's former, 'agonistic' sense, Puig de la Bellacasa also draws support from Stengers' (ibid.: 97) and Despret's (ibid.: 99) discussions of interest as an epistemological ethics, and, following Despret, uses 'interest' (ibid.: 88, 92, 94) and 'interesting' (ibid.: 92, 98, 101) to orient attention and describe attraction. This persistence of interest as an epistemic, ethical, and aesthetic principle, even despite explicit, well-intentioned efforts, such as Puig de la Bellacasa's, to move away from and beyond it, suggest it still has analytic value to offer. Recuperating interest and refashioning it for more-than-human use is part of my aim in Chapter 7, where I develop it as a key mode of shaping in the microbial taste shaping natures of translated fermentation.

This recent sense of interest as affective orientation and aesthetic attraction has shaped concurrent STS work that advances a feminist account of ecology and evolution, which will be useful in my discussion of taste shaping natures' biological consequences. Hustak and Myers' analysis of Darwin's work on orchid pollination is exemplary (2012). Though they only once—in a brief discussion of Stengers and Latour on propositions and attunement (ibid.: 105)—invoke 'interest' in the sense I develop, we can note how their central concept of 'involutionary momentum'—'the momentum through which organisms reach toward one another and involve themselves in one another's lives' (ibid.: 96)—is cognate: becoming in-between through specific, situated interactions, cast out to ecological scale and evolutionary time.[82] I use this concept of 'involution' to develop an 'ethics of involvement' as a key component of interest in Chapter 7.

By becoming 'involved' in the encounters between orchids and insects, as Hustak and Myers show, Darwin experienced 'becoming pollinator' (ibid.: 90): he glimpsed 'the nascent contours of an affective ecology forming the grounds for a science of interspecies relations' (ibid.: 79). Darwin's experience, Hustak and Myers argue, suggests the need to 'supplement… the reductive, mechanistic, and adaptationist logics [of evolution] that ground the ecological sciences' with 'an involutionary mode of attention.' (ibid.: 77) Such multispecies encounters are 'conditioned not just by a calculating economy that aims to maximize fitness but also by an affective ecology shaped by pleasure, play, and experimental propositions' (ibid.).

In their aim to redress this imbalance, Hustak and Myers's approach, while important, can come at the expense of the mutually necessary, evolutionary side of the relation. Species do evolve through 'involving themselves in one another's lives' (ibid.: 98); in turn, they are able to involve themselves and others only because of being evolutionarily differentiated. Neither involution nor evolution is prior; each makes recourse to the other. Accounting

[82] Hustak and Myers draw on Deleuze & Guattari's 'creative involution' ([1980] 1987), articulated from Bergson's 'creative evolution' ([1907] 1911). They link involution to Barad's 'intra-actions' (2007), Stengers' 'reciprocal capture' ([1997] 2010), and others' allied use (Chisholm 2010; Doyle 2011).

for involution and evolution together must involve not only ‘unhing[ing] the legacy of Darwin’s evolutionary logics’ (ibid.: 97) but also rearticulating this legacy differently. Much of evolutionary theory’s legacy has been questioned, as it must: it has been used to justify Social Darwinism, eugenics, racism—a host of social ills. Yet Darwin himself argues against evolutionary teleology (Darwin [1859] 1982). Evolution under neo-Darwinism has contributed to ‘militarized and economic logics that pervade the sciences of ecology’ (Hustak and Myers 2012: 106). But evolution is not inherently military or economic. If evolution has been articulated in certain ways, it can also be articulated otherwise (Grosz 2011). There is room here to reclaim an evolutionary politics of mutualism, and mutual necessity with involution (Haraway 2016b). I illustrate this mutual necessity in Chapter 7 through a discussion of the ecological and evolutionary consequences of my collaborative experiment with kōji.

Figures can also help concretise this mutual necessity. Citing the Oxford English Dictionary (OED), Hustak and Myers remind us that etymologically, evolution describes how organisms ‘roll out’ into ever new forms, ‘a kind of speciation through divergence in the shape of branching trees,’ (2012: 96) while involution describes how organisms ‘roll into’ each other, becoming involved in each other’s lives (ibid.: 96). Hustak and Myers are duly skeptical of the tree figure. Drawing on evolutionary theorists Gould and Lewontin, they trace the tree’s development from Darwin to the ‘overdetermin[ations]’ (ibid.: 95) of neo-Darwinist fetishes like Dawkins’ ‘selfish gene’, before citing Margulis’ work on symbiogenesis and her consequent insistence that ‘the right topology’ is thus ‘a net, a web, and no longer a tree’ (ibid.: 96). In figuring evolution with the tree, and involution as ‘rhizomatic associations’, Hustak and Myers call up Deleuze and Guattari’s famous figures of the tree and the rhizome (Deleuze and Guattari [1980] 1987) to articulate what makes involution different.

In doing so, and in letting Margulis, Deleuze and Guattari have the last word, they do not ask what happens when we put these figures together. Everything is connected, as van Dooren reminds, but not everything is connected in the same way (2014: 60). A net or web usually implies a relatively even weave (otherwise it won't be a very effective web or net). This figure might work for many microbes, as Margulis suggests, but to accommodate the whole panoply of lifeforms a more differentiable figure might be required. If evolution is a tree, and involution is a rhizome, then interest, accommodating both, might be closest to Ford Doolittle's famous 'reticulated tree', in which branches branch out and fold back into each other at various times and places (Figure 7).

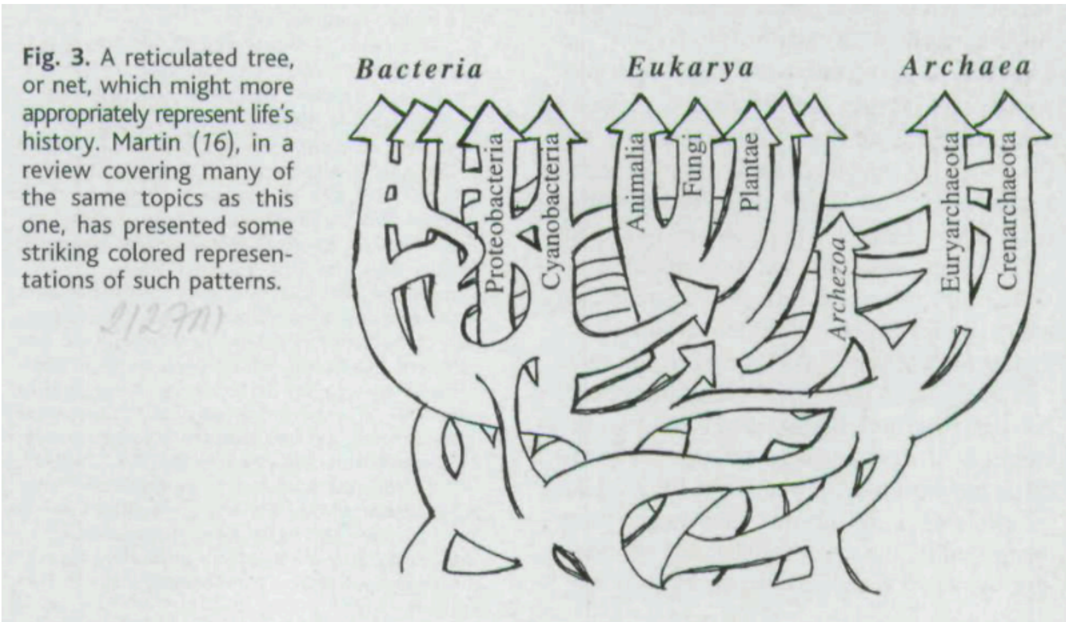

Figure 7—Ford Doolittle's diagram of the reticulated tree (1999).

Even in the reticulated tree, organisms evolve and involve at different moments. If evolution and involution are truly happening all the time, everywhere, for everyone, we need a slightly different figure that rolls out and rolls in simultaneously. Responding to these debates, and based on my analysis of how culinary fermenters and fermenting microbes shape each other in translated fermentation, I offer in Chapter 7 a new way of figuring evolution and involution's mutual necessity.

Based on such rearticulations of ecology and evolutionary theory, it is not surprising that a similar resurgence of 'interest' may now be occurring in multispecies studies. In his forthcoming work on 'multispecies solidarity' with and through Hawai'ian snails, van Dooren recuperates the long tradition of thinking with 'interests' in moral philosophy and recasts it for multispecies studies (van Dooren, n.d.; draft cited with permission). While I find his mobilisation of interests relies on somewhat unworkable notions of interiority, intentionality, consent, and *a priori* claims about which entities can and cannot have them,[83] making it not so usable for my purposes,[84] I similarly aim to recuperate interest as a form of concern and care (cf. Puig de la Bellacasa) and reorient it towards multispecies ethics (Ch7). I then use interest for comparison in a critical discussion of domestication (8.3).

The dialectical shapings of taste shaping natures show the need for a concept that can tie together epistemics, ethics, aesthetics and politics, evolution and involution, trees and webs. Interest is fit for the task.

2.3.4 MICROBIOPOLITICS & 'MICRO-GOVERNMENTALITY'

The multispecies relations in translated fermentation, however interesting and interested, are rarely if ever symmetrical. To analyse how human fermenters involve themselves in

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[83] Reinscribing a Western metaphysics of 'living' and 'nonliving' things (cf. Tallbear 2012; de la Cadena 2015).
[84] There is more to say here, but it will have to wait for another place (and for van Dooren's book to come out).

microbes' lives, I will also need a concept that helps me attend to these asymmetries, and specifically to how humans govern microbes in fermentation. Paxson's 'microbiopolitics' (2008; 2012) is a promising starting point. To examine its suitability for my purpose, I have gathered each definition of the term I could find:

(1) 'dissent over how to live with microorganisms reflects disagreement about how humans ought to live with one another.' (2008: 16)

(2) 'the creation of categories of microscopic biological agents; the anthropocentric evaluation of such agents; and the elaboration of appropriate human behaviors vis-à-vis microorganisms engaged in infection, inoculation, and digestion.' (2008: 17)

(3) 'the recognition and management, governmental and grassroots, of human encounters with the vital organismic agencies of bacteria, viruses, and fungi.' (2008: 18)

(4) 'means of social regulation carried out through control of microbial life.' (2012: 160)

(5) 'acting on recognition that human social relations are frequently threaded through microbial bodies.' (2012: 180)

Taken together, these definitions suggest that 'microbiopolitics' is about governing microbes only to the extent that it is instrumental for governing humans. The ultimate concern is with how humans live together (1), through the management of human encounters with microbes, not microbes themselves (3). If (4) implies that microbes are not included in the social, (5) makes it explicit.

(2) suggests where this human focus might come from. If microbiopolitics' ultimate concern is with 'appropriate human behaviour', it is because Paxson must find 'anthropocentric' tendencies in her data, and theorises the concept to account for them. Microbiopolitics is then anthropocentric by design, for analytic purposes. This anthropocentrism also makes the concept broadly useful, precisely because of how it draws attention to the variety of ways humans use microbes for biopolitical regulation of other humans.

However, if I also want to understand the inverse relation—how microbes are made into subjects and governed to yield successful fermentations, rather than as a means for governing other humans—the concept doesn't do quite what I need it to. I need a complementary notion for the governance of microbial life itself, and how this governance is 'frequently threaded through' human bodies and socialities: same actors, opposite relation.

As Paxson draws on Foucault's biopolitics to articulate microbiopolitics, Foucault's other main mode of biopower, 'governmentality' (Foucault [2004] 2008, 2009), would be fitting here. We can call this inverse, complementary concept 'micro-governmentality'.

To the degree that governmentality refers to 'the disciplining of individual subjects through various governmental regimes' (Lorimer 2020: 82), this concept does just what we need it to.[85] Yet a governmentality does not just refer to a regime of governance, but a mode of biopower through which certain kinds of knowledge come to form certain kinds of subject—namely, a subject that is willing to participate in their own governance (Foucault 2009). As Lorimer puts it, governmentality is a mode of governance that operates through 'shaping the knowing conduct of human actors' (2020: 7). An example would be what he terms 'holobiont governmentalities', such as helminth therapy, that 'target the self-aware behaviors of the human host' (ibid.: 83) to deliver desirable ecological services in one's holobiome.

What happens when the subject in question is not human, but microbial? The necessity of cultivating 'self-aware behaviors' might seem to some a stretch. Yet if we understand

[85] We can remain agnostic about whether the 'individual' in question is the single cell, population, or ecology; it can be any.

governmentality as the formation of subjects amenable to governance, all microbes involved in fermentation qualify.[86] Through backslopping, bodily and environmental inoculations, and other forms of passaging, all fermentation cultures, as species and ecologies, constitute microbial subjects that have been selectively formed by fermenters' practices in ways that make them more amenable to being governed. From the purest commercial cultures to the most ancient mixed ones, all are the result of micro-governmentalities human fermenters have enacted over generations. I develop this concept further in Chapter 7 in my discussion of different approaches to fermentation and their respective more-than-human politics.

The microbial taste shaping natures in New/er Nordic translated fermentation show the need for this concept of 'micro-governmentality' as a complement to microbiopolitics—humans shaping microbes for its own results, and secondarily for governing other humans. The modes of shaping I have discussed in this section also suggest general features of taste shaping natures: that humans and nonhumans shape each other through technoscience and experiment as culinary practices; that this mutual shaping involves aesthetics, ethics, epistemics and politics that are impossible to disentangle—what we can call 'interest'; and that, as I will discuss in Chapters 7 and 8, this mutual shaping has material consequences for biogeography, ecology, and evolution, and implications for more-than-human politics. Many more modes of taste and nature shaping each other are possible: fruitful areas for further research.

[86] Whether the microbial subject has 'knowing conduct' does not matter here; if it can sense the world, it has a sense of it, which is enough (Ch5).

2.4 CIRCULATING TASTE SHAPING NATURES

New/er Nordic translated fermentation emerged and changed through shifting notions of nature and different multinatures. New/er Nordic fermenters know their microbes through taste, which they enact as a multisensory, multispecies, and productively multivalent phenomenon. These fermenters and their microbes shape each other through experiment, interest, and micro-governmentality, with consequences for microbial biogeography, ecology, and evolution. Through these taste shaping natures, New/er Nordic translated fermentation offers contributions to current debates around domestication, which I take up in Chapter 8.

By weaving together these cross-disciplinary literatures on nature and taste with conceptual resources from multispecies studies and STS, I develop the concept of 'taste shaping natures' into a framework that addresses the thesis' first aim (1.4.1), and that might assist other scholars attending to how taste shapes natures, how natures shape taste, and with what consequences. A range of empirical cases would merit exploration here. For example:

- Indigenous foods, and other foods and culinary practices that have been obscured or suppressed;
- Rare/endangered/invasive foods that are threatened or threaten other species and ecologies;
- Ancient/archeological foods that could shed light on past and present foodways, more-than-human ecologies, migrations, and landshaping practices;
- Taste shaping natures where nonhumans are the main tasters and shapers—livestock grazing, plants rewilding, insects and microbes making compost, etc.;
- Taste shaping natures where humans are the main ones shaped by nonhumans—in bodies, behaviours, ecologies, and evolutions past and present;

- Politics of taste shaping natures—how different people's tastes have consequences for different humans and nonhumans, how taste and natures shape and are shaped by different political agendas and initiatives;
- Taste shaping natures of novel and 'future' foods—how 'taste' and 'nature' are mobilised for these technocratic, ecomodernist purposes, and their consequences for political ecology.

Just as conceptualising taste shaping natures requires bringing together multiple relevant literatures, studying them in action requires multiple methods. In the next chapter I discuss the methods I have needed for investigating the taste shaping natures of New/er Nordic translated fermentation.

3 MULTIPLIED ETHNOGRAPHY

Taste shaping natures bring together taste, nature imaginaries, more-than-human agencies, biological difference, and modes of shaping. In the same way, investigating them holistically requires bringing together multiple senses, species, sites, and methods. For the taste shaping natures of New/er Nordic translated fermentation, I have needed to combine multispecies ethnography, sensory ethnography, sensory science, microbiological experiment, and DNA sequencing. I might have done a more classic ethnography, or pursued the project in another discipline like molecular biology or food science—but none of these options would have enabled me to address the multiple dimensions of taste shaping natures together. Of these methods, ethnography may be the most capacious; I used it as the main one, into which I fit the others. In addition to being multi-method, my ethnography was multi-sited, multisensory, and multispecies—a multitude of 'multi's: what we might for expedience's sake call 'multiplied ethnography'.[87] Each 'multi' itself is

[87] This use of 'multiplied' calls up Mol's multiplicity in which multiple 'versions' (in this case of ethnography) can overlap, and be brought closer together, but do not necessarily coincide (Mol 2002, 2012, 2021). The result is an ethnography that can be thought of as 'more than one but less than many' (Mol 2002). This approach is somewhat more capacious than, say, 'multimodal ethnography', which is mainly concerned with the ethnographic analysis and use of multimedia (Dicks, Soyinka, and Coffey 2006) For the latter, see also the journal 'entanglements: experiments in multimodal ethnography' (https://entanglementsjournal.org/) and

nothing ground-breaking; but the particular constellation of methods I assemble yields a rather novel methodology, addressing the thesis' second aim (1.4.1) and offering one of its main contributions.

Each method I have selected addresses different components of the research question on New/er Nordic translated fermentation, and the subsidiary questions on natures, taste, and modes of shaping. In this chapter I describe and justify these methods and how they fit together. I first briefly justify my choice of the sites I described in Chapter 1, and outline my fieldwork. I then describe my main set of methods, 'multispecies multisensory ethnography', which combines multispecies ethnography, sensory evaluations with individuals and groups, and more classic ethnographic methods such as participant observation, semi-structured interviews, and discourse analysis. Here I introduce 'culinary discourse analysis' as a method for analysing culinary aesthetics as a material discourse. I then discuss two supplementary sets of methods embedded in my ethnography: 'collaborative experiments', microbiological experiments designed and conducted with my participants based on their existing culinary experiments; and DNA sequencing, which I situate as a multispecies-ethnographic method, and discuss its growing use in domestication research. Here I introduce what I call 'DNA agnosticism'—an approach to working with DNA ethnographically without naïve realism or necessary causal priority—and discuss how it relates to larger emerging approaches of doing 'social science with science' rather than 'social science of science'.[88] I then touch on aspects of analysing the ethnographic data, before shifting to reflexive considerations of my standpoint,

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the European Association of Social Anthropologists' 'Multimodal Ethnography Network' (https://www.easaonline.org/networks/multimodal/).

[88] See recent panel at 4S conference 2021: https://convention2.allacademic.com/one/ssss/ssss21/index.php?program_focus=view_session&selected_session_id=1859153&cmd=online_program_direct_link&sub_action=online_program#selected_tag.

positionality, and the project's ethics. I conclude with a review of my methodological contributions, some of the challenges and limitations I encountered, and notes on what changed compared with my initial plans.

3.1 BACKGROUND

Before describing my methods, I first provide some brief background on my choice of sites, and practical details on planning and conducting my fieldwork.

3.1.1 CHOICE OF SITES

I undertook this research among two leading culinary innovators in Copenhagen: Restaurant Noma, and a distillery called Empirical Spirits. Founded in 2017 by two Noma R&D alumni, Lars Williams and Mark Emil Hermansen, Empirical employs similar fermentation techniques as Noma, such as extensive and novel use of kōji, kombuchas and vinegars, to produce 'free-form' spirits and other products. Like Noma, the Empirical team also grows kōji on pearled barley, though in even larger quantities and for a different purpose: as a source of sugar to make alcohol, instead of malt or fruit or other sources, to then distil into their base spirit before adding botanicals, redistilling, and blending the final product.

The Copenhagen culinary world is closely knit, and while my ethnography was based around Noma and Empirical, I found myself meeting with additional participants through their links with and/or referral from these teams. These additional participants included team members at Restaurant Amass, founded by a former Noma head chef and situated near Empirical, and former team members of and visitors to Noma and Nordic Food Lab.

Meeting these participants seemed important to be able to contextualise the data from my main ethnographic sites, and their insights proved valuable in analysis.

Some scholars may wonder why, as one of my Transfer of Status (first year report) assessors put it, 'a luxury restaurant for the 1% should be granted the attention that, say, the SCOBY genealogy of Bulgarian peasants over the twentieth century is not'.[89] It's a valid concern. Such 'traditional' fermentation cultures are of course also worth study; yet these Nordic chef-fermenters are mixing cultures, substrates, and techniques in new ways to a greater extent and at a faster rate than most 'traditional' fermenters often are. This intensity, and the ideologies that give rise to it, make these promising sites for answering a key dimension of my research question: how the pursuit of novel flavours shapes microbial natures, in unintended ways. Furthermore, the global influence of the New/er Nordic generally and Noma's approach to fermentation in particular gives them a consequentiality that few fermentation traditions, Bulgarian or otherwise, could match.

The elite nature and exclusive political economy of my sites, rather than disqualifying their validity for research, are key parts of what specify this approach to translated fermentation and its taste shaping natures. While eliteness and exclusivity will be unpalatable to many critical social scientists on principle, they are not reasons to disqualify research sites—especially if these properties are in part what make the sites so promising for answering a research question.[90]

[89] SCOBY stands for 'Symbiotic Culture of Bacteria and Yeasts', and refers to the pellicle or 'mother' formed by microbial communities in kombuchas, kefirs, and some vinegars.
[90] Here I would also emphasise that proximity to the glamour of fine dining is not part of my motivation for conducting this research. While fine dining's glamour is also the source of much of its impact, and therefore difficult to entangle from what makes these sites so promising for research, it is something I am personally ambivalent about, and prefer to retain at least some distance to. But that is a discussion for elsewhere.

3.1.2 FIELDWORK

In December 2017 I spent ten days in Copenhagen conducting preliminary fieldwork. I met with key participants at Noma (David and Jason) and Empirical (Lars and Mark); we discussed their various fermentation experiments, and together identified those most promising for investigating microbiological change. At Noma I received six samples of miso and two of kōji, and gave these to colleagues at the Danish Natural History Museum (SNM)—Tom Gilbert, then head of the Section for Evolutionary Genomics and the PI who hosted and supported my sequencing work, Sarah Mak, his post-doc, and Jacob Rasmussen, his Master's student—to sequence.[91] These preliminary data would help assess the products' suitability for the main experiments, and possibly be useful later for comparison. With Tom, Sarah, and Jacob, I also discussed experimental design and sequencing plans.

My main fieldwork ran for ten months, from July 2018 to April 2019. The first month I immersed myself in participant observation, following my participants in their daily work rhythms, my time split equally between the two sites. At Noma, I was mostly in the fermentation lab, following David and Jason, the two stagiaires, and others who came by. At Empirical, I spent time with each section in production—kōji growing, brewing, distilling, R&D—getting to know the team and how the sections fit together. These initial experiences also helped in planning and setting up the collaborative experiments—how, where, and when I/we would grow the kōji, how and where it would be stored, etc. I collected data during participant observation using written field notes and photographs. I began the collaborative experiments with kōji and miso in August 2018. The miso

[91] During my time with the group it turned into the Centre for Evolutionary Hologenomics at the GLOBE Institute at University of Copenhagen; at the time of writing Sarah is now Tom's Laboratory Coordinator.

experiment ran for three months, until November 2018. The kōji experiment ran until April 2019. Participant observation continued throughout the fieldwork, developing context for the interviews, experiments, and tastings.

3.2 METHODS: MULTISPECIES MULTISENSORY ETHNOGRAPHY

Multispecies and sensory approaches are complementary to each other. Multispecies ethnography draws attention to different species' *umwelten* and charismas that operate across sensory modalities in different proportions (Kirksey and Helmreich 2010; Locke and Münster 2015; Lorimer 2007; von Uexküll [1934] 2010; Ch2). Sensory ethnography engages these sensory modalities to attune to these different multispecies *umwelten* and charismas (Pink 2010; Sutton 2010; Ch2). I bring these two approaches together into 'multispecies multisensory ethnography'.[92] These methods formed the foundation of the fieldwork.

3.2.1 MULTISPECIES ETHNOGRAPHY

In the previous chapter I introduced multispecies ethnography and discussed some of the possibilities and limitations of investigating nonhumans ethnographically—for example through the relationship between anthropocentrism and anthropomorphism (Candea 2010; Ginn 2013; Langford 2017; Plumwood 2009). In aiming to study nonhumans ethnographically, questions of method inevitably come to the fore. Some multispecies anthropologists and more-than-human geographers have identified the mismatch between these fields' 'more-than-human aspirations' and the 'human-centred methods' still largely used to pursue them (Hodgetts and Lorimer 2015). In response, an increasing number of

[92] Multisensory due to taste's necessarily multisensory nature (Ch2).

scholars in these fields are thinking about how they can 'engage natural science tools while remaining alert to the politics of knowing' (Swanson 2017). I situate my approach to using microbiological experiment and DNA sequencing as methods for multispecies, more-than-human ethnography within this emerging tradition.

3.2.2 Participant observation

Participant observation helped me attend to how humans shape and are shaped by microbes through practices, tacit knowledges, and the senses. At Noma and Empirical, participant observation often shifted into 'observant participation' (Moeran 2009; Thrift 2000), in which maintaining fluid immersion in the pace of group work limited documentation through notes or photos. The embodied knowledge gained, however, more than made up for it. For example, it attuned me to how habits developed through repetitive motions—in furrowing grains for kōji, adjusting moisture in a miso-to-be, or other daily tasks—always contain slight adjustments and improvisations. This knowledge, discoverable through what Roe and Greenhough (2014) call 'experimental partnering', informs my analysis of how culinary experiments work (Ch6), and would have been difficult to gain otherwise.

3.2.3 Semi-structured interviews

Semi-structured interviews suggested how participants think and talk about their fermentation practices, and their relationships with microbes; about their personal and professional backgrounds, motivations to ferment, what they value about food and fermentation, and how these relate to their personal taste preferences and professional taste norms; about their sources of inspiration, and attitudes to innovation and knowledge-sharing; and how they see fermentation relating to larger shifts in Nordic cooking.

I conducted 32 semi-structured in-depth interviews, each averaging 1.5 hours, with 9 participants at Noma, 10 at Empirical, and 13 from around the Copenhagen food industry who had worked at one of these places and/or were involved with fermentation and/or the NNC in some way. At Noma and Empirical, I identified in participant observation those most promising to ask to interview. At each site, about half the participants I interviewed were in more senior positions, and half more junior positions. Senior employees had often been at the company for longer, in some cases (at Empirical) since its founding, so could note how things had developed over time. As company leaders, they provided valuable information on how taste standards were set, in R&D and elsewhere. Junior employees, meanwhile, were often in closest daily contact with the microbes. Their thoughts about this work were also relatively 'unofficial' and not recorded anywhere else, making it particularly valuable ethnographic data. In contrast, senior employees' thoughts were usually already formalised and/or widely published in some form (and the form I often encountered in interview). I noticed this pattern during participant observation, through informal conversations with a range of employees, as the higher I went in the companies' hierarchies (especially at Noma), the more likely participants were to default to the official public story, as 'representatives' of the institution.[93] Each kind of perspective was important for addressing different dimensions of my research questions.

At Empirical, a newer company, most participants I interviewed I had only met since beginning fieldwork. Most participants I interviewed from the wider Copenhagen industry I had prior professional relationships with. At Noma, a large, established company with long-term team members and high stagiaire turnover, it was a mix of both.

[93] We might call this pattern 'hierarchical narrative formalisation'.

I prepared a range of questions about the participant's relationship with fermentation, microbes, and their work. A full list of interview questions can be found in Appendix C. I did not ask all questions in every interview, nor always in the same order; rather, I used them as a guide, to help the conversation develop in the directions that seemed most fruitful. Most participants I interviewed once, though with a few participants I made follow-up interviews. A full list of participants can be found in Appendix D. I include demographic information like self-identified gender and nationality to support eventual claims surrounding gender and internationalism in the analysis. I discuss why I did not anonymise participants in 3.6.3 on Ethics.

3.2.4 Discourse analysis

Throughout my preparatory research and fieldwork, I gathered key documents—cookbooks, publications, articles, interviews, videos, websites, Instagram posts. Analysing these discursively illuminated how fermentation has been constructed in the NNC and beyond; which tastes are valued and which less so; why fermentation is valued specifically; how the NNC has shifted over time; and the role of fermentation in these shifts.

Whereas copious materials, both in print and online, exist for documenting the emergence of the New Nordic, the Newer Nordic's shifts are not as evenly represented across media. Noma's last cookbook, for example, was published in 2014, so more recent shifts in their use of ingredients and presentation of dishes are found mainly online, particularly on Instagram. Here, through the accounts of René (@reneredzepinoma), Noma (@nomacph), and Noma fermentation lab (formerly @nomaferments, now at the time of writing @nomaprojects), one can follow Noma's day-to-day experiments, discoveries, failures and successes, in which these shifts become clear.

For these accounts (and Empirical's, @empiricalcph), I reviewed each post in chronological order, noting images and descriptions that signalled departures from and/or reworkings of the original New Nordic ideology. As I noted posts, I grouped them by theme, for example by their discursive approaches to regionality or representation. These themes became central to my analysis in Chapter 4. Posts of the former theme often featured unworked ingredients with short explanations or justifications for their use, so were fairly straightforward to analyse discursively. Post of the latter, on the other hand, featured dishes, sometimes with little language-based discursive framing content. Yet across these images of dishes, both on Instagram and those in Noma's cookbooks, certain patterns emerged—between the composition of dishes and techniques used, and their alignment with New or Newer Nordic culinary ideologies.

Drawing on visual methodologies (G. Rose 2011), digital food studies (Leer and Krogager 2021), and work in geography and cultural studies attending to how uneven geographies, social distinctions, and visceral (dis)connections to food are reperformed through Instagram (Boy and Uitermark 2017; Bozzi 2020; Walsh and Baker 2020), I developed a method of 'culinary discourse analysis' to analyse these dishes, and photographic representations of them, as artefacts of the material discourse of cooking.[94] Most discourse analyses of food have attended to the language-based discourse that surrounds dishes (eg. Fine 1996: Ch7; Scollon and Scollon 2005; Johnston and Baumann 2007; Frye and Bruner

[94] It is important here to note the difference between analysing dishes as media, and analysing photographs of dishes as media. Both are possible and useful, but proceed differently for different purposes. Here I focus on the former, which particularly in Chapter 4 I use to trace connections between different styles of plating and different culinary ideologies in the New and Newer Nordic. This is not to say I treat these images as wholly 'unmediated', as if technical and stylistic decisions had not been made to present dishes and ingredients in certain ways and not others. In Chapter 4 I also include discussions of what an analysis of the photographic style, rather than just the dishes or ingredients depicted, might be used to reveal (4.2.3; 4.3.2). See also Evans and Lorimer (2019) for an example where both approaches are engaged in analysing a short video on Instagram of Noma 2.0's first batch of peaso.

2012; Mapes 2018). Even works that study cookbooks (eg. Appadurai 1988; Gora 2019; Leer 2019) have rarely analysed actual dishes and their visual representations as forms of material discourse that can be 'read'. Culinary discourse analysis draws more on Roland Barthes (1972), for example, who analysed the iconography of classic French dishes such as Steak-Frîtes and red wine, and reorients such an approach toward the self-conscious innovations of fine dining.

At this culinary level, certainly at Noma, one may assume that every aesthetic parameter—form, colour, texture, placement, dishware, overall composition—has been considered and worked through. These decisions, 'conscious' or not, can thus be read as significant, responding to others, and thus participating in a discourse whose medium is not linguistic but culinary.[95] Such decisions—how to shape the veg, pour the sauce, or place the garnish—may seem superficial: frippery for those with means, arbitrary trends that change for change's sake. Sometimes they might be. But I will aim to show how many of these decisions are also 'articulate' (Latour 2004b). Regardless of their makers' intention, they animate dishes, turning them into works that, like those of the other arts, respond to and rearticulate larger social, political, and cultural concerns. As the next chapter will show, such dishes can thus be analysed for what they reveal about the world they reflect and transform: in Noma's case, shifting nature imaginaries and their more-than-human politics since the new millennium.

3.2.5 Sensory evaluations

A key component of the ethnography focussed on how my participants used all their senses, especially smell and taste, in their work in general, and in coming to know their

[95] For more on the relationship between taste and language, see 5.4.2.

microbes specifically. This focus drew on 'sensory ethnography' (Pink 2010; Roosth 2010) and 'anthropology of the senses' (Sutton 2010) to 'use the body as an instrument of research' (Longhurst, Ho, and Johnston 2008), an approach rooted in feminist epistemologies that challenge the historical primacy of vision in Western cultures (Haraway 1991; G. Rose 1993). My participants' sensory expertise offered a method for multispecies ethnography, opening up possibilities for ethnographic encounters with microbes.

This is more than wishful thinking. Taste, as contact-based chemical sensation and communication, is integral to microbial life, and has been for billions of years (2.2).[96] In recognising taste as a multispecies phenomenon, it then becomes clear that microbes' chemical productions in fermentation signify: they are not mere mechanisms of metabolism, but vital gustatory and olfactory transcripts, taste-able traces of microbes living, working, competing and cooperating with each other, enticing us to help or signaling to us to stay away. These 'chemical signatures' (Paxson and Helmreich 2014) are not *sui generis* but the inherited results of millions of past generations doing something similar, with incremental changes and diversifications along the way—the products of microbial appetites at work.

Tasting and smelling were constant daily activities in my ethnography. Through observant participation I attuned to the tastes and smells of interest to my participants, noting how and when participants tasted similarly and when differently from each other. Noticing these similarities and differences drew my attention to how participants' taste perceptions

[96] Microbes sense their environment chemically (eg. in chemotaxis, response to chemical gradients) and communicate chemically with each other (eg. in quorum sensing, microbial communities shifting behaviour based on cell count; Bren and Eisenbach 2000; Ereshefsky and Pedroso 2015; Kalamara et al. 2018; O'Malley 2014; O'Malley and Dupré 2007).

and preferences were in part formed intersubjectively (Shapin 2012a, 2016; Ch2), informing my theorisation of 'consipience'—how humans and microbes know together through tasting together, within and across species (Ch5). These tasting differences also suggest links with important questions of the social and political scripting of the visceral (2.2)—how social difference shapes taste, whose senses and sensory experiences are drawn upon in the NNC, and why it matters for the construction of 'good' food and 'good' taste. While consequential, these points are not central to my research question, and my data collection did not focus on them. They would however make excellent and important directions for further research on taste shaping natures.

In addition to daily informal sensing practices, I also engaged more formal sensory analysis methods from sensory science to assess the products of the collaborative experiments with miso and kōji. I employed rapid sensory profiling methods designed for use with food practitioners (Frøst, Giacalone, and Rasmussen 2015) for their quick set-up and completion and flexible timing, which worked best in Noma and Empirical's fast-paced and sometimes unpredictable work environments. I conducted a sensory analysis of the misos at Noma with Jason, and an olfactory analysis of the novel kōjis at Empirical with 20 team members. The methods can be found in Appendix G and the results can be found in Appendix H. These sensory evaluations with individuals and groups provided insight into how fermenters taste and prefer their culinary experiments, how they tasted and preferred the results of the collaborative experiments, and how these perceptions and preferences form individually and intersubjectively.

3.3 METHODS: COLLABORATIVE EXPERIMENTS

I became well-acquainted with Noma and Empirical's translated fermentations. These experiments were quintessential taste shaping natures, in theory. But to convincingly demonstrate their possible microbiological consequences, it would not be enough to sample them as they were. I would have to lightly control for some variables to ensure any observed biological differences could be tied to taste-based decisions in their conception and production.

Designing these 'meta-experiments' by gently restructuring my participants' existing experiments would be best done together. Based on my own fermentation experience at Nordic Food Lab and elsewhere (Ch1), I had some ideas about which products might be most promising to study. But I suspected that inviting some key participants, who had deeper knowledge and experience, to join me in this design process would be ideal: it might yield results of use to them as well as more robust results for me.

On my preliminary fieldwork trip, I met with David and Jason at Noma and with Lars at Empirical. I shared my interest in using DNA sequencing tools to investigate the possible microbiological consequences of their taste-driven novel fermentation experiments. I asked them if this idea was interesting to them as well, which it was. They shared examples of unexpected sensory changes in experiments and established recipes for production, that they suspected were the result of some microbiological change, but were never sure. I asked them, with DNA sequencing tools at their disposal, which products they might be most keen to know more about, and what they might like to know.

Kōji formed the core of Empirical's brewing process, and by this point had become a backbone of much of Noma's fermentation programme. It was immediately identified as befitting closer investigation. Lars told me how since his early days around 2010 learning to work with kōji at Noma and Nordic Food Lab, he had tried multiple times to passage the kōji, growing a new batch from previous spore, in hopes that it might eventually change into something adapted to 'being in Scandinavia'; but that every time, after a few generations, something would go awry. David had similar stories. This passaging practice opens up evolutionary continuity in which selection at each generation could be taking place—a necessary condition for hereditary change, and the core of domestication processes. Together we decided that an experiment to see whether the specific gastronomically oriented spaces of Noma and Empirical might lead to changes in kōji populations seemed useful for both our purposes—it might provide useful data for my theoretical interests, as well as information for Lars and David on what was going wrong and how it might be averted.

Another prominent interest was miso. As the first product Lars used his newfound kōji to make at Nordic Food Lab back around 2011, and one of the most established and variegated products in Noma's fermentation repertoire, miso emerged in discussion with David and Jason as promising for investigating how the pursuit of different tastes—in this case, through different proteinous substrates analogous to the traditional soybean—might also result in different microbial ecologies. Here too it was possible to design the experiment to yield information useful for all of us. David and Jason had experimented a bit with nixtamalised misos,[97] but had not explored the technique systematically across many substrates at once. We included nixtamalisation of the proteinous substrates as one

[97] Nixtamalisation is an ancient process developed in Central America to prepare corn. Cooking the corn in an alkaline solution (traditionally with *cal*, also known as slaked lime, or ash) breaks down the corn grains, making them more digestible, nutritious, and flavourful. One of the preliminary samples I took in December 2017 was a nixtamalised yellow pea miso—a more complex example of translated fermentation, mixing techniques from Central America and Japan with Nordic ingredients.

dimension of the collaborative experiment, in hope of producing both useful data for my study and sensory and culinary information useful for the Noma fermentation lab team.

Based on these interests of my key participants, with their consultation and ultimate approval and with feedback from scientist colleagues, I designed two controlled experimental setups to investigate these questions, using kōji and miso as tractable systems for investigating microbiological difference (B. Wolfe et al. 2014; B. Wolfe and Dutton 2015).[98] These collaborative microbiological experiments were essential for structuring participants' culinary experiments into a form that might yield rigorous data on how these taste-driven culinary experiments shape microbial natures.

I call these 'collaborative experiments' to differentiate them both from the culinary experiments my participants already pursued, and from more conventional controlled laboratory experiments that would be divorced from these participants' culinary practices, spaces, and interests. This approach aimed to revise the usual script of research, in which researchers produce knowledge which is then shared with publics after the fact (Kindon, Pain, and Kesby 2007). Instead, it sought to engage a key public to which this research might be interesting and useful, whom it was certainly about, and whom it might come to affect, in designing the research questions and experimental plans (Schubotz 2019). Nonetheless, it still was not, strictly speaking, 'participatory'.

[98] These collaborative experiments yielded performative effects: in addition to studying culinary fermenters' methods of more-than-scientific experimentation (6.3), they also (unintentionally) contributed to the ongoing incorporation of the life sciences into culinary discourse and practice (Ch6).

3.3.1 'Collaborative' rather than 'participatory'

STS scholars have called for science to move beyond a 'downstream' model of public engagement, whereby scientific knowledge is constructed solely by scientists then shared unilaterally with a passive 'public' (Callon, Lascoumes, and Barthe 2009). This model has been shown to be politically problematic (Callon 1999; Wynne 1992, 2006). One alternative is a more 'upstream' approach, in which lay experts and other publics enter into the process of designing and carrying out research with scientific experts. This approach is often called 'participatory' (Chilvers and Kearnes 2020; Kinpaisby 2008), and has already been engaged to explore the emerging public fascination with the microbiome (Lorimer et al. 2019).

My approach shares motivations with and takes cues from this participatory tradition. But I do not think I can call it truly 'participatory'.[99] Participatory approaches to research emerged in part as a response to researchers identifying the conditions of stark political and economic inequality of much research involving human participants and fieldwork. In this model, researchers (often from more wealthy places) arrive to a (often less wealthy) site with a pre-existing idea, go about the research according to pre-established protocols, extract the necessary data, and leave—what is sometimes dubbed 'parachute science' (Stefanoudis et al. 2021).

My context is not so comparable. My participants and I were embedded in overlapping political-economic and geographic circumstances. Though I was effectively playing the 'scientist', offering the possibility to co-produce knowledge of possible interest and usefulness, my participants did not need it, nor would it dramatically affect their

[99] For more on the politics of participatory methodologies, see Bergold and Thomas (2016).

livelihood. Furthermore, my participants and I did not 'have at least the same rights… when it comes to making decisions.' (Bergold and Thomas 2012) Though I was keen to involve my participants as much as possible, ultimately it was my responsibility to shape the research—perhaps a necessary result of the conventional expectations for a PhD.[100] Nonetheless, I endeavoured to conceptualise, design, and carry out the experiments in collaboration with my participants, based on their existing experiences and knowledge, such that both our interests could be fulfilled. I thus call these experiments 'collaborative'.[101]

3.3.2 EXPERIMENT DESIGN

Metagenomic sequencing data of the preliminary Noma miso samples suggested that misos made by the same recipe with the same kōji and salt and varied by substrate do exhibit differences in microbial ecology (Appendix G). Yet these data alone were not sufficient for drawing conclusions, as the misos were not made all at the same time, by the same person, and in triplicate to control for batch variation.

Based on conversations with and ultimate approval by my participants, scientist collaborators and advisors, I arrived at the following design for an experiment to investigate the diversity in microbial ecology of novel misos.[102] This experiment was based at Noma fermentation lab. Building on Noma's existing miso experiments, we created 8 misos, 3 batches of each (2kg each batch), using their standard recipe (2 parts ground pearled barley kōji : 3 parts cooked ground proteinous substrate, +4% total weight in salt).

[100] At least one without Participatory Action Research as a main focus (Klocker 2012).
[101] This use of 'collaborative experiment' is different from Gross' (2009), who briefly uses the phrase to describe experiments in social work carried out in society, as opposed to scientific experiments carried out in controlled laboratories.
[102] For full details, see Appendix G.

We did not backslop with previously made misos, because Noma did not usually do so. Proteinous substrates included: 3 Nordic legumes (yellow peas, Gotland lentils, and fava beans); rye bread; and soybeans (made with rice kōji, as a more traditional control). We used 2 treatments to prepare the 3 legume substrates: boiling and nixtamalisation, each cooked until al dente. We mixed the ingredients thoroughly with gloved hands (fresh gloves for each substrate type), packed them into large sterilised glass jars, covered the surface with one layer of cling film weighed down with ceramic weights, and fermented them for 3 months in the miso room at a constant temperature set at 28˚C and ambient humidity. I recorded metadata on the date, temperature of the miso room, and final pH of the misos. I sampled each miso at the start, middle, and end of the fermentation, and froze these at -80˚C for subsequent DNA sequencing. Jason and I conducted sensory analyses of the finished misos.

For the kōji experiment, based on the same conversations, I arrived at the following design to investigate potential divergence in populations of *Aspergillus oryzae* at three sites—Noma, Empirical, and the laboratory at SNM.[103] I grew kōji from the same bag of pure commercial albino white rice kōji spores (from Bio'c, Japan, used by both Noma and Empirical) in 3 parallel populations at each site for 25 generations, at 1 generation per site per week.[104] Spore from each generation was used to inoculate the next generation within the same population, keeping the populations separate. At Noma and Empirical, I grew the respective kōji populations according to each site's standard production method. In the laboratory I grew the kōji in an incubator, set to 30˚C, on plates of barley-agar medium I

[103] For full details, see Appendix G.

[104] Similar laboratory experimental evolution studies with fungi have exhibited genetic change after 20 to 27 propagation cycles (de Crecy et al. 2009; Jeon et al. 2013; Schoustra et al. 2006, 2007). I originally aimed for 30 generations, but significant change was observed after 25, so I halted the experiment.

had prepared, wrapped around the edge with parafilm tape to keep the moisture in. I passaged from one generation to the next with sterile implements under flow hood. Essentially this was a classic experimental evolution approach (for which there is demonstrable precedent and feasibility), though undertaken across both laboratory and field sites. For each population in each generation at each site, I recorded metadata on date and time, temperature, humidity, and any changes in appearance. Once each population of sporulated kōji was dry, I collected them in plastic Ziploc bags, used them to inoculate the following generations, then stored them in the freezer, temporarily at -20˚C at Noma and Empirical before being moved to the -80˚C laboratory freezer. Samples from generations 1 and 25 were sequenced. I conducted informal sensory evaluations with Noma and Empirical team members throughout, and formal olfactory analyses of the final generation 25 kōjis with 20 team members at Empirical, and with Jason and David at Noma.

3.4 METHODS: DNA SEQUENCING

DNA sequencing enabled analysis of samples from participants' culinary experiments and our collaborative microbiological experiments.[105] These experiments and the DNA-based analysis of their results help answer the third subsidiary research question on biological consequences of humans shaping microbes in translated fermentation.[106] In this section I situate DNA sequencing as a multispecies-ethnographic method, and discuss the growing use of DNA in studying domestication.

[105] For a detailed outline of my sequencing and analysis methods see Appendix G.
[106] The limitations of traditional culturing methods made them not so useful for my purpose here (Ch1). Similarly, microscopy would not help me gain a sense of overall ecological composition and diversity, or potential evolutionary change.

3.4.1 DNA sequencing as multispecies-ethnographic method

DNA is more than DNA. It's frequently invoked metaphorically as a fundamental essence determining one's nature or identity. This is what Redzepi means, for example, when he says the effects of New Nordic nature's dramatic seasonal cycles (Ch4) are 'stamped into [Noma's] DNA' (Redzepi 2014a: 203–4).[107] This common understanding of DNA as a deterministic essence—perhaps, thanks to the 'post-modern synthesis' (Ch1), no longer quite so prevailing in the sciences as it once was—is one reason why social scientists and STS scholars have been so critical of genes, genomes, genomics, and DNA (Barnes and Dupré 2013; B. Hall 2012; Keller 2012, 2014; Keller and Harel 2007; Nelson 2016; Reardon 2001; TallBear 2013; Zuss 2000). So proposing to use DNA sequencing as a method for multispecies ethnography may, I recognise, invite some social scientists' scepticism.

I approach genes and DNA pragmatically, as situated constructions that, regardless of their metaphysical status, can suggest partial but still meaningful things—always subject to revision, always 'in action' (Latour 1987)—about multispecies microbial worlds. This agnostic, pragmatic approach toward using methods typically associated with natural science is comparable with Heather Swanson's adoption of scientific techniques for studying salmon scales and otoliths (ear bones). She develops these tools as multispecies-ethnographic methods for tracing these fish's histories and lifeworlds more deeply and richly, getting to know them as individuated subjects (Swanson 2017).

Swanson is aware of the risks and concerns such a proposal poses, and justifies it thoroughly. She reassures that 'science and its tools are not the only way to learn about

[107] The metaphor extends far beyond food—see eg. Kendrick Lamar's 'DNA.', a wry hip-hop twist on the trope (Lamar 2017; www.youtube.com/watch?v=NLZRYQMLDW4).

salmon and their worlds.' (ibid.: 92) She acknowledges that such an approach may be somewhat risky, but argues that 'amid profound environmental crises, the risks of policing the practices that we are allowed to use to know multispecies worlds are far greater. Indeed, science methods are so useful for querying non-humans that it seems irresponsible to refuse to engage with them.' (ibid.: 93) Related is her recognition that 'all methods are contaminated; imperfect tools are the only ones we have.' (ibid.) She then urges anthropologists to move beyond persistent assumption that animism, for example, enlivens the world while science deadens it, reminding us that 'science can itself be "non-modern"—and can be a part of making other worlds. Animistic science is not an impossible neologism.' (ibid.) She reminds us of the many feminist science studies scholars who, having trailblazed 'critiques [of] scientific epistemologies and practices, including fundamental ideas of scientific objectivity,' are also 'firmly not anti-science; rather, they engage deeply with science and are often scientists themselves. Instead of rejecting science, they simply do it otherwise.' (ibid.: 94) Drawing on this tradition, she reasserts the possibility—and 'imperative' (ibid.)—of using scientific tools 'while keeping critiques of scientific knowledge claims in the frame' (ibid.). Citing Haraway's engagement with the Southwest Native American figure of the trickster (Haraway 1988), Swanson argues for 'a willingness… to move back and forth between worlds, to be oneself multiple' (2017: 93). 'In order to take up the methods that a serious study of non-humans requires,' she argues, 'multispecies anthropology needs to bring back the "both-and" rather than intensify the "either-or".' (ibid.; 7.5)

Swanson frames her example of working with salmon scales and otoliths as 'a stand-in for a whole range of science practices that might be able to help us better engage other species in anthropological work.' (ibid.: 91) Drawing on Swanson's approach, I contend it is possible to use the techniques of DNA sequencing in a similar way, without also adopting the whole apparatus of positivism. I call this approach 'DNA agnosticism'.

Opening up scientific methods to multispecies-ethnographic use still doesn't suggest why DNA sequencing specifically is what I need. Taste-oriented translated fermentation results in different registers of microbiological consequence—not only changes in whose DNA is there, but who is living and dead, who dominates, who competes with whom and who cooperates, who produces which flavours—that might be studied through various methods.[108] I have chosen to use DNA sequencing because of the particular kinds of consequences I am interested in—shifts in ecology and evolution. For this purpose, they are well-suited.[109]

Just as using these methods for multispecies ethnography requires justification to social scientists, it also involves some qualification to natural scientists to whom these methods are typically proper. The purpose of employing DNA sequencing methods in this project is not to produce knowledge at the cutting edge of meta/genomic sciences. Indeed, many of the scientists I sought guidance from in designing the experiments, conducting the labwork, and interpreting the results expressed bemused tolerance, if not outright befuddlement, at the way I framed what I hoped to find. Ecological and/or evolutionary difference is exactly what one would sooner or later expect, they would say; it is the null hypothesis.[110] What is interesting and worthwhile from a molecular biology perspective

[108] In trying to get to know microbes, many microbiologists also readily acknowledge that sequencing alone is not enough (Shank 2018).
[109] Even here, genes are not the only way to investigate this kind of change; questions of hereditary change, in kōji for example, could also be addressed with epigenetics. This is a more advanced project.
[110] And worth noting it is what social science theories of relationality would expect too (eg. Haraway 2016).

would, for example, be figuring out why: the causal relationships between changes in genome, transcriptome, morphology, behaviour, and/or flavour.[111]

For my purpose, I do not need to explain difference; I need simply become attuned to it. This difference comes not from the biological data alone, but how the biological and ethnographic data interact. If these microbes have changed, it does not carry the same meaning, ethnographically, as just any other ecology shifting or lineage evolving. Changes here would be bound up with a specific set of more-than-human relations: taste-driven translated fermentation practices at Noma and Empirical within the New/er Nordic Cuisine. If the microbes have not changed, this is also a significant finding—and suggests that fermenters' practices are involved in maintaining this stability. Either way, the biological data promise to tell us something not only about the microbes themselves, but human relations with them. They are thus multispecies-ethnographic data.[112] The lack of intention to generate microbial difference also positions these experiments, and the use of DNA sequencing to analyse their results, to contribute to broader conversations about inadvertent domestications in the ethnographic present (Ch8).

3.4.2 DNA, domestication, and hereditary change

Domestication is more than taming. It operates not only on individuals, but populations and lineages. Tamed creatures can go 'wild' again; they may in principle leave the domus with little trace that lasts beyond their own life. Domesticated ones may not in the same way—instead they go 'feral' (Tsing & Bubandt 2017), and continue to evolve, shaped by

[111] This is also a fascinating question, but one outside the scope of my PhD to answer.
[112] Using DNA sequencing methods in this way to address questions outside molecular biology is closer to doing recuperated 'natural history', as undertaken by anthropologists Gan, Tsing, and Sullivan (2018) to study anthropogenic landscapes.

their time in the domus and subsequent selection pressures, or they die. This irreversibility is captivating, in both senses; there is something deeper that binds together both parties, something indelible that neither, alone or together, can undo.

While changing genomes and epigenomes are part of domestication, they alone are not enough. Genomes and epigenomes are changing all the time.[113] What matters is when genomes, epigenomes, morphologies, behaviours, tastes, affects, and relations shift together into specific configurations of 'reciprocal capture' (Stengers [1997] 2010: 35–6). Just as a proper theory of domestication must account for these combined, co-constituting 'natural'/'material' and 'social'/'cultural'/'symbolic' dimensions (Ch1), satisfactory study of domestication must engage multiple corresponding methods. This also is why I needed to bring DNA sequencing into my ethnography.

Using DNA sequencing to investigate domestication follows recent shifts in domestication studies. The rise of ancient DNA sequencing has added additional methods to the examination of animal and plant remains, archaeological artefacts, and historical records—the more classic methods in domestication research (Ch1).[114] Yet most subjects of these studies continue to be those charismatic plants and animals of the last 12,000 years already identified as having central roles in agricultural history (Larson and Burger 2013; Larson

[113] Evolutionary biologist colleagues remind me that genetic change does not in itself signify evolutionary adaptation. There are also many sources of genetic change: genetic drift, in which random sampling of a population leads to changes in its genetics (a bottleneck, or founder effect); baseline mutation accumulation; HGT/LGT; symbiogenesis. Many biologists studying domestication will be interested in selections for specific traits (whether through 'unconscious' or 'artificial' selections). But I am interested in broader changes—first simply documenting the variation on which any selection relies. Here, genetic drift—simply by moving a culture from Japan to Copenhagen, for example—is also relevant. If separation of populations was involved in past domestication processes, it should be just as well in the present.

[114] Integration of these methods has posed challenges, but is revolutionising the field (Allaby et al. 2017; Dobney and Larson 2006; Edwards et al. 2007; Flink et al. 2014; Fuller, Allaby, and Stevens 2010; Irving-Pease et al. 2018; Larson et al. 2005, 2007, 2010, 2012, 2014; 2015b; Marshall et al. 2014; Orlando, Gilbert, and Willerslev 2015; Zeder et al. 2006).

and Fuller 2014). Because microbes for the most part do not leave examinable remains, as most animals and some plants do, studying ancient fermentation archaeologically through DNA is still tricky.[115] These tools have nonetheless opened up new horizons in studying microbial domestication histories through genomes from contemporary samples.[116] Because of how quickly microbes change compared to plants and animals, fermentation microbes also provide particularly tractable models for studying domestication processes experientially, experimentally, and ethnographically in the present (Bodinaku et al. 2019; Evans and Lorimer 2021).

3.5 ANALYSIS & WRITING

By the end of my fieldwork, I had gathered a range of materials—books, articles, Instagram posts, field notes, interview transcripts—which I collated and coded using NVivo. I developed three categories of code: 'sites', to differentiate my data by place; 'actors', to differentiate by participant, kind of microbe, and type of fermented product; and 'concepts', the themes I anticipated being important for analysis. I gradually assembled this list of codes by drawing out salient themes that emerged across my Transfer of Status report, research questions, interview questions, key interview responses, ethnographic materials, and reading of the literature. I tested these codes on a subset of the most relevant materials in NVivo, refining the list before proceeding with the full coding.[117] During coding, I created an additional code ('!') for passages that stood out as exceptionally promising for writing.

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[115] Analyses of chemical residues for eg. isotopes is somewhat more feasible (see eg. Grainger 2020).
[116] I detail this literature in Chapter 8, where I discuss insights from thinking domestication microbially.
[117] The list of codes can be found in Appendix E.

Some materials fit well to the codes; others less so. I found myself often aware of how the coding could be done otherwise, different cuts made, things done again slightly differently. This path could quickly lead to anxiety, if not madness, so I forced myself to embrace that small irreducible messiness, that contingency, and accept the fact that the coding would always be a bit shaped by my mood (was I feeling generous or parsimonious), the weather, the time of day, etc. and trust that the big picture that would emerge in the end would likely be pretty similar despite these small differences in the fine grain of coding.

In the process of coding, I noticed how the codes were already helping to contain and shape the analysis, even before I had done any real analysing. If something was interesting but didn't fit to a code, I became better at leaving it out—'interest', in this case, was not enough (cf. Ch7). Though tedious, coding also formed the crucial process of turning the data into mine, rather than just something 'given'—re-terming things, organising, culturing, giving new form to the material.

It was a similar feeling I had while transcribing the interviews. Though it would have saved time to enlist a transcriber, I wanted to do it myself both because I knew the material and so could likely produce more accurate and nuanced results, and also because undertaking the process, though even more tedious than coding, already, I discovered, formed part of the analysis. It was first in transcribing that I began to identify emerging themes, notice particularly alluring passages, and develop the list of codes.

Once I had coded everything, and had a sense of dataset's shape, I grouped codes together based on how they might best answer my research questions. I compiled the most promising passages from these grouped codes, which I then brought into dialogue with the literature, identifying potential theoretical contributions, and gradually organising and reorganising into rough chapter outlines. My analytic approach was thus quite inductive. It took somewhat longer than it might otherwise have to arrive at a thematic, conceptual analysis of the material, rather than one hewing to empirical categories (of miso and kōji, for example). But it also helped the resulting conceptually-focussed analysis remain close to the ethnographic detail.

Each analytic chapter develops a single concept, and lays out some of its interacting dimensions. Nature, Experiment, and Interest are both actors' categories drawn from the empirical material and analytics I draw from the literature and my theoretical framework—they emerged as key concepts that would help me tie the data and the literature together. Consipience is a neologism I developed to draw together my ethnographic data on taste as a knowledge practice with multispecies studies and cross-disciplinary literatures on epistemologies of tasting and smelling.

3.6 REFLEXIONS

Having outlined my methods, I now reflexively consider my relation to the research.

3.6.1 STANDPOINT

My project has a few theoretical and methodological starting points it is worth explicitly acknowledging. I take these not as given, so much as well-established positions in certain fields. They have emerged from my professional work with food, cooking, agriculture and food systems as well as my scholarly reading and thinking.

One is a multispecies/more-than-human acknowledgement—that nonhumans have agency (though not necessarily symmetrically). I am aware that this interest in relations between humans and nonhumans can sometimes push difference among humans, more classic social science questions of politics and inequality, to the background of analysis. These are also not incompatible positions. I have worked to keep this latter strand present throughout the thesis, if not my primary focus, and it could be developed in further work on taste shaping natures.

Another is a sensory acknowledgement—that the senses matter, and that this materiality is indispensable in discussing taste. I am aware I may have a more gastronomic approach than many researchers, even many working on food.[118] I believe it is important what things actually taste like, and I am willing to engage with more elite situations if they can help advance research (3.1.1), rather than being satisfied merely with critiquing them as indicative of and implicated in larger systems of inequality. I recognise this fact might make my analyses, and indeed the entire project, suspect for some. I have endeavoured to qualify this flavour-focussed aspect of the analysis by situating it in its larger social and political context. I do not relinquish it though, as it is integral to my research question.

A third is an acknowledgement of what we might call 'more-than-critical' STS. Following scholars like Latour (eg. 2004b), Despret, Stengers, Haraway, and others, I am committed to critique, and practise it, while also being aware that critique alone is not enough. I understand critique to be a starting point but not an end—we must use it to build new theory, make new connections, nurture new conversations, pose shared questions with, for example, natural scientists, developing new kinds of relationship between social and natural scientists post-Science Wars. On the other hand, new materialist and world-making impulses without critique are also insufficient. Swanson's both–and is also my aim.

[118] By 'gastronomic' I do not mean luxurious, but an acknowledgement that flavour matters, along with a concern with figuring out what 'eating well' means (see theorists in Ch1, especially Donati 2016).

Linked to being 'more-than-critical' is my approach to meeting the often implicit expectation in the critical social sciences that analysis sooner or later come back to the political—who benefits and who does not, how inequality and oppression structure the findings, how could the world be otherwise, etc. etc. I have become further sensitive to these considerations. I also believe there are other kinds of question and analysis that work alongside the political. Though the political question is always valid, it does not explain everything, and analysis neither should nor can be reduced to the political by default. To do so represents a curious kind of un-self-critical, 'off-the-shelf' form of critique, which I decline. This recognition structures the kinds of theory I develop, which is committed to the political as it is to investigating how the political emerges through and alongside aesthetic, ethical, and epistemological concerns, and to the understanding that these dimensions cannot always be reduced to the other.

3.6.2 POSITIONALITY

My position with respect to Noma, Empirical, and the Copenhagen culinary world enabled the research, and shaped it in certain ways. I knew these teams, particularly their founders and leaders, and they knew me; we had previously worked together in gastronomic research in Copenhagen. Our mutual familiarity was, I believe, in large part what made them willing to give me access to their spaces for collaborative experiments and fieldwork.

On the other hand, the fact that I had been away from the city for two years, and was returning as somewhat of an outsider, shaped how and to what extent I was welcomed into each team—neither complete stranger nor full colleague. In Noma's case, not only was I no longer 'part' of the institution (though when I worked at Nordic Food Lab, we were even then not truly 'part' of the restaurant, institutionally or culturally), but I wasn't even any longer working in the restaurant industry. Returning as a researcher compounded this ambiguous status. Some Noma team members, particularly beyond the fermentation lab and those who did not know me from before, seemed unsure of my status, and thus how open they could be; I myself was also sometimes unsure.

The reticence I sensed toward me at Noma was perhaps exacerbated by the fact that I was not there all the time.[119] At the start of my ethnography, when I was there the most, it was only two or three days a week; for the rest of my fieldwork year, I was regularly there Monday to Thursday mornings, before most of the kitchen staff arrived, to run the kōji experiment, as well as some other intermittent sessions. Kitchen cultures like Noma's value being there for the job from start to finish, if not earlier and later. They value work whose required effort is physically apparent and whose output is immediately tangible. The fermentation lab's research-inflected micro-culture was somewhat different, but still part of the dominant culture of the larger restaurant. I was there only some of the time, to do work whose results wouldn't bear fruit for a couple years, and I was acutely aware of it. Even if I had based my research only at Noma, I still wouldn't have been able to be there for the 12-, 14-, 16-hour days the team puts in, and still manage to do all the other necessary parts of the research. The project's multi-sitedness was more valuable and necessary to the ethnography, and to the kōji experiment in particular, than sole commitment would have been.

These reflections are somewhat speculative. The degree of certainty that 'full' reflexivity would require is neither possible nor desirable (Rose 1997: 318–9). I offer them to outline some of the trade-offs and preclusions in my research design. The ambiguous position I

[119] Things were somewhat different at Empirical, perhaps because it wasn't a restaurant, was a newer and smaller company, and didn't have quite the same level of star power and attendant self-protectiveness.

found myself in was somewhat inevitable. I have sought to use it to the project's advantage, offering my findings from the perspective of a 'critical friend'—honouring the familiarity that has given me access and the intimacy this afforded, while retaining the distance necessary for analysis.

3.6.3 ETHICS

Compared with some research projects in the social sciences, mine posed negligible potential harm to participants.[120] While I included anonymisation as an option on the consent form, each participant gave me consent to use their name and other identifying data. Based on this permission, I chose not to anonymise participants, as most would be easily identifiable given the unique positions of the institutions I studied (which themselves wouldn't be easily anonymised for the same reason). I also opted to keep participants named because the minimal risks of participation were outweighed by the ethics of giving credit where credit is due. My participants offered their time, knowledge, palates, labour, interest, logistical support, and keen insights; the least I could do in return, especially if it posed little risk and was by their own consent, was to acknowledge my participants by name, as the sources of these valuable contributions.

[120] The research has been carried out in accordance with the CUREC ethical approval granted by the University of Oxford Medical Sciences Interdivisional Research Ethics Committee, under reference number R57570/RE001. The Participant Information Sheet and Written Consent Form can be found in Appendices A and B. I applied for ethics approval through the Medical Sciences committee because I had hoped also to sample the hands of fermenters, and sequence and analyse the DNA, to see if their hand microbiomes had any relationship with the microbiomes of their products. There was not time to pursue this component here, but it will form part of my further research (Ch8).

3.7 RETROSPECTS

In this final section I review my methodological contributions, outline some challenges and limitations I faced, and discuss what changed between my initial plans and the actual research.[121]

3.7.1 METHODOLOGICAL CONTRIBUTIONS

Developing my methodology formed a significant part of the project. It addresses the thesis' second aim (1.4.1), and offers one of its main contributions. It also offers a few more specific contributions. First is the justification for basing research at elite culinary sites. Second is the combining of multispecies and sensory ethnographies. Third is a way of analysing culinary aesthetics as a material discourse, a method I call 'culinary discourse analysis'. Fourth is the development of 'collaborative experiments' as a form of research co-designed with participants (but not strictly 'participatory'), and their integration into ethnography. Fifth is the similar integration into multispecies ethnography of DNA sequencing, as one of many methods that can help researchers get to know microbes, without reifying DNA and genes—an approach I call 'DNA agnosticism'. Taken together, the methodology provides one model for how to study taste shaping natures holistically, with wider applicability to other cases, such as those proposed at the end of Chapter 2.

3.7.2 CHALLENGES & LIMITATIONS

My main challenge throughout was simply that I was trying to do a lot. Probably more than necessary for a PhD. I knew from the start that the research design was ambitious, that I would have to learn a lot of new skills and rely on the expertise of many other people,

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[121] Alternatives for the experimental sampling and sensory analyses I discuss alongside the results in Appendix H. New questions raised and directions for further work I discuss in Chapter 8.

especially with analysing the DNA sequencing data because I did not have the time to learn the coding skills to do it myself. So it took a lot of coordinating with others, asking favours, patience, reminders, dead ends, reorienting plans etc. Ultimately my goal became not necessarily to become expert in the DNA methods and analyses, but to become literate enough in them to be able to work with them in a multispecies-ethnographic framework, and to build up enough knowledge to be able to work with experts in these fields in the future.

The DNA sequencing posed the most obvious limitations on the project. These included my own limited skills, limited guidance (because it was based on favours), limited time (as it was just one part of my project, rather than doing an actual PhD in molecular biology), limited resources (as I did not have any actual funding to do the sequencing, and relied on Tom's generosity for covering my bench fees, reagents, sequencing costs, and the time of his students and postdocs who helped me through the planning, labwork, and analysis), as well as limitations of my own disposition (I have learned that perhaps I am actually not so best disposed after all to the repetitive tedium of labwork, or the technical demands of bioinformatics; there must be reasons I read humanities). These limitations, beyond the more general ones of what DNA sequencing as a method can and cannot tell us about multispecies microbial worlds (3.4.1), all offer potential improvements for further research.

3.7.3 WHAT CHANGED

Initially I thought the ethnography and DNA sequencing would be equal, complementary aspects of the project. My Transfer of Status assessors recommended that one take precedence as the main methodological framework, in which the second could be embedded. This was a good piece of advice. I made the ethnography the main framework, as it could best accommodate the other methods. As I began analysis and writing it became clear that, because the ultimate purpose of the thesis is to contribute to social-scientific theory and methodology, it also made most sense for the DNA analysis to support the theory-making, rather than writing a chapter or two of DNA results in the style of molecular biology. I will write these scientific papers later with collaborators, but the thesis was not the place for it (and so detailed discussion of the methods and results are in appendices).

I had also hoped to use Nanopore portable sequencing technology, for technical, theoretical, and social reasons.[122] The combination of the depth and accuracy of Illumina with the long-reads, speed, and analytical accessibility of the Nanopore might in principle have yielded particularly robust data to track potentially fine-grained changes in the meta/genomes of these collaborative experiments. Furthermore, comparing two different sequencing technologies with the same samples might have addressed important theoretical questions in STS around how different technologies construct different knowledges (Latour 2000), enacting 'the same' microbes differently. Finally, the Nanopore might also have offered my participants the opportunity to play with sequencing technology, engaging in the process of designing, sampling, and producing knowledge about their own fermentations. The Nanopore ended up not being quite technically ready for these participatory plans at the time of my fieldwork. After trying various ways to make it work I eventually put this dimension on hold. This is why I frame my use of DNA sequencing as a multispecies-ethnographic method specifically, but not yet as an ethnographic method in general. Now, a few years later, the technology has developed

[122] See https://nanoporetech.com/products/minion.

sufficiently to allow this sort of participatory work, which Jamie and I intend to pursue further.[123]

At the start I had (ambitiously) also planned to become proficient in all aspects of the DNA sequencing labwork and bioinformatic analysis. I pursued this goal as far as I could. With guidance, I ended up doing the labwork for the metabarcoding protocol for my miso samples. The shotgun metagenomics protocol for the kōji samples was more complex, and by that point after having completed the metabarcoding samples I had a better sense of how much work and time labwork took. So my lab supervisor suggested that one of his research assistants complete the kōji samples labwork for me, both to free me up to focus on my ethnographic analyses and to give the assistant some experience with the protocol. I had also tried to learn the basics of the coding for the bioinformatic analyses, and quickly realised this would be a whole project in itself. So I was lucky to draw on the expertise of a handful of collaborators, who took on different aspects of the miso and kōji analyses, which I then brought together in the discussion, revised through their feedback. I do not pretend to have become an expert in these methods, especially the bioinformatics, or that the results presented in the thesis are crystalline, of utmost relevance for a molecular biology audience, and conform to their conventions. But, I believe I may have become knowledgeable and proficient enough to be able to participate in these discourses and collaborate with researchers in the field, and that the results I have generated are sufficiently sound to support my theoretical claims—both of which have prepared me to develop this work further in the future. Above all I have gained a deep appreciation for the skill, knowledge, technical and critical capacities it takes to use these DNA methods, let

[123] Another challenge of engaging participants with DNA sequencing data I will have to keep in mind, as Lorimer et al. (2019) encountered, is how to make the eventual data be interpretable and visualisable in terms that non-experts find legible and useful.

alone trying to integrate them with others (Sirén et al. 2019). As for the results, the kōji experiment went quite differently from how I thought and initially hoped it might. The findings took me a while to interpret, but eventually I used them to make what I think is more interesting and nuanced theory than I otherwise might have (Ch7).

The project was not the only thing that changed; I also changed as a researcher. I sense my naïvety may have lessened slightly. For example, when I started out writing I for some reason believed I would be able to write the thesis as a book that many, my participants for example, might read, understand and enjoy—in a sort of in-depth, rigorous, yet journalistic style. I struggled for some time with accepting the nature of the task—that the purpose of the thesis was a) an examination, not really a public work, and b) not merely or mainly to convey the details of my case in an alluring narrative form, but to assemble these observations into more general contributions to theory, to a readership interested principally in conceptual questions rather than the specifics of my case. I have come to see and appreciate theory as a way for scholars with different empirical interests to talk to one another. I have become more aware of and accepted the nature of academic production, its limitations and possibilities.

4 NATURE

When it opened in 2003, Noma was not a 'Nordic' restaurant. Its initial focus was even more restricted, to the foods of the North Atlantic. On a scouting trip to the Faroe Islands, Iceland, and Greenland,[124] René found pristine products with revelatory flavours (Redzepi 2010: 11). Back in Copenhagen, transforming them into a similarly revelatory cuisine proved challenging. Sometimes the products did not arrive in the same state. But there were deeper conceptual problems. Simple substitution was limiting: a crème brûlée with sea buckthorn instead of vanilla might gesture to something Nordic, but its animating idea was still French (Redzepi 2014a: 40). René and his team might have been seeking a new culinary 'vocabulary, an alphabet to build sentences and paragraphs' (ibid.: 37) in dishes and menus, but he saw they were still forming their prose, to extend his metaphor, based on borrowed syntax and grammar.

[124] All former Danish colonies. Iceland is now an independent state; the Faroe Islands and Greenland are part of 'Det Danske Rigsfælleskabet', the 'Danish Commonwealth', in which they are autonomous territories managing their own internal affairs, and represented by Denmark in foreign affairs. It does not seem coincidental that René and Claus' first 'expedition' should visit all of Denmark's former Nordic colonies. Indeed, some critical commentators have endeavoured to show 'how the New Nordic Kitchen not only draws upon but also continues the colonial power relations between Denmark and former Danish colonies.' (Andreassen 2014: 438)

So, in March 2004, a few months after opening, René returned to Greenland's inland ice sheet to shoot musk oxen with his suppliers. 'Between long nights and short days' he 'had all the time in the world to ponder on what was wrong.' (Redzepi 2010: 13)

> …we had to exploit the seasons in a better way, so that you could only get a particular dish here and now. We should explore the extremes of nature, seek out the thousands or more species of edible fungi, the many wild plants, roots and seashore plants. That became the embryo of an idea. The guests dining at Noma should feel a sensation of time and place in their very bones. That was to be the starting point, the core, the first layer…

On his sojourn in the stark, forbidding, epitomised 'wilderness' of Greenland, René glimpsed the outlines of a New Nordic nature. For René, this was a nature of 'extremes', of dizzying diversity, of fundamental wildness, of unique moments of 'time and place' reproduced with perfect fidelity on the plate. It was a nature beyond and before humans, to which they might nonetheless gain immediate access. It is also a nature ripe for analysis.

4.1 SHIFTING NATURES

While all cooking relies on the material-semiotic transformation of nonhumans, the NNC has invoked 'nature', as a combination of imaginaries and materialities, particularly explicitly (2.1). Its 'natures' have also shifted over time, which I trace in this chapter, along with their shifting approaches to fermentation and associated shifts in taste.

Responding to widespread environmental destruction, the New Nordic valorised 'wilder' nature, ostensibly 'untouched' by humans. In response to anxieties about the homogenising forces of globalisation (Hermansen 2012),[125] the New Nordic used this

[125] Some scholars have also argued that 'the "gastronationalism" expressed via Noma and the New Nordic Kitchen should… be understood more as a reaction to the national society (the national home country) becoming more racially and ethnically diverse than as a reaction towards a broader international globalization.' (Andreassen 2014: 443). While it is important, as Andreassen suggests, to acknowledge the

imaginary of a timeless, pristine nature prior to humans to naturalise a regional Nordic identity through a politics of purity (Shotwell 2016). From here I observe some important shifts from the New to what I call the 'Newer' Nordic (1.1.3), and propose some potential reasons for them. As awareness of humanity's planetary entanglements grew, for example through discourses around climate change, notions like 'unspoilt nature' (Redzepi 2010: 13) became increasingly quaint, even ignorant and reckless. Concurrently, the European refugee crisis starting in 2014 and the concomitant rise of right-wing ethno-nationalisms made purity politics and appeals to a naturalised Nordic identity politically uncomfortable for largely left-liberal institutions such as Noma and its cosmopolitan clientele. For a restaurant like Noma, whose pre-eminence is based not only on unrelenting technical innovation but the power to shape discourse, the New Nordic was no longer enough; their style and story had to change. These shifts gave rise to the Newer Nordic, with a nature shaped by and in feedback with people, and a corresponding politics that valorised cosmopolitanism and exchange over purity.[126]

With this chapter, in addition to addressing the thesis' third aim (1.4.1), I offer four conceptual contributions to critical cross-disciplinary scholarship on nature, and illustrate a methodological contribution to food-related fields.

The New Nordic and Newer Nordic each puts forth a particular vision of nature. Each of these mixes different ontologies of nature—'wilder' and wild, pastoral and post-pastoral

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intersectional social shifts that gave rise to and shaped the NNC, in coining 'gastronationalism' DeSoucey frames it as emerging from, rather than in contrast to, forces of globalisation (DeSoucey 2010), so I find it sufficient to do the same.

[126] While at Noma around which the analysis is centred, the New Nordic is now largely in the past, it continues to reverberate in the present; and in other circles, it persists. I thus tend to use the historical present to describe both the New and Newer Nordic as general phenomena (and for the former, where appropriate, the past tense), even as their histories and temporalities are not equivalent, and the latter is sedimented upon the former.

(Chapman 2006; Cronon 1996; Gifford 2012, 2014; Paxson 2012; see 2.1.2)—in different ways for different purposes. While in principle, these various ontologies are incompatible, my analysis of New/er Nordic natures will show how in practice they can be combined, in various proportions. Drawing on Latour's 'multinaturalism' (Latour 2004c), designating 'both the multiple trajectories along which any ecology might evolve and the various ways in which they can be sensed, valued and contested' (Lorimer 2012), I call these mixed ontologies of nature 'multinatures'—a concept that might help other scholars analyse how different nature imaginaries and ontologies are mixed, and with what consequences.

While neither the New nor Newer Nordic mobilises pastoral imaginaries (2.1.2), each employs the postpastoral, in different ways. In this chapter I identify two variants of the postpastoral: a 'timeless' postpastoral in the New Nordic, that imagines the identity of certain cultivated products as 'naturally' and self-evidently Nordic; and a 'historical' postpastoral in the Newer Nordic, that acknowledges shifting natures of cultivation and accepts any product that 'does well' in its climate.

Whereas the New Nordic presents a classic case of a nature that sought to naturalise itself (Castree 2005), the Newer Nordic does something more theoretically distinctive. Instead of 'actively concealing' its agenda, invoking nature to frame its contingent interests as facts, as most invocations of nature might do (Castree 2017), the Newer Nordic acknowledges and even celebrates its nature's constructedness, as a key to its affirmative, cosmopolitan politics. Such natures—what I call 'unnatural natures'—are not described by geographies of nature, and the Newer Nordic offers a novel theoretical contribution here.

Taken together, the New and Newer Nordics' respective multinatures illustrate a key feature of taste shaping natures: that the relation between taste and nature works both ways. The New Nordic, on the one hand, posited a pre-existing nature that could dictate human taste preferences and ethical–aesthetic values: a nature that shapes taste. The Newer Nordic, on the other hand, became aware that when a changing social context changes tastes—what is both gustatorily and socially palatable—it changes nature in turn: a taste that shapes nature.

In addition to these four conceptual contributions—multinatures, the timeless and historical postpastorals, unnatural natures, and taste shaping natures' bilateralism—I also illustrate a methodological one. The shifts described above are traceable with established discursive methods. Some features, however, rarely if ever enter into linguistic discourse. In such cases, I argue, they can still and often only be read in the dishes themselves—for dishes, and their ingredients and techniques, comprise the material discourse of cooking, and are legible as such (3.2.4). I call this method 'culinary discourse analysis', and provide examples throughout the chapter. It might be of use for scholars in any food-related field.

The chapter's first two sections describe New and Newer Nordic multinatures, through 'Time', 'Place', and 'culinary interest', a compound of ethics and aesthetics (theorised further in Chapter 7).[127] The third section discusses how these New/er Nordic multinatures have shaped and been shaped by translated fermentation. The final section reviews the chapter's arguments and contributions, and discusses these shifting natures' tastes in preparation for Chapter 5.

[127] This is not to suggest that time and space are possible to disentangle (Massey 2005), but as Noma's own edict (see the title and organising principle of their second cookbook; Redzepi 2010) it provides a useful heuristic for organising the analysis.

4.2 NEW NORDIC NATURE

As the NNC's figurehead, Noma played a central role in constructing and disseminating New Nordic nature. This section traces the emergence of this nature through Noma's cookbooks, and identifies its key features: a multinature that valorised wilderness and wildness supplemented by the timeless postpastoral; and a culinary interest in 'reproducing' nature.

4.2.1 New Nordic Time: 'wilder' seasonality

New Nordic time is set by wild nature, not by human artefacts like the Gregorian calendar. Wild plants connect chefs and diners to daily and yearly rhythms: 'the new year finally kicked off: the first wild garlic was brought in.'[128] (Redzepi 2014a: 38) This wildness also includes larger forces like the season and climate that govern all life, humans and nonhumans alike:

> Noma's guests should… follow the conditions that govern existence in these regions, with sharp changes in the range of available raw materials from spring to summer, summer to autumn, autumn to winter and winter to spring; from being flooded with light to stumbling about in the dark, from airy abundance to bone-numbing cold. (Redzepi 2010: 13)

The vertiginous contrast between Scandinavian summer's bounty and the inhospitable rest of the year is, in the New Nordic, no longer a source of survival anxiety but a celebrated part of regional identity. Seasons' steep shifts become sublime: a wilder nature Redzepi and team could access in the city even if they were far from landscapes full of grandeur and terror. Similarly, Redzepi valorises the weather's affective agency (McCormack 2018) as

[128] For more on the temporal experience of the year based on ecology, see Kassam et al. (2018).

exceeding human comprehension and control (Redzepi 2014a: 203–4). This seasonality and weather bolstered the New Nordic's wilder imaginary.

This New Nordic sublime impelled Redzepi to cook in a certain way—not just to cook *with* the season, but to let the season cook itself onto the plate:

> The sharp bite from the horseradish, slightly reined in by the cream and rounded by seaweed broth, lifted the pure flavour of the cooked leeks. It was a great reproduction of winter. Deep and intense, a bright transparency in the flavours, and the horseradish sharp and cutting, like this endless frosted season. (ibid.: 29)

For Redzepi, the dish is not a representation of winter, but a direct 'reproduction' (4.2.3)—as if he and his team are mere technicians, facilitating the wilder New Nordic season to reveal itself.

4.2.2 New Nordic Place: wilderness, wildness, and the timeless postpastoral

Noma's interest in wilderness and wildness is not surprising. It and the New Nordic emerged alongside increasing public awareness of environmental degradation and the destructiveness of industrial agriculture (Pollan 2006; Shiva 1991, 2001), fueling their valorisation of wild and wilder natures (Nordic Council 2004; Risvik et al. 2008). The New Nordic also valorised timeless postpastoral natures in a supplementary role—cultivated natures that do not question their products' historicity. Though cultivated postpastoral produce provided most of Noma's material substance, wild products, while less in volume, occupied places of prominence in dishes, maximising their sensory and discursive power.

Noma and the New Nordic have an ambiguous relationship to the wild, based on a conflation of wilderness and wildness. In discourse, they often invoke the former—in the NNC's description of the 'purity' of Nordic nature (Risvik et al. 2008: 7), or in Noma's descriptions of 'the rugged surroundings… of Greenland's magnificent, almost uninhabited landscape' and the 'unique unspoilt nature of the North' (Redzepi 2010: 13).[129] In practice, New Nordic actors work with more relative wildness. 'At dawn during the days in March,' for example, René 'and a team of his cooks set off for the most untamed of the Copenhagen parks, a mere ten or fifteen minutes' cycle ride from the restaurant, where the wildlife is left to flourish as it likes.' (Redzepi 2010: 17) The mood may be pastoral (i.e. effortlessly bountiful nature there for people), but this nature is valued for its wildness—far from, though yearning for, the 'wilderness' imaginary.

This ambiguity of the wild has produced some curious effects. While Copenhagen emerged as the epicentre of the New Nordic movement, Denmark has the least wild land, by any definition, of the Nordic countries. Denmark is the smallest autonomous Nordic state, and its relatively flat landscape has been thoroughly shaped by centuries of human activity: agriculture, landscape engineering, forestry, and other industries. Its physical geography also connects it more closely to population-dense continental Europe than the sparser Scandinavian peninsula. Invoking the wilderness imaginary in Denmark is impossible. The closest to it one can locate in Denmark are spaces of relative wildness, often shaped by 'feral dynamics' where past human uses have shifted or relaxed (Bubandt and Tsing 2018a, 2018b). The former brown coal mine at Søby in central Jutland that Bubandt and Tsing studied might be such a 'wild place' (Bubandt and Tsing 2018a). And they recognise that

[129] Scholars and journalists have noted the racial and ecofascist resonances of this 'purity' discourse (Holm 2011; Andreassen 2014).

its 'mild apocalypse' is an exception, an island in 'the sea of…intensively managed countryside' (ibid.).[130] Noma's discourse is subject to similar limits.

Much of the New Nordic's power in Denmark has been contingent upon linking its own relative wilds with the 'wilderness' imaginaries further north in Norway, Sweden, Iceland and Greenland, where there is more land, more forbidding nature, and fewer people.[131] Noma's New Nordic regionality has thus always required distance (in absolute Cartesian terms).[132] This is not to say that even the most remote, forbidding areas of Norway and Sweden are 'real' wildernesses, wholly untrammeled by human action—and not only because of the Anthropocene. These are the ancestral lands of the Sámi, the indigenous peoples of Scandinavia, who, like many indigenous peoples worldwide, have been dispossessed of their land by the state (Cronon 1983, 1996; Guha 2017; Spence 1999) and who have actively shaped these lands since time immemorial. It is significant that the Sámi have not featured in the NNC discourse or Noma's storytelling, which would have contradicted the New Nordic's invocations of wilderness (1.1.2). It is also hard to imagine the funders of the NNC, supranational politicians on the Nordic Council, being oblivious to the Sámi and their precedence on Nordic lands. A more likely explanation for this

[130] Elsewhere, Tsing and colleagues are even more circumspect: 'Søby may be the closest Denmark offers as a wild place. "Wild" here merely means ungoverned; Søby landscapes have been under less discipline than most of Denmark.' (Gan, Tsing, and Sullivan 2018).
[131] Neuman and Leer (2018) have noted similar national differences in how the NNC is invoked in different Nordic countries. While most of their Danish sources 'referred to a shared Nordic culinary identity', in their Swedish sources the NNC was 'more peripheral' and 'culinary excellence was construed as specifically Swedish'. They 'thus criticise the generally accepted idea that NNC is a post-national food movement, seeing it instead as a means to achieve difference gastronationalist ends for these two Nordic countries.'
[132] In this sense Noma has never been strictly 'locavore'—a food movement prioritising proximity of production. See Kingsolver, Kingsolver, and Hopp (2009), Smith and MacKinnon (2009).

absence is that enlisting Sámi traditions to the New Nordic cause would have been politically and culturally compromising.[133]

Valorising the wild is not just discursive—wild products are also valued materially, for flavours that are difficult or impossible to obtain otherwise, especially within the constraints of the NNC: wild sorrels such as wood sorrel (*Oxalis acetosella*) and sheep sorrel (*Rumex acetosella*) yield a fresh, puckery sourness from oxalic acid; wood ants (*Formica rufa*) bring an electric, volatile acidity from formic acid (for defense) and dozens of aromatic compounds, including citrussy-smelling citral and citronellal (for communication; Morgan 2008); woodruff (*Galium odoratum*) contains high levels of coumarin, offering an alluring smell usually associated with the more exotic tonka bean. These flavours in turn are valued not only because they are diverse and unique (in the region at least), but because they promise the taste of a nature humans have not designed for themselves through selection and cultivation—the taste of a nature that is bountiful and diverse but not ultimately there for people (2.1.2).

Many wild plants thus become both materially and semiotically significant. Some deliver revelations, such as the sea arrowgrass (*Triglochin maritima*) Redzepi tasted on a seemingly barren, windswept beach, rewarding him with the unexpected flavour of coriander, a plant decidedly un-Nordic, at least in the New Nordic's vision. Reminding him of his trips to Mexico, the sea arrowgrass revealed to Redzepi that Denmark too 'could

[133] Andreassen (2014: 448) picks up 'a colonial echo' in Redzepi and Meyer's first cookbook (2006), in which, for example, they describe some local Greenlandic people as 'spectators, trappers and hunters – not [culinary] refiners' (ibid.: 6). Such a description reminds Andreassen how 'central to Europe's colonialism in the nineteenth century was the export of raw materials from the colonized countries to the colonizing countries as well as a view of the colonized subjects as more backward and less civilized than the colonizers.' (2014: 448) While Andreassen attends to Greenland and not Sápmi (the Sámi territory), and some of her claims can read as somewhat tenuous, unevidenced and/or overgeneralised, these questions of colonialism and neo-colonialism indeed suggest important directions for further social, empirical research.

be a "spicy" nation' (J. Zimmerman 2011). This experience, and foraging in general, gave Redzepi not only valuable ingredients to cook with but an ethic for how to cook with them:

> When you get close with the raw materials and touch them while they are still one with nature, taste them at the moment they let go of the soil, you learn to respect them. As a result, there is never any question of altering the raw material to such an extent that, when it reaches its destination on the plate, it no longer has any connection with its origins. (Redzepi 2014a: 66)

Working with the wild demands both a 'land ethic' (Leopold 1949) and a corresponding 'cooking ethic'. Just as harvesting from wild landscapes requires treading lightly (and sometimes, it is imagined, the land having never been tread at all), so cooking with wild products should be done with a light touch, letting the main presence on the plate be New Nordic nature's, rather than the chef's. Just as the wild and especially the wilder imaginary must gloss over human activity, so did New Nordic cooking present dishes that attempted to efface their human makers.

4.2.3 New Nordic Interest: 'reproducing' nature

This 'cooking ethic' gave rise to a specific culinary aesthetic. This ethical-aesthetic compound we can call 'interest' (2.3.3, Ch7). As discussed (4.2.1), the New Nordic's main culinary interest was to 'reproduce' nature.

> Fundamentally, it was about time and place and about reconstructing habitats… If we had one special ingredient, we surrounded it with the foodstuffs it lived among or on, for instance wild boar with corn and berries. It brought real meaning into my world, and at that moment I knew for certain that we would get the upper hand. It was no longer just food on a plate. There was a story contained in it. (Redzepi 2010: 14)

A dish should not just be used to narrate in words the story of its products' ecological origins, as was common in the contemporaneous 'farm-to-table' or 'field-to-fork' movement; it should itself reproduce a scaled-down version of these origins and relations on the plate. Developing such dishes relied on direct experience of the creature-in-question's habitat: field observation as culinary method. Redzepi recounts how, while foraging in the woods, he watched 'a snail slowly wander through the moss. [He] followed as it inched along, unaware that it was selecting its own garnish.' Later, back in the kitchen, he cooked the snail 'very tenderly, glazed a little in a tasty, intense broth, then lovingly encircled by cooked and raw roots, plants, shoots and flowers': a 'small mouthful' reproducing 'a few square metres of a particular Danish forest on that exact day.' (Redzepi 2014a: 68)

This New Nordic culinary interest rested on the conviction that 'you can take a creature out of its habitat, but you can never remove the habitat from a creature.' (ibid.: 51) For Redzepi, this insoluble connection between a creature and its habitat did not mean the ingredient could be treated in any way without consequence; on the contrary, he saw his job as a chef being to preserve and concentrate this connection as much as possible—creating 'little worlds' (123) in dishes for a Weberian 're-enchantment' (Bennett 2001) of the world at large.

> I simply can't see the link to the natural environment of the raw material if it's served up looking like a chessboard [as other fine dining restaurants might do]. We serve the food organically, so it tastes of where it comes from and looks like what it is, as if there's a connecting thread running from the natural product through to the way it's prepared. It also shows that we respect our raw materials. (Redzepi 2010: 16; Figures 8–10)

In contrast to French haute cuisine,[134] which operates on a demarcation between the 'nature' from which the product is obtained and the 'culture' of the kitchen that transmutes it into food, Redzepi sought to articulate a continuous, non-dichotomous relationship

[134] There are exceptions, of course; for example Michel Bras, a chef Redzepi names as a source of inspiration (Redzepi 2014a: 37).

between his kitchen and the multinature that supplied it. Redzepi's reproduction aims not to remove the product's 'aura' (Benjamin [1968] 2007), but to intensify it.

The New Nordic multinature and culinary interest can be discerned not only in linguistic discourse but also in the dishes themselves. Wild and wilder natures (the latter imaginary rendered by materials of the former) feature prominently here, in dishes like 'Crispy reindeer moss and cep powder', which 'co-exist on the plate as they do in nature' (Redzepi 2014a: 29; Figure 8) on a bed of moss; 'Langoustine and sea flavours', a whole langoustine tail arranged with dots of seaweed emulsion and served on a rock (Figure 9); or 'Sweet shrimps, sea urchin, and sea succulents', raw shrimps arranged on a cold plate among stones, beach plants, a sauce of cream split with dill oil, and urchin roe frozen and powdered, giving the appearance of sand (Figure 10, the last component not pictured).

Figure 8—'Crispy reindeer moss and cep powder' (credit: Checked-in to the Clouds).

Figure 9—'Langoustine and sea flavours' (credit: Saveur).

Figure 10—'Sweet shrimps, sea urchin, and sea succulents' (credit: Phaidon).

Such dishes aiming to reproduce wilder natures illustrate some of the complications of 'Time & Place'. The reindeer moss, for example, could come from specific time-places in Finland, Sweden, or Norway; but its power in the dish is that it stands in for all reindeer mosses everywhere in the region, resting on the 'same' idealised forest floor in hundreds of servings a week. To reproduce Time & Place requires removing the product from its actual time and place. Nothing new here—simply commodification (Marx [1867] 2004). The question is less whether a product is commodified, and more to what scale and ends. If in industrial production a product is commodified to be made globally fungible, in New Nordic 'Time & Place' it is made into a 'quasi-commodity', fungible but only regionally, with any other instance of its Nordic brethren.[135]

Postpastoral cultivated natures also feature here, supplementarily. Such reproductions aim to recreate where the ingredient was grown: 'Radishes in a pot' (Figure 11); a 'Vegetable field' of small root tops arranged over root purée and edible soil (Figure 12); a 'Smoked quail egg' served in a nest of hay (Figure 13).

Figure 11—'Radishes in a pot' (Redzepi 2010: 186).

[135] Such 'quasi-commodities' still have global reach, for example through the cookbook or the distance food tourists will travel to eat at the restaurant.

Figure 12—'Vegetable field' (Redzepi 2010: 120).

Figure 13—'Smoked quail egg' (Redzepi 2010: 221).

Often, wild and postpastoral are mixed in the same dish, as in 'Grilled asparagus and tender spruce' (Figure 14; Redzepi 2014b). On a visit to their local asparagus farmer the team noticed pine trees growing at the edge of the asparagus fields—another result of 'look[ing] at an ingredient in its natural context.' (Redzepi 2014a: 62)

Figure 14—'Grilled asparagus and tender spruce' (Redzepi 2014b: 86).

Whenever cultivated products are used, however—asparagus, root vegetables, eggs—the contingent histories by which they have become 'Nordic' are not discussed; they are taken as 'Nordic' categorically, for all time. This is the 'timeless' postpastoral.

Sometimes, these reproductions aimed to be mere 'productions'—presenting the product itself with absolute minimal dressing, often raw, fresh, sometimes alive. This kind of dish often centred around wild products, seasoned with a timeless postpastoral one: for example, a dewy bundle of foraged herbs, with crème fraiche and live ants (Figure 15); or live fjord shrimp, served on ice, with brown butter, to be eaten with the hands (Figure 16).

Figure 15—'Bouquet of greens & black ant dipping' (credit: Noma: My Perfect Storm).

Figure 16—'Fresh fjord shrimp with brown butter' (credit: A life worth eating).

If this style of dish aimed to efface human hands by serving wild products entire and simply, another aimed for the same through garnish. Many of Noma's New Nordic dishes were garnished with various small herbs, often but not always wild, placed on the dish in a particular way: with the top of the leaf down and the stem curling delicately into the air, as if having just dropped there on their own accord (as opposed to having been carefully tweezed into place, as they often in fact were; Figures 17–20). This nature garnished itself, it was implied—not by human technicians; an engineered spontaneity whose engineering was backgrounded.

Figure 17—'Turbot skirts and cheeks, asparagus and verbena' (Redzepi 2010: 78).

Figure 18—'Dessert of carrot and sea buckthorn' (Redzepi 2014b: 54).

Figure 19—'Sweet water pike grilled with summer cabbage' (Redzepi 2014b: 96).

Figure 20—'Dessert of fresh and dried grasses' (Redzepi 2014b:104).

Here at last was Redzepi's own culinary syntax and grammar. He argues that for Scandinavians, it 'reminded them of something lying hidden way back in their memory.'

(Redzepi 2010: 14) For foreigners, 'it was like hearing a new language and being able to understand what was being said.' (ibid.) Cooking as reproducing nature was instrumental to creating this impression of immediate, pre-cultural access to the New Nordic's 'external' nature (Castree 2014b), prior to and untrammeled by humans.[136]

By drawing together 'wilder' seasonality, wilder and wild natures supplemented by timeless postpastoral ones, and a culinary interest in 'reproducing' nature, Redzepi and Noma used New Nordic 'Time & Place' to efface their own agency in naturalising the Nordic region through their cooking.

4.3 NEWER NORDIC NATURE

While some actors perpetuate the New Nordic, most, including Noma, have since reoriented. Whereas the New Nordic valorised wild and wilder natures prior to and untouched by humans, the Newer Nordic valorises historical postpastoral, cultivated natures to celebrate nature's plasticity: as made and potentially remade. This shift has been shaped by the larger political and discursive context. As awareness of humanity's planetary entanglements grew, for example through discourses around climate change, notions like 'untouched nature' became unworkable. Concomitantly, the rise of Right-wing ethno-nationalisms in response to the European refugee crisis from around 2014 made the

[136] This imaginary was constructed not only through the aesthetic tropes of the dishes, but also those of their photographs. Figures 13–14 and 17–20, all from Noma's cookbooks, illustrate this importance of photographic technique and styling. The overhead view gives the impression of total observation, surveying a territory like that of a map; the background of lightly crinkled, unbleached and undyed linens suggests an older, simpler time of high-quality materials made with 'traditional' production methods; the lighting is largely natural, without flash, unidirectional—possibly enhanced or softened with a lightbox, but not significantly altered. All these decisions serve to enhance the imaginary of the New Nordic's 'external', reproduced, 'unmediated' nature. A similarly combined mobilisation of content, styling, and photographic technique is also present in visual constructions of the Newer Nordic nature imaginary; see 4.3.2.

politics of a naturalised regional identity undesirably evident.[137] In response, and for their own creative growth, Noma organised three ‘pop-ups’ from 2015 to 2017 in Japan, Australia, and Mexico, rebranding themselves as cosmopolitan and outward-looking. They then moved to a new custom-built location in Copenhagen in 2018—dubbed ‘Noma 2.0’—offering the chance to articulate a reworked vision of Nordic nature.

Newer Nordic linguistic discourse rarely makes explicit reference to climate change as such (though it occasionally has to immigration and multiculturalism). This absence is not surprising, as addressing such overwhelming, apocalyptic notions might threaten Noma’s main purpose as a purveyor of pleasure. However, I argue that an awareness of and response to these notions are evident in their culinary practices and dishes. This is where culinary discourse analysis becomes particularly useful. While at the time of writing Noma has not published any cookbooks in this more recent period, the Newer Nordic’s shifts can be discerned elsewhere, such as on Instagram and in other online photos. In this section I chart the emergence of the Newer Nordic and its key features: a multinature based on a ‘tamed’ seasonality and the historical postpastoral, supplemented by feral wilds; and a culinary interest in ‘representing’ nature.

4.3.1 NEWER NORDIC TIME: SEASONALITY TAMED

In 2016, when Redzepi announced Noma’s relocation, he also shared how the restaurant would structure the year into three distinct seasons. For each they would develop a new menu according to when they deemed different products to be ‘at the pinnacle of their

[137] The NNC has been recently so invoked by Denmark’s far-right populist party, ‘the Danish People’s Party’, as an acceptable form of ‘food culture constantly developing’—in contrast to allegedly nefarious forms in which ‘the classic Danish dishes are increasingly replaced by foreign ingredients and spices’, such as ‘halal meat’ (Dansk-Folkeparti 2021: 13; author's translation).

quality': seafood from January to May, vegetables from June to September, and 'game and forest' season from October to December (Noma 2016). If the New Nordic saw weather and season as wilder, shaping but not shaped by human activity, implicitly treating the four standard European seasons as self-evident, then the Newer Nordic treats seasonality as mutable—discursively, with seasonal distinctions being a matter of convention, and materially, with the tacit understanding that, with climate change, an appeal to wilder weather no longer works. If seasonality becomes a construction, then it is possible, as Noma 2.0 has done, to reconstruct it otherwise.

Questioning the four-season convention was not new. Many chefs I spoke with understood seasons as many more than four, both sequentially in the year (early summer, midsummer, late summer) and overlapping seasons for specific products (asparagus season, strawberry season, pea season). Japanese cuisine was often cited as having an exceptionally fine-grained sense of seasonality. What was new about Noma's proposition was specifically to reduce the number of seasons. Many participants found it provocative, because of its glaring simplifications and its abstraction away from Time & Place.

Redzepi could not be unaware of these inconsistencies. They could even be deliberate, as this new seasonality offered new constraints to fuel the team's creativity and maintain their vanguard position (Tan 2020). Innovation alone, however, does not explain why this 'tamed' seasonality of Newer Nordic time is so formalised and public. What does explain it is the Newer Nordic's pursuit of an 'unnatural nature': a nature that is not only made, but explicitly displays its madeness as a virtue.

4.3.2 Newer Nordic Place: the historical postpastoral & feral wilds

As Newer Nordic time grew more formal, Newer Nordic place similarly came to celebrate its constructedness. This multinature prioritises the postpastoral, supplemented by the wild—the inverse of the New Nordic. The postpastoral and wild here are different from before. This postpastoral asks how products have come to be cultivated in the region and celebrates anything that will grow: the historical postpastoral. This wild has turned away from valorising 'wilderness', instead focussing on wild plants with anthropogenic, feral histories (Bubandt and Tsing 2018a). This shift in multinature was accompanied by a shifted topology of 'regionality'. While the New Nordic's regionality relied on an 'imagined community' of discrete nation-states made continuous in Cartesian space (B. Anderson 1991), the Newer Nordic's regionality involves a relational geography of product flows and organismal flourishings (Deleuze and Guattari 1987; Hinchliffe et al. 2013; Lorimer 2017; Massey 2005; Whatmore 2002).

These shifts in multinature and regional topology are particularly visible through Redzepi's Instagram, where, over the past few years, many of Noma's developments are first heralded—including their celebration of ingredients previously restricted (Figures 21–25; @reneredzepinoma 2018f, 2018c, 2019b, 2019c, 2019e).

Figure 21—Tomatoes, 15.9.18 (@reneredzepinoma 2018f).

Figure 22—Danish 'Chiles', 19.9.18 (Redzepi is using the Spanish spelling; @reneredzepinoma 2018c).

Figure 23—Citrus, 12.3.19 (@reneredzepinoma 2019b).

Figure 24—Coriander, 6.5.19 (@reneredzepinoma 2019c).

Figure 25—Local 'Chiles', 8.9.19 (@reneredzepinoma 2019e).

Tomatoes, citrus, coriander, chilies—flavours tied to many regions, but not so historically 'Nordic'. In the New Nordic, if they were used, it was judiciously (some drops of lemon juice, a few fresh coriander seeds), and importantly, they were not highlighted. In the Newer Nordic, with the right agricultural knowledge, skills and care, such ingredients are made to belong. Tomatoes, grown with the right varieties and practices (and a warming climate), now belong because they taste 'like tiny pulpy jewels… sweet as cotton candy' (@reneredzepinoma 2018f). Coriander went from being an 'exotic herb' that 'most people didn't like' to one as common as parsley (@reneredzepinoma 2019c). Citrus was always a 'question' they 'struggled with', especially at 'the end of winter in Denmark' when 'many places in Europe still have citrus growing'; now, in the Newer Nordic, what matters is having found the right supplier (@reneredzepinoma 2019b). Forgoing Mediterranean citrus was quintessentially New Nordic; now celebrating citrus suggests continental rather than merely regional solidarity, in a time of rising nationalisms and strain within the EU.

Some of these photographs, particularly those of the citrus and chilies, demonstrate a specific kind of Instagram post: the so-called 'laydown' or 'flat lay', in which objects are carefully arranged and photographed from directly overhead. Noma uses laydowns not only to depict individual ingredients, but especially since 2.0 have styled elaborate laydowns for the advent of each 'season'. These laydowns show not only a dazzling panoply of ingredients, but a diversity in which chilies, tomatoes, and corn are nestled alongside cabbages, pinecones, and dill, each given equal status (Figures 26 & 27).[138]

Figure 26—'Opening day' for 'game & forest season' 2021 (@nomacph 2021).

[138] As with the use of photographic representations to construct New Nordic nature (4.2.3), here too both the content and the styling contribute to the construction of Newer Nordic nature. While Newer Nordic regionality is demonstrated through the inclusion of products like tomatoes and chilies, Newer Nordic seasonality is expressed through the lighting and colour grading. The laydown for 'game & forest season' 2021 features darkened hues and deepened shadows, conjuring up the oblique winter light and shortening days of November and December (Figure 26); the laydown posted when bookings opened for 'vegetable season' 2022 is full of bright light and saturated colour, inviting one into spring and summer (Figure 27). Notable in the latter is the ingredients' arrangement by colour, and decidedly not by geographical origins.

Figure 27—'A cornucopia of color' for 'vegetable season' 2022 (@nomacph 2022).

Of these many 'new' ingredients, chilies may be the most telling and overtly political illustration of the Newer Nordic's historical postpastoral and relational regionality. Justifying their use by his childhood holidays spent with family in Albania and his relationship with Mexico as an adult (@reneredzepinoma 2018c), Redzepi proclaims these globetrotting Mexican fruits 'naturalized citizens' of Denmark (@reneredzepinoma 2019e). They are an exemplary historical-postpastoral ingredient, presenting Newer Nordic regionality as contingent and mutable, rather than transcendental and fixed. Newer Nordic place is aware of history, open to change, and compares human and nonhuman migrations. In the Newer Nordic, to use chilies is political—it states, through culinary discourse, that in determining belonging one's provenance is less important than one's contributions. 'I always say,' Redzepi writes, that 'if it grows well here, it belongs here.'[139]

Redzepi explicitly develops these connections between Newer Nordic regionality and cosmopolitan politics in an anthology of essays published by his non-profit, 'MAD', in 2018, with the thesis that 'Deliciousness is an undeniable benefit of immigration'—a kind of gastronomic polemic against Trumpism and the Right (Ying, Redzepi, and MAD 2018). In his own essay, Redzepi charts how and why Noma moved away from 'purity' (ibid.: 87). In this retrospective telling, the constraints of New Nordic place were only ever an initial engine for self-discovery, always meant to change along with their identity (88).

> Our original idea to use only local products eventually started to collapse under the weight of new questions: When is an ingredient truly local? What makes it belong here? What does it take for an ingredient to be integrated to the point where you think, *Now I can put it on the menu. Now it makes sense*?' (ibid.)

Redzepi's shifting sense of products' belonging was informed by a growing awareness of their historicity. 'If you go far enough back in time,' he reminds us, 'you'll find that almost everything in your everyday pantry actually came from somewhere else.' (ibid.) It is the nature of both things and people, Redzepi proposes, to move around, to make new sense of themselves.

Linking products to people, Redzepi turns the question on himself.

> And recently, if I take into account the time we've spent doing pop-ups in Japan, Mexico, and Australia over the past three years, I've probably only lived in Denmark half the time. It makes me wonder, Am I Scandinavian? Am I local to this place? The way I see things today, if something grows here, it belongs here. If a Mexican farmer gives us a

[139] This 'belonging' as a matter of 'doing well' echoes the respectability politics found in narratives and expectations around immigration and assimilation, for example in valorisations of the 'model immigrant'. I thank Anna Sigrithur for drawing this point out.

> seed and we put it in the ground in Denmark and something delicious emerges, I say, welcome to the family. (90)

Redzepi's equivalence between human and nonhuman belonging changes the rubric of belonging from a Cartesian, timeless regional geography to a relational, historical one configured around networks of connection and exchange, while also serving to justify his international lifestyle. His own background as half-Danish and half-Macedonian, neither immigrant nor mythically 'Nordic', aligns with this relational belonging. What has not changed is the underlying notion that 'nature' is belonging's arbiter. The Mexican seed may sprout, 'something delicious' may emerge, but the human practices of care (Puig de la Bellacasa 2017), the 'arts of attentiveness' (van Dooren, Kirksey, and Münster 2016) that enable that seed's success are glossed over.

Redzepi is ambivalent about whether care, for humans and nonhumans, is part of this nature. Sometimes he suggests that belonging involves 'effort', as in his discussion of Noma's international team, from which he derives a general cosmopolitan edict.

> Multiculturalism is difficult. It will continue to be difficult. Nothing good comes easily. Growing a tolerant, empathetic culture doesn't happen simply by mixing people from other cultures. Everyone must put in the effort to accept and appreciate that you and the person next to you will never be exactly the same. People from countries like Denmark and the United States often demand that immigrants make an effort to assimilate. But it works both ways. As a host, you have to make it a little bit easier for newcomers. (Ying, Redzepi, and MAD 2018: 91–2)

Here, belonging is cultivated. Elsewhere, Redzepi suggests otherwise.

> Our cooks and stagiaires come from all over the world. Many people find it very difficult to figure out how to fit in when they first arrive, but if you can learn how to navigate an environment with people from dozens of countries—if you can understand and sift through all those different opinions and demeanors—you'll do fine anywhere you go. (ibid.: 91)

Here, the ambitious, sometimes cutthroat fine-dining kitchen is a crucible for building self-reliance. Belonging is earned through individual struggle and emerging on top. Only the fittest survive. Why might Redzepi, in the Newer Nordic, be ambivalent about the role of care and involvement (Ch7) in cultivating belonging? Perhaps because it affords the benefits of each: a regionality that can still act as arbiter of belonging, and be shapable when convenient.

This ambivalence features not only in the Newer Nordic's historical postpastoral, but also in its feral wilds. One illustration is 'invasive' Japanese knotweed (Figure 28; @nomaferments 2018).

Figure 28—Wild Japanese knotweed, 4.5.18 (@nomaferments 2018).

This plant is both an 'unwelcome visitor' and a 'wild treasure' (@nomaferments 2018). Its desirable taste, similar to the more familiar Nordic citizen rhubarb, makes it the latter, without relieving it of being the former. This ambivalence reflects larger debates around invasives, around whether some invasives may be overall more boon than threat (Pearce

2015; Thomas 2017) while still enacting 'invasive' as a neutral, apolitical term (Simberloff 2003; cf. Warren 2007). This ambivalence also reveals a crucial but elided condition of Redzepi's 'If it grows here' mantra: '…and if we want it here'. Wild invasives reflect the Newer Nordic's tension between the original New Nordic notion of a timeless native land with a normative ecology, and the more recent vision of a more cosmopolitan nature shaped by relational flows of organisms who belong here if they do well—and, crucially, are also worth eating. With chilies, Redzepi's growing–belonging relation more or less works, because while chilies can't claim geographical provenance in the Nordic region, they also don't significantly disrupt its existing ecologies. The same cannot be said of knotweed, and this is where things get more challenging: how to reconcile an open-border cosmopolitanism where every life is equally worthy with the fact that some non-native species, like knotweed, cause significant ecological harm—especially in places, like feral wilds, already shaped by human disturbance.

Tsing offers helpful terms here for dealing with the Anthropocene's 'monsters' like knotweed (Tsing and Bubandt 2017). When novel species assemblages emerge, particularly after disturbance, the ecology exhibits 'resurgence' if the species get along (Tsing 2017); if one predominates at the others' expense, the ecology exhibits 'proliferation' (Bubandt and Tsing 2018a). It's a normative distinction, in which 'resurgence' is generally preferred. The knotweed introduces some ambiguity. It is clearly an instance of 'proliferation'. It is also culinarily desirable. In terms of political ecology, however, it is not fully 'welcome'—it is a second-class citizen, tolerated for the specific function it serves, but warily, held at bay. The Newer Nordic multinature may embrace historicity and relational geography, but it is still 'after nature' (Strathern 1992; Paxson 2012: 18) in its desire for nature-based norms for human action. It may be cosmopolitan, but it is not 'cosmopolitical' (Stengers [1997] 2010).[140]

4.3.3 Newer Nordic Interest: 'representing' nature

As with the New Nordic, these shifts in the Newer Nordic's multinature and culinary interest are evident not only in linguistic discourse and ingredients used, but also in the dishes themselves.

Noma's Newer Nordic multinature (especially at 2.0) is clearly expressed in their use of trompe l'œil.[141] Culinary trompe l'œil in general is nothing new; El Bulli (Ch1) pursued it avidly (Freedman 2007) and it was a prominent feature of medieval cookery (Freedman 2012). It even featured occasionally in Noma's New Nordic style—in the use of 'edible soil', for example (4.2.3), or in a dish of 'branches', malt crackers shaped to look like gnarled twigs, dusted with spruce and juniper needle powders, and nestled among the seasonal bouquet already placed on the table when the guests sat down (Figure 29). Yet in its Newer Nordic style Noma deploys this device more systematically, and to different effect. When it appeared in the New Nordic, it was for 'reproducing nature'—the edible soil should look utterly like soil, the branches should be so convincingly shaped and disguised among the bouquet that they are not noticed until indicated. In the Newer Nordic, the trompe l'œil is not backgrounded as part of a landscape or hidden within it, but served up front, the technical ingenuity and consummate craft part of the dish's intended impressiveness.

[140] I thank Eben Kirksey for this insight, which I take to describe how the Newer Nordic multinature welcomes a previously excluded mix of nonhumans to the table, but does not let all members of this novel more-than-human assemblage figure out their interrelations on equal, open-ended terms.
[141] A term from visual art (lit. 'deceive the eye'), describing the illusion of three-dimensional depth on a two-dimensional surface; now used in many media to describe making certain materials appear as others.

Figure 29—'Branches' (Redzepi 2014b: 74).

If the New Nordic's interest was in 'reproducing nature' (4.2.3), reworking products to make them appear just as or even more 'natural' than in their original context, the Newer Nordic's interest is in 'representing nature': working certain products to make them appear otherwise. The Newer Nordic interest thus reflects its multinature: a Time & Place, whether of the historical postpastoral or feral wilds, in which traces of human activity are always apparent.

This ‘representation’ takes two approaches, according to the relationship between the dish’s ingredients and form. In one approach, an ingredient is reflected in the form. For example: a ‘Sunflower’, egg yolk cured in squirrel garum, with sunflower seeds & greens, arranged to look like a sunflower (Figure 30; @reneredzepinoma 2018e); ‘Duck feet’, a duck-foot-shaped toffee made with duck fat instead of butter (Figure 31; @reneredzepinoma 2018d); ‘Crab flatbread’, a deep-fried malt flatbread shaped like a crab topped with crab meat (Figure 32; @reneredzepinoma 2019d); and ‘Shrimps’, a shell of rose hip and gooseberry constructed to resemble a shrimp, stuffed with flowers and raw shrimps marinated in seaweed and Arctic thyme (Figure 33; @reneredzepinoma 2019f).

Figure 30—Sunflower, 31.8.18 (@reneredzepinoma 2018e).

Figure 31—Duck feet, 10.10.18 (@reneredzepinoma 2018d).

Figure 32—Crab Flatbread, 11.1.19 (@reneredzepinoma 2019d).

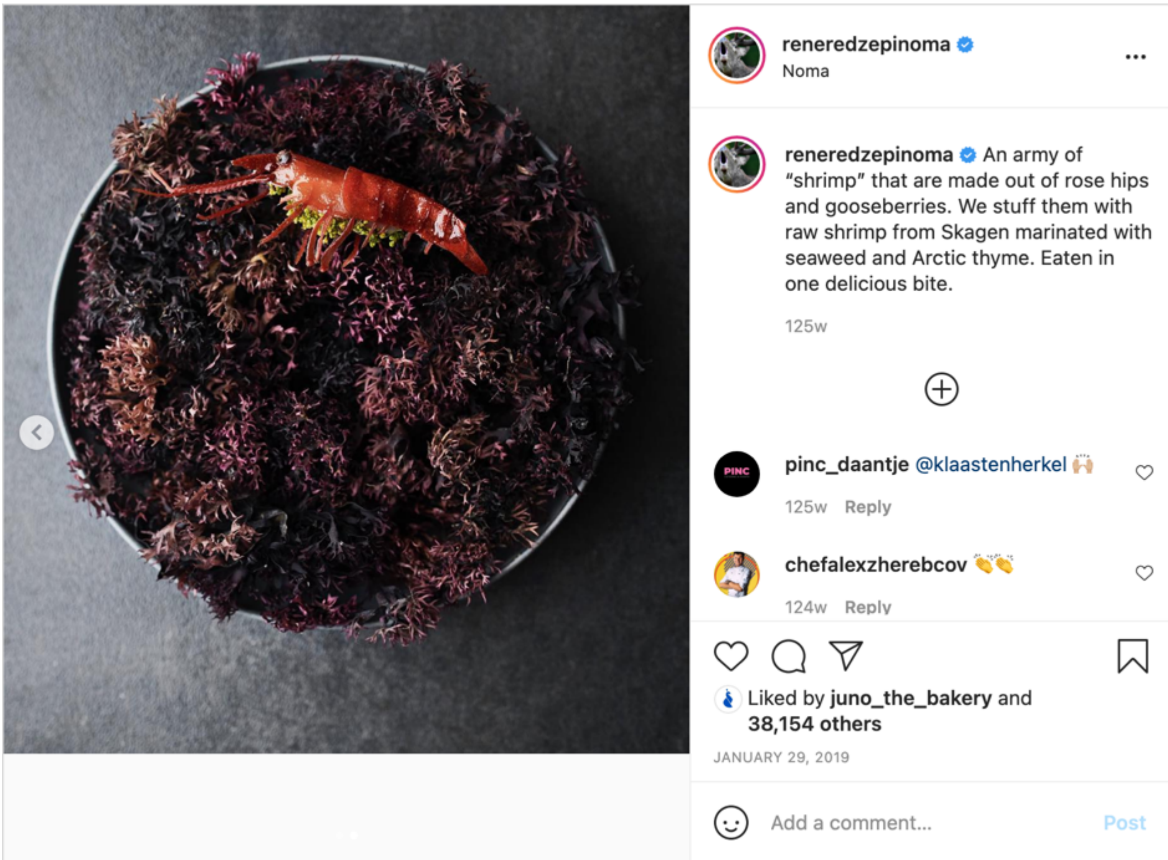

Figure 33—Shrimp, 29.1.19 (@reneredzepinoma 2019f).

These are perhaps not true trompe l'œil, but something more like mimesis—an imitation of the ingredient's original form (Auerbach 2013; Burrow 2019). As with 'reproducing' nature, the product itself is present; but rather than trying to create the impression of immediacy, these 'represented' dishes are highly stylised, and call attention to their craftedness. Compare this shrimp, for example, with the whole, live shrimp served at New Nordic Noma (4.2.3). One aims for the most immediate possible encounter with the product; the other for a highly wrought one that valorises the stylistics of mediation.

A second approach to 'representation' goes further than mimesis, containing none of the product it represents. This, we could say, is true trompe l'œil.[142] For example: 'Beetle', a

[142] In this sense, the edible soils of the New Nordic would also be true trompe l'œil, while the branches would be closer to mimesis, as they contain needles of spruce and juniper. Food journalism has also occasionally

thin beetle-shaped shell of mainly blackberry filled with flowers, presented as an entomological specimen (Figure 34; @reneredzepinoma 2018b); ‘Baby Jellyfish Salad’, squid broth thickened with agar and shaped to resemble jellyfish, with cream, elderflower oil, caviar, and cooked seaweeds (Figure 35; @reneredzepinoma 2018a); ‘Butterfly’, a butterfly-shaped flatbread with flowers and pollen paste (Figure 36; @reneredzepinoma 2019a); or ‘Starfish’, a saffron cardamom caramel formed to resemble a starfish (Figure 37; @reneredzepinoma 2019g).

Figure 34—Beetle, 20.11.18 (@reneredzepinoma 2018b).

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used the former term to describe this style of dish, including at Noma (Canavan 2019), but does not distinguish between it and mimesis.

Figure 35—Baby Jellyfish Salad, 13.12.18 (@reneredzepinoma 2018a).

Figure 36—Butterfly, 9.8.19 (@reneredzepinoma 2019a).

Figure 37—Starfish, 23.2.19 (@reneredzepinoma 2019g).

Some of these, like the Jellyfish and Starfish, ended up as trompe l'œil because the actual ingredient was ultimately unfruitful to work with (real jellyfish was infeasible in the required quantity; real starfish just wasn't delicious). Others, like the Beetle and Butterfly, never began as mimesis at all but went straight for trompe l'œil. The starfish might be the most extreme example of 'representing' nature. While the Jellyfish, Butterfly, and Beetle are all made of products with at least some ecological relation with the organism they 'represent', the starfish has none. Its form and materials are unrelated.

This culinary style of 'representing' nature suggests a complication of non-representational theory (Thrift 2007; Thrift and Dewsbury 2000). While, like all cooking, it is non-representational in that it is embodied, guided by and inviting affect, contextual, ephemeral, and never still (Roe 2006b; Roe and Buser 2016), it is also formally representational, through mimesis or trompe l'œil. These dishes aim to 'represent' nature: presenting formal studies of organisms while celebrating the human craft that realised them. As Redzepi writes for the 'Crab flatbread': 'It is the ingredient, but it's also the craft, it's the technique… and pride in the work we do everyday [sic].' This attitude toward the product is rather different to that in the New Nordic. Whereas before, pristine nature was celebrated and the chef was effaced, here, in the Newer Nordic, nature is affirmatively shaped by human hands—and the dishes tell us so.

A final example illustrates this difference unequivocally. We may recall that New Nordic Redzepi foreswore anything resembling a 'chessboard' for its unnaturalness (4.2.3); in the Newer Nordic, such arbitrary forms of human design, like the squares of seaweed cooked in aronia berry juice in the dish pictured below, signify a new naturalness (Figure 38), whose traces of human agency are not only unavoidable but celebrated.

Figure 38—A dessert of sheep's milk yoghurt, with squares of seaweed cooked in aronia berry, preserved berries and young pinecones, in a juice of white currant and geranium; February 2019 (credit: iwillmakeualist).

4.4 NEW/ER NORDIC FERMENTATION

These shifts from New to Newer Nordic nature are also apparent in their respective approaches to practising and narrating fermentation. These developments in fermentation, from the New Nordic's focus on 'wild' fermentations expressing unique microbial terroir to the Newer Nordic's more 'involved' fermentations expressing universal microbial terroir, have in turn also helped drive these shifts.

4.4.1 New Nordic Fermentation: 'wild' & unique

Fermentation at Noma began by accident. Not to waste a wrong delivery of unripe gooseberries, the test kitchen made a quick experiment by dividing it up and adding different percentages of salt (Redzepi 2014a: 107). Redzepi and team did not recognise the resulting lacto-gooseberries as 'fermented' at first, merely as 'salted' or 'cured' (Redzepi and Zilber 2018: 9). But the success of those gooseberries, from green and tart to round and tropical, sparked a desire to explore fermentation more deliberately (ibid.: 115).

From there, the experiments proliferated at Noma's test kitchen and Nordic Food Lab, through mixing traditions and techniques from around the world with typically 'Nordic' ingredients: 'translated' fermentation (Ch1). In 2014, Lars Williams (then head of Noma's test kitchen) and his flavour chemist colleague Arielle Johnson set up a devoted space at Noma for fermentation R&D and production, dubbed the 'Fermentation Lab': three shipping containers in the lot behind the restaurant, fitted with a small kitchen and workspace and multiple temperature-and-humidity-controlled chambers.

In a handbook for Noma chefs and stagiaires to understand how to make the restaurant's fermented products, Williams and Johnson frame Noma's fermentation programme as

> a logical extension of preservation techniques used extensively in Scandinavia for millennia. Salting, pickling, smoking, drying, and lye curing (a technique akin to nixtamalization), are all ancient techniques for preserving food in this region, and fall into what we loosely term 'fermentation'. The tremendous abundance during the summer needed to be preserved in order to survive the long harsh winters. (Johnson and Williams 2016: 18)

'Salting, pickling, smoking, drying, and lye curing' are not strictly fermentation, as they do not involve the transformation of foodstuffs by microbial action (Ch1, Ch8). Salting may, if done at a low enough concentration; pickling may, if done by lacto-fermentation rather than vinegar brine, a more recent method. Grouping all these techniques and more as 'fermentation' based on what they do—preserve—allowed Johnson and Williams to frame their novel translated experiments in continuity with Nordic tradition. This rationale fits squarely within the New Nordic imaginary: a wilder, inhospitable region with precipitous swings in season made methods like fermentation crucial for survival, and thus a key part of New Nordic identity.

Williams, Johnson and the team developed a range of novel products specific to Noma. Such products couldn't be replicated elsewhere, not only because of Noma's particular palate, team, and network of suppliers, but also because of a hypothesised regionally distinct mix of microbes:

> Now practically every ingredient, whether oil, vinegar, spice, or umami rich paste, is painstakingly produced at the restaurant, which gives us certain flavours that cannot be reproduced elsewhere—beautiful local produce transformed by the microbes around them, a logical extension of time and place as seen through the paradigm of deliciousness. If one were to bring Copenhagen ryebread to New York, and make Rye-so [rye bread miso] there, it would taste different, due to the local microbes. There is a palpable joy in tasting something new, and traveling to savour something which tastes of its place, its landscape. (ibid.: 90)

This is the idea of 'microbial terroir', which had emerged a few years previously. A New York chef named David Chang posited that locally specific microbes were contributing to locally distinct flavours (Felder, Burns, and Chang 2012). This possibility was tantalising for many chefs around the world, influenced by the New Nordic, for whom 'microbial terroir' promised access to the taste of 'wild' nature.

As their interest in fermentation grew, Noma's storytelling shifted from foraging for wildness 'out there' to fermenting wildness 'in here'. These wildnesses are related but not identical. In foraging, 'wild' is contrasted with 'cultivated' or 'domesticated', while in fermentation, it is contrasted with 'inoculated' or 'backslopped'—what we might call more 'involved' techniques (Ch7). 'Wild' fermentations are begun without any deliberate starter culture, though the built environment, utensils, and producer often seed the microbial ecology, as with lacto-fermentations like sauerkraut or kimchi. 'Inoculated' fermentations begin with an existing microbial culture, often a pure culture as with kōji or certain cheeses, while 'backslopped' fermentations begin with some of the previous batch of the finished product, like kombucha or vinegar, or a reserved starter culture like a sourdough.

Many of the earliest fermentations at Noma were 'wild' lacto-fermentations, for example of plums or ceps, or the fabled gooseberries. This was partly because they were quite straightforward: simply add a small amount of salt (often 2%), keep the product in its own brine, and wait, tasting until the desired balance of sourness is reached. But these fermentations also played directly into the New Nordic's wildness imaginary. Lars describes the process of making lacto-fermented plums as 'very like terroir': 'this [microbial community] is what happened to be on the food at the time, so [the] lactic fermentation that happens on plums that were grown in this place in Copenhagen thus will have that flavour'. Most of the variables that shape the flavour of the final product are decided by human fermenters, such as the way the plums are cut, the amount of salt, the temperature, and the length of the fermentation process. That Lars downplays these involvements (Ch7) and emphasises the microbes themselves reflects the New Nordic priority of linking lacto-fermentation to wildness and unique microbial terroir.

This beguiling ecological vision could accommodate foraged produce and wild lacto-ferments, but it had to be reworked as more complex fermentations like kōji and miso were developed. As we have seen, these products involve inoculation, strict hygiene practices, and (at least at Noma and Empirical) digital technologies for the atmospheric control of temperature and humidity—features harder to reconcile with a naturalist aesthetic in which human agency tries to efface itself. Translated kōji and miso began entering Noma's menu around 2012, and their production became more codified around 2014 with the establishment of the fermentation lab. From this perspective, the development of more diverse and involved fermentations not only reflects but can also be seen as having helped drive the shift from the New to the Newer Nordic.

4.4.2 Newer Nordic Fermentation: 'involved' & universal

If New Nordic fermentation mobilised 'microbial terroir' for timeless regional uniqueness, the Newer Nordic reframes it as 'the largely unseen world of mold, yeast, and bacteria responsible for fermentation [that] are omnipresent, transcending countless cultures and culinary traditions.' (Redzepi and Zilber 2018: 11) Though it is still the case that 'the microbes indigenous to any given region will always have their say in the flavor of the final product, in the same way that soil, weather, and geography affect wine,' (ibid.) the focus has shifted to microbes as ubiquitous agents that 'transcend' human-imposed geopolitical and cultural boundaries. The Newer Nordic naturalises microbes as cosmopolitan and 'glocal' (Robertson 1995), greater than regional concerns; 'indigenous' here means something can now be found living in a place, whether or not it originated there.[143] This shift in microbial terroir reflects the general shift from New to Newer Nordic, from naturalised regional purity to naturalised historical cosmopolitanism.

> At the time, people were talking about Noma as the restaurant responsible for defining modern Nordic cuisine. From our perspective, we felt saddled with a tremendous responsibility. How could we claim to be cooking Nordic food if we used techniques from abroad? The notion of microbial terroir helped change everything for us. Fermentation knows no borders. It's as much a part of the cooking tradition in Denmark as it is in Italy or Japan or China. Without fermentation, there is no kimchi, no fluffy sourdough bread, no Parmigiano, no wine or beer or spirits, no pickles, no soy sauce. There is no pickled herring or rye bread. Without fermentation, there is no Noma. (Redzepi and Zilber 2018: 11)

Like Williams and Johnson, Redzepi and Zilber also mobilise fermentation as a universal category. But where the former did so to connect their novel fermentations to a Nordic past, the latter do so to connect theirs to all other fermentation traditions around the globe. In the Newer Nordic, 'microbial terroir' becomes the shared heritage of an undifferentiated, universal 'humanity': an onto-political move that implicitly grants freedom to use any technique regardless of its origins (Ch1, Ch8).

Redzepi and Zilber make an even greater revision to Noma's discourse, retroactively prioritising fermentation over foraging:

> People have always associated our restaurant closely with wild food and foraging, but the truth is that the defining pillar of Noma is fermentation. That's not to say that our food is especially funky or salty or sour or any of the other tastes that people associate with fermentation… Try to picture French cooking without wine, or Japanese cuisine without Shoyu and miso. It's the same for us when we think

[143] This is a significant slippage from the term's usual meaning, and a dilution with great political implications if applied back to humans. There is a lot more to unpack here, but for now it is worth noting how microbes—perhaps because of their smallness, invisibility, rapid mutability, transience, and/or the relative difficulty in resolving their phylogenetic origins—seem to enable this slippage more readily than plants or animals. I thank Anna Sigrithur for noting this important point. It would be harder to call a chili pepper 'indigenous' to the Nordic region, even if it can now be grown there.

> about our own food… Fermentation isn't responsible for one specific taste at Noma—it's responsible for improving everything. (ibid.: 11-13)

While this claim may be true now, it probably was not ten years ago, when Lars and others were only just beginning to experiment with fermentation. Similarly, while fermented flavours have increased on the menu over time, Noma has not stopped foraging. So why place fermentation above foraging? Because it is more amenable to the Newer Nordic agenda of cosmopolitanism, whereas foraging, as seen with the ambivalent status of 'invasive' Japanese knotweed (4.3.2), is more difficult to unambiguously reconcile to the Newer Nordic cause.

If the New Nordic linked fermentation to the historical need to preserve the growing season's bounty (4.4.1), the Newer Nordic frames fermentation as solely for cultivating new flavours (Redzepi and Zilber 2018)—and thus also, like the historical postpastoral, a way to render Nordic regionality under perpetual revision.

4.5 SHIFTING NATURES, SHIFTING TASTES

The New Nordic and Newer Nordic enacted different natures in response to different worlds (Table 3). In the face of environmental destruction, mass monocultures and fear of globalisation's homogenising effects, Noma spearheaded the New Nordic with a multinature emphasising 'wilderness' and wildness, supplemented by the timeless postpastoral, and a culinary interest in 'reproducing' nature—all to naturalise a regional identity based on a politics of purity. As awareness of humanity's planetary entanglements grew, and Right-wing nationalisms rose, invoking this ostensibly politically neutral, ahistorical, 'external' nature to ground a 'pure' Nordic identity became untenable. The Newer Nordic enacted a different, almost inverse multinature: emphasising the historical postpastoral, supplemented by feral wilds, with a culinary interest in 'representing' nature, it naturalised a relational regional identity based on a politics of cosmopolitanism—for products and people. Novel fermentation practices and discourses reflect these shifts, and helped drive them—as translated fermentation's increasing technical complexity, from 'wild' to more 'involved', became harder to accommodate within the New Nordic, alongside a discursive shift from unique to universal microbial terroir. While the innovation imperative of vanguard restaurants like Noma explains that the NNC changed in general (Tan 2020), it is this combination of broader social, political, and cultural shifts, as well as specific culinary and technical ones, that help explain the particular way it did.

	New Nordic	**Newer Nordic**
Time	'wilder' seasonality	seasonality tamed
Place	'wilderness', wildness, & timeless postpastoral	historical postpastoral & feral wilds
Culinary Interest	'reproducing' nature	'representing' nature
Politics	purity	cosmopolitanism
Fermentation	'wild', for preservation	'involved', for flavour
Microbial Terroir	unique	universal

Table 3—Key features of New/er Nordic natures.

In this chapter, in addition to addressing the thesis' third aim (1.4.1), I have offered four conceptual contributions to critical scholarship on nature, and illustrated one methodological contribution to food-related fields. First, 'multinatures' describe how conceptually incompatible ontologies of nature are assembled and enacted together—in this case, the different proportions of 'wilder', wild, and postpastoral imaginaries and materialities. Second, this New/er Nordic history illustrates two versions of Paxson's postpastoral: the 'timeless' postpastoral, a cultivated nature that effaces its historicity; and the 'historical' postpastoral, a cultivated nature that acknowledges it. Third, this historical postpastoral, and the Newer Nordic multinature it informs, are exemplary 'unnatural natures': natures that, rather than aiming to naturalise themselves, celebrate their constructedness—in the Newer Nordic's case as a key to its cosmopolitan politics. Fourth, if the New Nordic mobilised its multinature as a source of timeless taste, and the Newer Nordic framed its multinature as always becoming, shaped by changing tastes, together they illustrate the bilateral, dialectical nature of taste shaping natures: that taste and nature are constantly shaping each other in turn. Fifth, the discussion throughout this chapter has illustrated how dishes and ingredients can be 'read' as objects of cooking's material discourse, through the method of 'culinary discourse analysis'. Taken together, these features of taste shaping natures suggest a contribution to the politics of nature, highlighting the role of taste in shaping the imaginaries, materialities, and cultural politics through which nature is made and negotiated.

I have focussed on how the New and Newer Nordics constructed different natures for different culinary and political ends, and investigated how these taste shaping natures have shaped microbes in translated fermentation (Ch7). But there is much more to this story. Further research might focus on these natures' performative and political consequences, with varying results for different humans and nonhumans. For example: how New/er Nordic multinatures have come to materially shape ecologies, maintaining certain kinds of 'wilderness' imaginaries, wild lands and associated forms of expertise, and creating new forms of 'cultural landscape' (Plumwood 2006); how the New/er Nordic has been mobilised differently in different Nordic countries, with different effects (eg. Neuman and

Leer 2018); and how it has variously included and excluded indigenous Sámi and Inuit communities, shaping their lives, livelihoods, and relations with their lands.

New/er Nordic natures have shifted alongside New/er Nordic tastes; the latter have no lesser role. Many participants—Noma chefs, journalists, and others—suggested that in Noma's New Nordic cooking, the predominant taste was sourness. This was the taste of New Nordic nature: wild plants, unripe fruits, 'wild' lacto-fermentations, a short growing season, a long winter demanding preservation. It was the taste of the 'purity, freshness, simplicity, and ethics' put forward by the NNC manifesto (Ch1). This sourness was a marked contrast to Spanish modernism. As journalist Lisa Abend noted, Spanish cooking, traditional and modernist, relative to the New/er Nordic, is 'sweet!'

As Noma became more interested in fermentation, wild, sour lacto-fermentations gave way to more involved, umami-oriented techniques. This shift from sourness to umami has shaped and been shaped by the shift toward Newer Nordic nature. With its pursuit of umami, Newer Nordic Noma has moved even further away from 'freshness'. Whereas when cooking seafood in Spain, Lisa says, one is often 'trying to keep it fresh and sweet,' Newer Nordic Noma frequently uses fermented umami condiments on seafood, meat, and vegetables alike, yielding a predominant savouriness and 'a thread of similarity' between dishes that is distinctly 'not fresh.'

In the next chapter, I trace how these shifts in taste emerge in specific moments of tasting, between humans and microbes and among human fermenters. These intimate, tasty encounters and the pursuit of novel, diverse flavours lie at the heart of the 'microbiology of desire' that drives translated fermentation—and its biological consequences.

5 CONSIPIENCE

The Noma fermentation lab has some high-tech kit: an ultrasonic homogeniser, rotary evaporator, and 3-litre centrifuge are used almost daily, and an enormous Supercritical Fluid Extractor for high quality aroma extractions takes up a full workbench. Yet there is no microscope—not because the team doesn't know how to use one, or because they can't afford one, but because they don't need one. A combination of sensory observations and basic scientific knowledge of different microbes' required growth conditions is sufficient for the team members to know who is living (or not living) where and when, and whether a fermentation is going well or awry.[144] Across sites, products, scales of production and degrees of professionalisation, the fermenters I came to know at Noma, Empirical, and around Copenhagen all exhibited a similar epistemology, relying on all of their senses, and especially smell and taste, for success. Fermenters showed me how increasing acidity in lacto-fermenting vegetables and fruits signalled the growth of desirable lactic acid bacteria, while alcohol and bready smells signalled that yeasts were taking over, a consequence of too much sugar and/or too little salt. They showed me how increasing volatile (smellable)

[144] Identifying by family or paraphyletic groupings of taxa, such as 'lactic acid bacteria', 'acetic acid bacteria', or 'salt-tolerant yeasts' is often sufficient here, rather than having to resolve taxa to genus or species (with filamentous fungi like *Aspergillus oryzae* it is a different story).

acidity was a sure sign that acetic acid bacteria were successfully dominating a vinegar-to-be, and the visual, haptic, olfactory and gustatory warning signs—surface moulds, ropiness, nail polish remover smell or decreasing acidity, for example—that a batch might be veering off track. And they showed and told me in detail how they knew the microbes in kōji and miso.

For many of these fermenters, this epistemology is not something they developed specifically for fermentation—it is general to their profession as chefs. Paying close attention to products is crucial for whether to accept a delivery from a supplier, whether to retain or dispose of individual ingredients while sorting, breaking down, and preparing them for service, and how to adjust their preparation to achieve consistent results, or draw out their particularities (6.4.2), as the context requires. While the Noma team draws on different kinds of knowledge for their work, 'in the end,' Jason explained to me, 'we do everything by taste… One of the biggest things I've been reinforced with at Noma is using your chef's palate. Like if something tastes good it tastes good, if something tastes like shit, it tastes like shit.' This notion of the 'chef's palate' recurred throughout my ethnographic observations in the fermentation lab and in interviews: one's intuition for the delicious shaped by one's training and calibrated to the 'house style' of one's current institution (Tan 2020; 7.2.2).

Throughout these diverse fermentation practices, human fermenters were not the only ones smelling and tasting—their microbial partners were also sensing their environment through chemical and physical signatures, and responding accordingly (2.2). Kōji sensed the starches in steamed barley to degrade into sugars, whether the grains had the right amount of moisture from soaking, and the right water activity and gelatinisation from appropriate cooking. They sensed how much the grains had been pearled, whether the starchy endosperm was easily accessible or, if there was still significant bran on the surface, whether they needed to produce extra enzymes to break this down to help their hyphae gain access. And they sensed how different areas of their mycelial network were faring in their respective metabolisms. Similarly, the bacteria and yeasts in miso sensed how much moisture and sugars were present to facilitate their growth, and how much salt was there to inhibit it. As some began to grow more than others, they sensed the production of acids, alcohols, and other compounds to inhibit the growth of susceptible taxa, and of further chemical signals to coordinate behaviours within and across species.

The humans and microbes of these translated fermentations sense each other's presence and activities through smell and taste. They produce knowledge together, within and across species, by tasting together. They are what I call *consipient*.

5.1 WHAT IS CONSIPIENCE AND WHY DOES IT MATTER?

I am far from the first to note the dual meaning of the Latin verb *sapere*: 'to know' and 'to taste' (Perseus Digital Library, n.d.). Beyond philological charm, I wish to explore the analytical potential of taking this semantic connection seriously. What happens when we consider processes of knowing and processes of tasting as inextricable, as even sometimes one and the same?

One thing that happens is that the necessity of a concept like consipience begins to become apparent.[145] My purpose in developing this notion of consipience, in addition to addressing

[145] While 'consapience' might have been more overtly faithful, a vowel shift is not new to this etymology. The Greek cognates of 'sapio', σαφής (saphís) and σοφός (sophós), already exhibited some vowel variation (see

the thesis' fourth aim (1.4.1), is to offer a tool to ethnographers who seek to make sense of the chemical senses, and how these senses shape knowledge production within and across species. Consipience thus responds to recent interest among ethnographers in 'chemo-ethnography', an approach that senses chemicals as 'increasingly useful linking figures' to 'follow complex, multisited, and multiscalar phenomena' (Shapiro and Kirksey 2017: 481; see also Landecker 2015). Consipience promises to contribute to some of the areas less covered by the authors' survey of a range of 'chemosocialities'. Most of the chemical situations discussed—chemotherapy, environmental pollution, chemical warfare—involve some element of danger or destruction; while these studies are urgent and necessary, the ubiquity and diversity of chemosocialities is also found in more benign, quotidian, and flourishing encounters. While there is recognition that 'chemosocial communities can form around shared pleasure, rather than shared suffering' (Shapiro and Kirksey 2017: 484), the examples offered are limited to the pleasures of drugs (hallucinogens) and sex (PrEP), and do not extend to those even more fundamental ones of food and drink. Finally, the authors focus on molecules that require technological apparatus to sense, whether through DIY sensors or high-tech spectrometers. But many kinds of chemical encounters accessible to and important for ethnography do not require such technological mediation. The authors' concern that 'the epistemological affordances of sensors risk reinforcing the dominance of science in society and promoting the modernist dream of the imminent calculability and knowability of the material world' (ibid.: 488) may apply quite

Perseus entry above). So, I hope the classicists will not mind my taking a small and not unprecedented orthographic liberty here for the sake of both sense and sound. 'Consipience' also makes a fine echo with 'consilience', the scientific principle whereby a theory is strengthened when supported by multiple converging modes of evidence (see Whewell (1840) for the original coinage, and Wilson (1999) for a recent, if overreaching, expansion). This echo gestures toward the commensuration work, however partial, involved in becoming consipient, within and across species.

differently to how fermenters sense microbes through smell and taste—an approach inflected but not dominated by scientism (6.3).

Elsewhere, recent ethnographic work has begun to attend to how taste works in practice, such as Sarah Besky's ethnography of the role of taste in shaping the global tea industry (Besky 2020). However, the tasting agents here are only humans. The tea itself could be said to have agency in shaping human tastes, even a kind of 'liveliness' (Bennett 2010), but when tasted the leaves are no longer strictly living. There is certainly a robust taste shaping nature at work here, and definite consipience among humans; but consipience that shapes multispecies relationships between living, interacting, mutually tasting bodies is absent.

Drawing on the characterisation of taste developed in Chapter 2, consipience is positioned to make a few contributions to the literature. First, it does not rely on Cartesian notions of interiority, intentionality, or autonomy as preconditions for experiencing or knowing. In this sense, it is sensible to talk about microbes or any nonhumans 'knowing'—as long as they sense the world, they also have a sense of it.[146] Second, consipience is thoroughly immanent: a consipient subject is never separate from the world they are sensing, but always also a consipient object. In other words, if one can smell and taste, one can also in principle be smelled and tasted. The etymology of *sapere* is again helpful here: it has no passive form, because the active form can mean both 'to taste' and 'to taste of', depending on the context.[147] Third, consipience brings together two prominent bodies of work in and around science studies previously unconnected but with complementary potential: how

[146] This aspect of consipience draws on extensive work in ethology, philosophy, and more recently multispecies studies. See Deleuze and Guattari (1987); van Dooren, Kirksey, and Münster (2016); von Uexküll (2010).
[147] Perseus Digital Library. In many cases the same is already true in English, as occurs throughout this chapter. Relatedly, in certain cases *sapere* is also used to mean 'to smell', which further supports the inclusion of both smelling and tasting in consipience.

human subjects come to make shared, 'intersubjective' understandings of the world (Shapin 2012a, 2016), and how human and nonhuman individuals 'become-with' each other by 'learning to be affected' by each other, becoming 'attuned' to each other's differential 'articulations', 'cultivating arts of attentiveness' and 'arts of noticing' (Bubandt and Tsing 2018b; Despret 2004; Haraway 2008; Latour 2004b; Tsing 2015; van Dooren, Kirksey, and Münster 2016). Linking these two bodies of work extends intersubjectivity to nonhumans, while offering a framework to make sense of how subjects become-with each other both across species and among members of the same species simultaneously.

In this chapter I illustrate consipience as the co-production of knowledge through taste, within and across species, with ethnographic examples in New/er Nordic translated fermentation. The first two sections investigate the fleshy, embodied experience of becoming consipient. 'Interspecies consipience' considers how individual humans and microbes become consipient across species, while 'Intraspecies consipience' situates these dyadic interspecies dynamics socially, probing how groups of human fermenters work to achieve intersubjectivity in sensing their microbial partners. Building on these two complementary sections, the third, 'Epistemology of consipience', draws out general epistemic considerations of fermenters' intra- and inter-specific consipient methods. Finally, the conclusion considers the broader applicability of consipience to other domains in which more-than-human subjects come to know each other through smell and taste.

5.2 INTERSPECIES CONSIPIENCE

The fermenters I came to know had developed a range of related methods for becoming consipient with their microbial partners. Here I describe three prominent ones: how fermenters subjectify their microbes, how they learn to both be affected by and affect them, and how they navigate the spatial differentiation necessary for microbial care.

5.2.1 SUBJECTIFICATION

Fermenters frequently form relationships with their microbial partners, knowing them more individually than as taxa or consortia.[148] Many fermenters know their sourdough starter or kombucha mother by its own sensory properties and metabolic behaviours. Lars at Empirical, for example, showed me the distillery's 'super robust and happy'[149] kombucha mothers that he knows by their exceptional productivity (Figure 39), fermenting batches of 25 litres in 'four days' instead of 'two weeks', as appeared common for many of his peers.

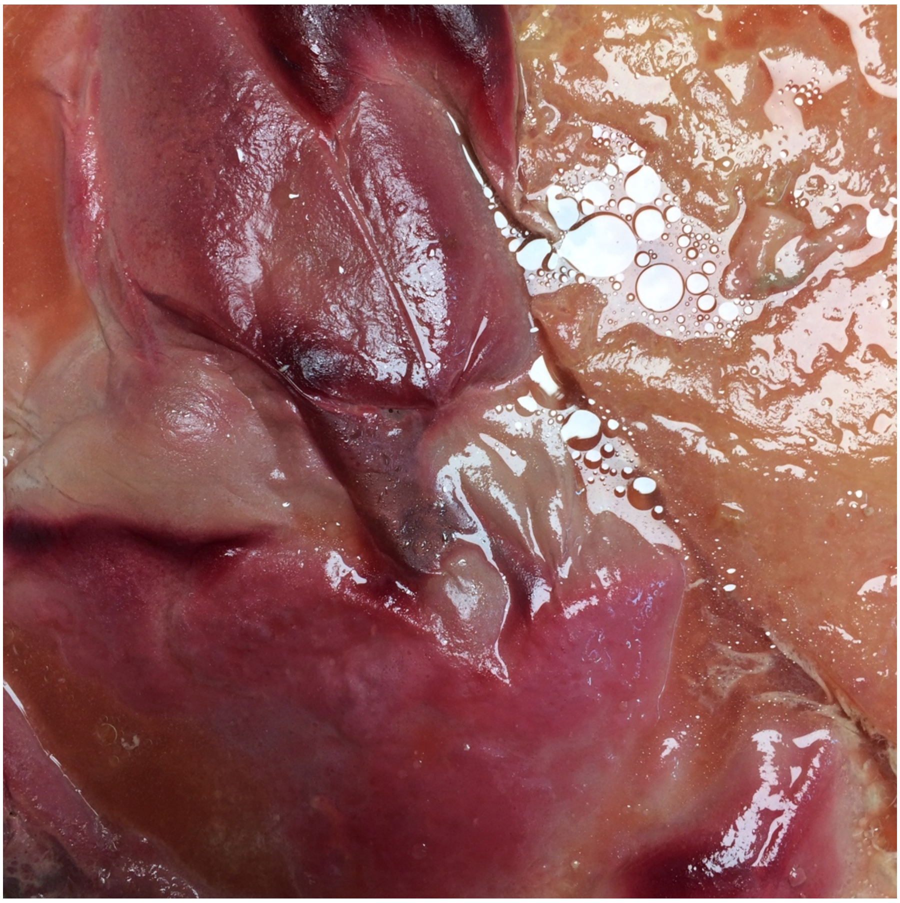

Figure 39—One of Lars' robust kombucha mothers.

[148] See Dunn (2018: 243–53) for another such example with sourdough starters.
[149] This is not to say that metabolic speed and microbial 'happiness' are always correlated. I thank Erika Szymanski for this point. For more on nonhuman 'happiness', see Miele (2011).

Similarly, with kōji,

> it's one of the microbes that has the most variation in terms of how it changes given the environment you put it in... whether pushing it towards creating more amylase or creating more protease [by increasing or decreasing temperature], it actually looks and smells very different. In the case of something like awamori[150] the taste becomes wildly different because you have to let the temperature fall off to then create the citric acid—which I still believe is malic acid, [because] it tastes much more like green apple than it does like citric acid to me.

Specific growth conditions induce microbes to smell and taste differently, his sensory knowledge of which Lars comes to trust more than official textbook knowledge because of the intimate consipience he has with the microbes in question (as well as many years of attuning himself to the different taste articulations of different acids).

These different sensory relationships also afford different affective relationships. For Lars, different microbes—both different taxa, and different individual cultures—'definitely seem to have their own personalities and quirks' in addition to different 'amounts of care and certain things you need to look after.' 'Not to anthropomorphise them, but to anthropomorphise them,' he says, with a laugh—acknowledging that, for an 'empirical', scientistic company like his, attributing personality to microbes might sound questionable, but ignoring their specific characters as producers of gastronomic value would be even more egregious. Nordic fermenters like Lars know their microbes through their sense-able traces, not as fungible chemical factories but as vital, social beings with needs, desires, and differentiated lives: in short, as subjects.[151]

Lars' wry, knowing anthropomorphism recalls Donati's 'strategic anthropomorphism' Donati (2016: 296)—the deliberate extension to nonhuman subjects of certain features

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[150] A black kōji, originating in Okinawa, used in the production of an eponymous alcoholic beverage.
[151] For more on the formation of microbes as subjects amenable to governance, see 7.3.2.

once or sometimes assumed to be the exclusive purview of humans, as a performative ethical intervention and corrective to speciesism (2.3.1). As Donati writes,

> Making space for nonhuman desire risks critiques of anthropomorphism, [but] to anthropomorphise, just a little, might perhaps cultivate a greater sensitivity to subjectivities beyond the human… This is not to assume likeness between human and nonhuman pleasure [or sensation, or emotion, or cognition] but to create the space for acknowledging that perception, affect and agency are not the exclusive realm of humans. (ibid.: 93)

Lars' approach is comparable, and particularly effective because it remains agnostic about the question of interiority. What matters for subjecthood is not necessarily whether one thinks or feels (though, contra behaviourism, one also may), but whether one acts and reacts, is affected and affects, in a distinctive way.

5.2.2 LEARNING TO BE AFFECTED, LEARNING TO AFFECT

Learning to sense these actions and reactions is an important part of being able to recognise microbial subjects, and subsequently become consipient with them. Vinciane Despret's notion of 'learning to be affected' is useful here (Despret 2004; see also Despret 2013). For most fermenters I came to know, learning to be affected by microbes through the traces they leave was never 'merely' sensory—it was always also affective. This is especially true with particularly charismatic microbes such as kōji. The better attuned one becomes to kōji's needs and desires, the better the resulting kōji. Yu Ting Lin, then a stagiaire in the fermentation lab, described how she learned to care for kōji by 'becoming even more delicate and sensitive' about whether a certain action—how she inoculates the grains with spore, how she furrows the grains to redistribute the growing fungus and dissipate heat—makes the kōji more or less 'happy'. 'The smell is very important' for determining how 'happy' the kōji is. 'When I smell it, I touch it, I know ah, this time they will be good. Or ah this time, ugh, maybe something wrong.' Touch is also a crucial sense, establishing not only kōji's happiness but its subjecthood: if 'the temperature's not right, and they are not heating themselves,' it's like a 'person' with 'no energy inside'.[152]

Yu Ting's practice also illustrates the converse of Despret's rubric: in fermentation, learning to be affected simultaneously means learning to affect. Working to increase kōji's 'happiness' means becoming ever more intimately involved in guiding its growth (Ch7). Kōji's metabolic power means that, if inoculated into a glut of fresh substrate and left to its own devices, it will easily overheat and kill itself (Prologue). As Yu Ting learned, involving oneself to slow and modulate the fungus' growth made both it and her 'happier' in the end (Figure 40).[153] Neither became so 'happy' alone. The results of Yu Ting's skill in reciprocally sensing and shaping kōji's affective states—learning to be affected and to affect—meant that by the end of her *stage* she was always put in charge of making the kōji: 'I furrowed them, I made them, I checked them, I saw them every day.' Yu Ting's relationship with kōji had developed into a rich affective economy of consipience—an exchange of affect ('happy', 'love') through sensory signs (smells, temperatures, textures):

> I love the flavour, I love the smell, I love the touch, I love to furrow them properly, I know they will be good, and after 48 hours when I pull them out, it's beautiful, whole piece koji—a whole huge cake… In the end I was quite happy that I made nice kōji.

[152] Touch recurred alongside smell and taste throughout my ethnography, and, as it is part of taste's multivalence (2.2), it is also worth mentioning in discussing consipience. David and Jason knew the right consistency and moisture content for miso by squeezing the paste, and for vegetable 'bushi' by pressing with their finger. Jonas Astrup Pedersen, a baker and food developer, cited the German term 'Fingerspitzgefühl' (lit. 'fingertip feeling') to describe the insuperability of touch in baking bread, and the connections between knowledge, skill, pleasure and desire in becoming an attentive baker—what he termed 'dough lust' (playing on the Danish *lyst*, which means 'pleasure' or 'desire', and occasionally also connotes its English cognate, 'lust'). The lusty exchange of signals for many of these fermenters had a distinct quality of Deleuzian desire, a force thrumming through and tying together all things (Deleuze and Guattari [1980] 1987; Gao 2013).
[153] An illustrative instance of interest and micro-governmentality (Ch7).

The more consipient Yu Ting and her kōji became, the more difficult it became to distinguish, as Despret writes, 'what is cause and what is effect, what affects and what is affected.' (Despret 2004: 125) Their 'happinesses' had become inextricably entwined.

Figure 40—Relatively 'happy' kōji in the Noma fermentation lab (not Yu Ting's).

Consipience does not always involve this high level of affective attunement. But the level of consipient affect, high or low, always shapes the results. Jia Hao, the other stagiaire in the fermentation lab for the same period as Yu Ting, noticed that the latter's 'much more hardworking, organised, precise way' of making kōji meant 'you can actually see the differences in the koji that she makes and the koji that I make. The koji that she makes grows much better, and it actually tastes a lot fruitier.' According to Jia Hao, David and Jason had noticed this variation, but hadn't, at the time we spoke, linked it to the different stagiaires. 'David is very logical and methodical. To him it is just about the process—if you get the process 100% correct, and you do everything he's said, there's no way it won't taste the same.' Jia Hao himself attributed this difference not to work ethic but to affect. He described photos of kōji Yu Ting had taken and posted on her Instagram, which she captioned with

> 'These are my babies, that I take care of,' right, and 'every batch that I make from now on must be better than the previous batch,' right. 'I work hard to strive.' The fact that she cared [for] them like her children, and the fact that she kept striving to improve, made her koji taste much better than mine. While I tried to do it to the best of my ability, I didn't have the same emotional affection [for] them as watching it like my kids.

Jia Hao attributed his more detached attitude to having worked in a biology laboratory during his undergraduate degree, during which

> you inoculate bacteria so often, you don't have any more emotional affinity to them. I don't care for [the kōji] the same way because to me it's just another batch of 'bacteria' I have to deal with. And I feel like this mentality actually made a visible difference…a senseable difference.[154]

Hand taste is thus not only about one's microbiome, practices, and habits (Ch1, Ch7, Ch8), but also how these are differently shaped by affect. While Yu Ting and Jia Hao each became consipient with kōji, the former's affective consipience and the latter's scientistic, 'de-passioned'[155] consipience brought senseably different kōjis into being.

5.2.3 DIFFERENTIATING SPACES

Fermenters' relationships with microbes are shaped not only by how well they have learned to affect and be affected. Different spaces facilitate different microbes to flourish, whether

[154] This is not to say that many scientists don't have affective relationships with microbes in the lab. See for example McLeod, Nerlich, and Mohr (2017), and Calvert and Szymanski (2020).

[155] 'To "de-passion" knowledge does not give us a more objective world, it just gives us a world "without us"; and therefore, without "them" – lines are traced so fast. And as long as this world appears as a world "we don't care for", it also becomes an impoverished world, a world of minds without bodies, of bodies without minds, bodies without hearts, expectations, interests, a world of enthusiastic automata observing strange and mute creatures; in other words, a poorly articulated (and poorly articulating) world.' (Despret 2004) See also, in the medical and lab animal worlds, the concept of 'compassion fatigue', the decreased capacity to care for self and others as a result of excessive demand on one's emotional resources (Figley 1995, 2002).

in the built environments of fermented food production or broader scales of biogeography (Bokulich, Lewis, et al. 2016; O'Malley 2008), and these spatial differences also constrain and shape which consipient relationships with different microbes are possible.

At Empirical, the team grew hundreds of kilograms of kōji at a time in a shipping container lined on the inside with douglas fir, mimicking a traditional Japanese kōji room, to help regulate humidity and temperature (Figure 41). Making kōji here, at this scale, is a strenuous full-body experience: raking a few hundred kilograms of freshly steamed grains of barley back and forth to cool turns the room into a sauna, and the humidity must stay high throughout the growing process, including when it is turned and eventually transferred to trays for cold storage.[156]

Figure 41—The Empirical production team harvesting finished kōji.

[156] Andrew Lê, on the production team, described it as 'meditative': 'it's so hot, you can't think. It's like a test. That's why I do it.' Others described it as 'peaceful' and 'therapeutic', like going into 'a different realm'.

'The conditions are horrible, and more complicated to work in, because you're in the same environment with the kōji,' I was told by Daniel de Haas, then a brewer at Empirical. Yet for many kōji makers like Daniel, subjecting themselves to these trying conditions required to grow kōji by hand at this scale also offers the pleasures of an intimate relationship. 'Seeing the growth up close, seeing the different phases…going in every couple of hours to furrow it,' all mean 'there's more of a relationship that's built with koji.' Daniel further described the pleasure of the embodied knowledge he gained: 'You can close your eyes and just by how you're feeling it know, oh this is way too sticky it's not supposed to be like this. Or this is still too dry, it's not ready, it's not moist enough, it needs more humidity.' Becoming attuned to temperature and humidity, not only by hand but through one's whole body, emerged as a vivid example of the combined pains and pleasures of becoming consipient with kōji:

> It's hard to get used to the humidity, but there's a moment where you also realise, there is a certain humidity the room needs to be in, and without even looking at the sensor you walk in and you know, woah, this is wrong. You can really feel it. Or the temperature's weird, like this is not how it's supposed to be. And then you go check the beds and the thermometer.

The pleasure of becoming attuned to kōji's physical environment, for Daniel and others, came to outweigh the discomfort of inhabiting it.

Working with kōji is hard, but nonetheless Daniel says, 'it's soothing, it's a lot more laid back, it's more hands on, whereas with yeast you can't actually do that, you can't jump into your fermentation tank and play around with the yeast.' With yeast, the fermentation of sweet wort into alcoholic 'wash' to be distilled into the base spirit happens in closed, stainless steel fermentation tanks. So

> you really rely on utensils [eg. for measuring pH and specific gravity] more… it's a lot harder to use flavour or your senses to work with yeast

> than kōji. Kōji allows you to actually create a relationship—you feel like you're more one with the kōji. Where the yeast you're more, ok, I'm paying you to do your job by giving you sugar, now do it, sort of. So I prefer koji 100%.

Because the yeast must be sequestered from the environment, the relationship Daniel forms with it is simply transactional. He and his teammates can become consipient with yeast only in a more limited and indirect way—through occasional smelling or tasting of fermenting wort, then mainly through the results of its metabolic labour, once the yeast cells have died and only its spirit remains. Though kōji makes demands on its fermenters' bodies and minds, requiring attention and stamina at regular intervals, the resulting closeness Daniel and his teammates gain with kōji is worth the difficulty; the transactions involved in working with yeast may be 'easier', but the spatial separation it requires makes the relationship less rewarding.

These spatial differentiations are necessary to enable different kinds of microbe to flourish.[157] They also have wider effects. They become human-facilitated parts of these microbes' 'ecological charisma' (Lorimer 2007)—the totality of morphological and behavioural factors that differentially shape the 'detectability' of an organism by humans. Here, kōji and yeast's respective ecological charismas are shaped not only by their own features and behaviours, but also by the spaces their human fermenters build for them to thrive.[158] These spaces in turn come to shape the relationships the human fermenters are able to form with these microbes in different ways.[159] While the 'kōji sauna', though

[157] An approach echoed by Jason at Noma fermentation lab, who grouped microbes together conceptually and spatially based on their ideal 'temperature ranges', what he called 'temperature families'.
[158] Not that the distinction between the space and the microbe is always clear-cut. I thank Erika Szymanski for this point.
[159] And just as they shape the humans and their experience differently, they must also come to shape the microbes and their *umwelten* (von Uexküll 2010) differently depending on how they are constructed—the size, shape, materials used, and methods of temperature, humidity, and airflow regulation would all have an impact.

difficult for a human to inhabit, only increases kōji's charisma through the direct, embodied, multisensory engagement it allows, the sealed stainless-steel tanks the yeasts require to thrive (within Empirical's sensory standards, at least) dampen their charisma. They may remain charismatic 'in spirit', through the sense-able traces of their metabolic work, desirable flavours left in the alcoholic wash, distillate, and eventual blend after they die, but not 'in body'. The extent of consipience with yeast here is thus somewhere between that with kōji and that with Besky's tea (2020). While it is possible to become consipient with yeast as it grows and metabolises by removing small tastes of the fermenting wort from the tank, 'bodily' charisma and its spatiality greatly shape how much one can become consipient with a living, metabolising organism, microbial or otherwise.

5.3 INTRASPECIES CONSIPIENCE

Through consipience, Nordic fermenters come to know their microbes as subjects, in mutually affective encounters, differentiated by space—but they do not do so alone, as isolated individuals. They continuously share, circulate, and revise the necessary and co-constitutive sensory, conceptual, linguistic, and scientific knowledges among their teams. It is through this process of intraspecies consipience among humans that new team members are trained and attuned to microbial labours, and that each team is able to coordinate their sensory knowledge and inter-calibrate their sensory experiences.

Intraspecies consipience takes two forms. While 'convergent consipience' involves calibrating different palates to sense in a coordinated way, 'divergent consipience' involves the opposite—collecting different impressions of the same product from different palates to gain a richer understanding of its taste potential. Both forms involve intersubjectivity, but in different ways for different ends. They contribute not only ethnographic detail but also additional theoretical dimensions to Shapin's concept of intersubjectivity: convergent consipience accounts not only for how teams align their different tasting capacities but also for how they deal with the 'consistent variance' inherent to food production and fermentation, while divergent consipience illustrates the social value among fermenters of tasting the same product differently—an undertheorised dimension of intersubjectivity.

5.3.1 Convergent consipience

Because the Empirical team grows so much kōji—while I was there, hundreds of kilograms a week—they have both ample opportunity and a strong imperative to become attuned to its articulations, individually and collectively. New members learned what to aim for and what to avoid by participating in shaping this shared standard—converging on consipience. 'When every new batch of koji comes out,' Priyanca Patel, a member of the production team who had recently been put in charge of the 'kōji chamber', described to me, the team would 'taste it together', describe the smell and taste, and evaluate its desirability. 'The things you should look for… are honey-like, almondy, nutty, hazelnut, floral, fruity, sweet. Things you should [avoid are if] it's like dog food, or like urea, or [what] they [the heads of production and R&D] call the *natto* [smell],' which happens if the kōji overheats, kills itself, and is taken over by bacteria.[160] Pri had noticed that this process of 'articulating smells and tastes' with shared words had not only 'increased [her] vocabulary', but had also helped her palate 'evolve' over her time in Copenhagen, first at the Noma fermentation lab, then at Empirical. The knowledge gained in consipient interactions with her more experienced teammates helped her become attuned to what

[160] *Nattō* is a Japanese product of cooked soybeans fermented with the bacterium *Bacillus subtilis* until delectably mucilaginous and ammoniated. *Bacillus* spp. are sometimes present in small amounts in kōji, but it should not outcompete *Aspergillus*.

makes good kōji, such that she could increasingly 'pinpoint' kōji's characteristic 'honey, fruity, floral' notes 'coming through' in the final spirit, after brewing and distillation.[161] For Priyanca, intraspecies consipience among her human colleagues was a key part of gaining interspecies consipience with her microbial ones.

At Noma, where a larger production team must become consipient with each other for hundreds of products, such close, in-person convergence with the whole team is impracticable for each product, so additional approaches are necessary. Luke Kolpin, then sous chef at Noma and head of the production kitchen where raw materials are prepared for service, described to me how the constantly changing kitchen team calibrates their individual palates to the restaurant's 'house style' not only through direct tasting but also with a kind of gradated interpolation. Having me imagine 'ten lacto-plums out on a table', in order from young and almost fresh to old and pungent (eg. Figure 42), he explained to me how, while his personal preference might be the fourth and mine might be the sixth, the restaurant wants the fifth, for its specific balance of acidity and alcohol and sweetness, freshness and fermentedness. Neither of us must prefer the fifth lacto-plum (*pace* Bourdieu; 2.2), but we must be able to recognise its specific flavour, its balance of tastes, and replicate it in future batches of lacto-plums—even when starting with different varieties of plum, at different ripenesses. This collective standard is set by the heads of the R&D/test kitchen and/or fermentation lab, who would taste the lacto-plums, decide the flavour they wanted, and 'that's the one [the rest of the kitchen] would go for,' such that it became 'engrained in people's heads.'

[161] This process of attunement is comparable to what other scholars have described in eg. wine tasting and perfumery (eg. Thrift 2003; Latour 2004b; Shapin 2016).

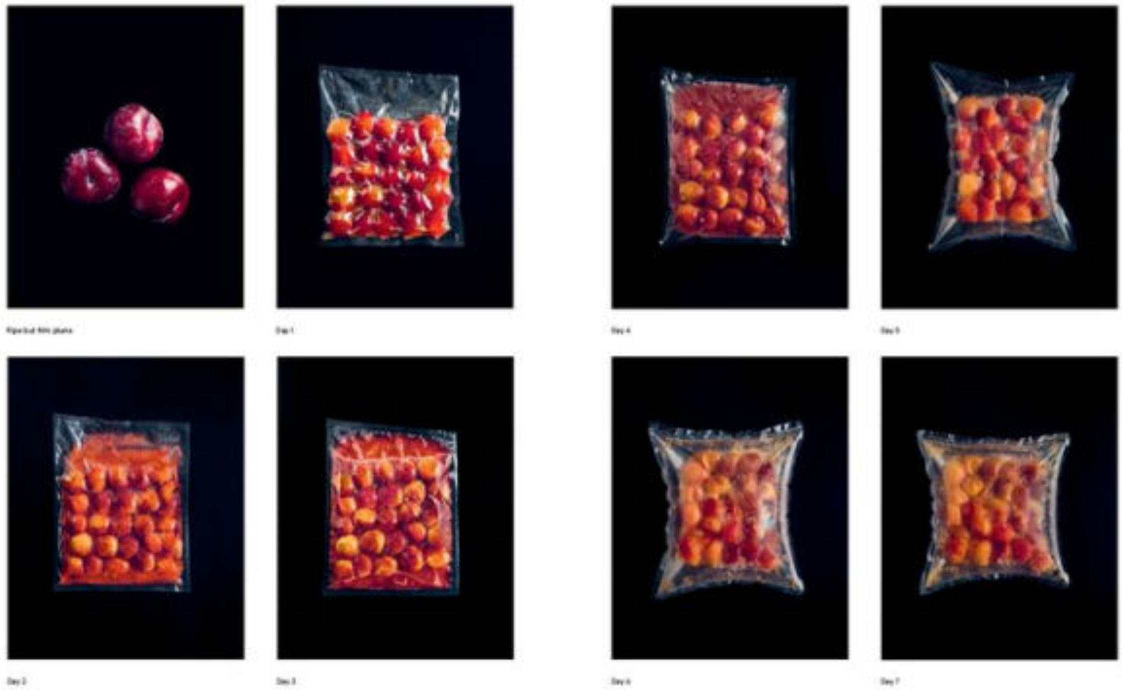

Figure 42—Stages of lacto-fermenting plums (Redzepi and Zilber 2018: 70–1).

Yu Ting described this training process from a stagiaire's point of view:

> When I taste the lacto-plums, or lacto-fruits, they [David and Jason] say when you taste it you must notice what kind of balance the sourness and the sweetness [have], if it's not right, or it needs more time, or it's already done, or it's too much. I think it's still very hard to explain orally [in language] because it's a taste. Like the first time when Jason let me taste, he said it's still too sweet. So for me it's like, ok, this is too sweet, so I try to remember [that this] is too sweet, for the right lacto-ferment. So next time when I taste them myself, I will say, oh ok comparing to my previous experience, it's still too sweet, or it's less sweet than last time, so maybe this one is done.

Notable here is the ambivalent role of language: while Yu Ting finds it difficult to verbally explain the taste standard (because it exceeds language, and her knowledge of it is tacit; Polanyi 1962, 2009), linguistic signifiers such as 'too sweet' are also necessary to how she comes to share the standard with Jason and become consipient with him. Even though she cannot articulate what the standard is, she can articulate when the standard is reached. The standard itself, Latour would say, is 'articulate' (Latour 2004b).[162]

Especially in training stagiaires, sometimes it happens that a stagiaire must check a fermentation without having tasted the standard before. In such cases, Luke encourages the stagiaire to cultivate a consipient imagination: if a plum rested with salt for a few hours is a 1 on the lacto-plum spectrum, and a plum having become fully sour and alcoholic is a 10, then 'we're trying to achieve 4 or 5 or 6'—'we want a little bit of that salty vegetable or fruit, and we want a hint of that alcohol… we're trying to achieve right in that middle spectrum, because of the flavours we want to be going into this dish.' Using this abstracted, partly *a priori* scale, Luke can advise stages that a product should be '10% more or 10% less of what it is' currently, and 'they usually understand where we're trying to go'—a process we might call 'imagining consipience'.

Over Luke's eight or nine years working at the restaurant, he had seen and adjusted to different flavour standards for hundreds of products. Of course, in tasting hundreds of products all day every day, individuals' palates can and do gradually drift away from the standards over time, leading to products that come to taste differently from the standard. Day to day, a '5%' margin of error from the standard is inevitable: 'the variance is consistent—it's always going to be up; it's always going to be down.' But sometimes, when 'everybody comes together… over a problem that's happened,' for example, and notices that something is '20% away from where [it] started,' they will 'all taste it and talk about it and bring it [the standard] back to where [they] think that playing field might be.' To

[162] Yu Ting also had the experience of having preferences different from the house style. For her, 'the lacto-cep juice' is 'too sour' when David and Jason say 'it's done.' Nonetheless, she could remember and replicate it.

correct for excessive 'consistent variance' of the taste standard resulting from palate entropy, the team uses constant, deliberate sensory calibrations—maintaining what we might call 'coordinated intersubjectivity'.

Consistent variance happens not just between individuals tasting the same product, but also in the taste of different batches of the same product. While the fermentation lab and production team work to keep this kind of consistent variance to a minimum, its inevitability shapes how the sous chefs like Luke work to realise reproductions of the same dish to the same standard based on a constantly shifting team roster and stock of ingredients. Accommodating inevitable consistent variance in products requires, as Luke says, a 'one-eye's-open-one-eye's-closed kind of taste'—having 'one eye that's focussing, and one eye that's tasting, you know, a little bit closed. It's like, does it taste good? Ok let's go for it!' This 'wiggle room' is what makes the kitchen's work possible in practice. A 5% margin of error is acceptable: less than that becomes unworkable, more than that becomes sloppy.

Some products, because of higher consistent variance in their production, lead to greater consistent variance in tasting. To illustrate, Luke compared 'baking' (pastry) and 'working with ferments'—the latter, he posited, can have higher consistent variance in production, 'because it's alive'. This tendency for higher variance in the product can make maintaining consipience among human tasters for some fermented products a particular challenge; however, this same variance emerging from microbes' liveliness offers other potential rewards. Expecting slightly more variation from the standard—in production and in tasting—keeps open the possibility of noticing when a batch of some fermentation is exceptional, or particularly useful for a different purpose.[163] If 'you're playing with the boundaries, who knows, maybe that time when it's 10% over, you taste it, and you're like, wow, that's actually a really good quality.'

This 'rolodex of overdevelopment flavours and underdevelopment flavours' becomes a key resource when the sous chefs have 'to try to recreate something [like a component of a dish they] don't have' any more of.[164] Luke recalled a batch of lacto-fermented gooseberries he had tasted previously which in that context had been a bit overdeveloped, but for revising the salted quince sauce for a dish of cod swim bladder he thought would have just the 'extra pop' he needed. Consistent variance in convergent consipience allows new flavours to be noted for future applications, and illustrates why intersubjectivity is never achieved once and for all but must be constantly maintained.

5.3.2 DIVERGENT CONSIPIENCE

While in some contexts, teams want to taste things similarly and become convergently consipient, in other contexts they explicitly value tasting things differently. This divergent consipience is a crucial part of how the Empirical team blends their finished spirits from many 'cuts' of distillate, often dozens of cuts for each distilled component.[165] 'When you blend you need two people,' Andrew Lê, brewer and blender at Empirical tells me, 'because not everyone's palate is the same, but you can readjust your palate, redefine what you're

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[163] Similar, Luke noted, to variation and selection in evolution.
[164] It also demonstrates how knowing when to halt a fermentation is linked to its 'ontonorm' (Mol 2013; 7.3.3).
[165] Once the alcoholic wash—the beer made from kōji, malt, water, and yeast—is finished fermenting, it is distilled into 'low wine', the first round of distillate. This low wine is then used to macerate various botanicals under different conditions, and each is redistilled separately. Each distillation—of low wine, as well as kombuchas, vinegars, and other hydrosols for balance in the final blend—is separated into 5l 'cuts' as the distillate comes off the still. These cuts, usually at least a few dozen per distillation run, capture the different flavours that emerge in the distillate over the course of distillation, which can then be recombined in different proportions to optimise the final blend.

thinking by someone else.' In blending, having different palates—different sensory-perceptual inclinations, preferences, and vocabularies—is not a challenge to overcome through coordination and calibration, as it is in convergent consipience, but an asset, even a necessity. 'We pick up on certain things,' Andrew tells me about blending with a partner. 'We describe things very differently, just cause of our backgrounds.' So 'we can use each other' to identify different features of the emerging blend, and different ways the same emerging blend might be perceived and understood by different eventual tasters.

Daniel also relies upon other members of the production team having fresh palates, unattuned to the specific product or blend he's working on, to help him fill in his own inevitable blind spots resulting from his own palate's proclivities and habituations. He will take samples to people 'all working on different things in different parts of the building' and ask them what they think, to get the widest range of impressions possible, from different palates working on different things in different contexts.

> When you are making something really often, you tend to know the flavours really well, and so I know that sometimes, because you want to taste that flavour, that's the flavour that your brain focusses on. So that's what you're mostly tasting. Where if you get someone who's not tasting it all the time, maybe they'll say, I taste that, but this is what I find is more dominant. And then you get another person to taste it and they say the same thing, you realise, ok it's just because I make it all the time and this is what I want to taste… I think it's a good approach cause if you're making it all the time, it's very hard to have a very honest opinion about it. Because you're seeing the time and effort that goes into it, because you're seeing all the steps, because you might taste a bit more of this because you know it's going in there.

If there is a particular note Daniel is looking for, or is particularly excited about, he will ask his colleagues if they can taste it—but mostly he does not prime them with his own impression, because he is aware of how suggestible taste is. This approach is shared by many members of the team, who even extend it to people outside the company, such as visitors to the distillery, some of whom may not even be food professionals with 'developed' palates.

> If you only have developed palates tasting something and giving you feedback, it's not really helpful either. Because developed palates can taste things well and put words onto those flavours, but it doesn't mean that someone else doesn't taste them—they're just not used to tasting, so they muddle the flavours up a bit more. But maybe in that way they have a more honest flavour because they're not singling things out and they're tasting it kind of as a whole. And so their perception in general is very complementary to what you [as a professional] perceive when you're singling out those flavours.

The value of involving certain visitors' 'lay' palates in the development of spirit blends was also related to the fact that the Empirical team was so used to tasting high-proof distillate that their tolerance for its strong taste had increased relative to the average consumer. Johannes Bay, part of the marketing team with a background in wine, not spirits, told me that when he first joined the company and the R&D team gave him samples to taste, his 'palate was just blown out, [he] couldn't taste anything apart from alcohol.' After some months, however, as his palate adjusted to the higher Alcohol-By-Volume (ABV) levels, he could start to 'pick up on subtleties the same way [he] could pick them up in wine.' Becoming attuned to specific microbes and their products helps fermenters affect the fermentation process in desirable ways, but it can also make one physically unable to taste the same product as a less-attuned palate would. Both divergent articulations among comparably 'developed' palates, and divergent kinds of palate entirely, help consipient teams know as much as possible about the tastes they work with—what we might call 'comprehensive intersubjectivity'.

5.4 EPISTEMOLOGY OF CONSIPIENCE

From this discussion of the experience of becoming consipient both across and within species, some general epistemological features of consipience emerge. While the fermenters introduced here place great weight on knowing through smell and taste, their use of these senses always involves knowledges beyond what happens chemically at the interfaces of nose and mouth. Psychologically speaking, they are never merely 'sensing' but 'perceiving', and this perception involves complex cognitive relationships—for example with science and with language.

5.4.1 SCIENCE & TASTE: CO-CONSTITUTING KNOWLEDGES

Scientific knowledge is frequently contrasted with craft, indigenous, traditional or folk knowledge, also in the anthropological and STS literature (eg. Ingold 2000; Paxson 2012).[166] Many chefs' accounts of the relationship between the 'theoretical' knowledge of science and words and the 'practical' knowledge of tasting mobilise an analogous distinction.[167] David illustrates this contrast in describing different modes his team uses to sense acidity in fermentation. 'You could use a pH meter or pH strips to test how acidic your vinegar is—a pH range of 3.5 to 4 is usually just right—but in all honesty, we find taste to be a better guide.' (Redzepi and Zilber 2018: 177) For these fermenters, this conclusion is not, in contrast with an analysis offered by Paxson (2012: 147–9), because the tools for measuring pH are not 'objective' as such, but because the concentration of hydrogen ions measured by pH tools (when they are working properly, calibrated, and skillfully used) does not reliably correspond to how sour something actually tastes. While Zilber continues

[166] While this distinction is also readily questioned, it is not a matter I can take up here.
[167] See Chapter 6 for further discussion of the role of technoscience in translated fermentation experiments.

that 'exacting fermenters may find these tools helpful' for specific technical tasks and adding consilience to sensory observations of microbial activities (Redzepi and Zilber 2018: 41), he cautions that 'sugar, viscosity, and the flavor of your vinegar can all affect the perception of acidity on your tongue [so] a mechanical measurement [alone] may not necessarily lead to the product you want.' (ibid.: 177) For this reason, tasting knowledge takes priority: 'Ultimately, what you find palatable should dictate what you think the "right" pH is.' (ibid.: 41) In this and comparable instances, scientific and craft knowledges are co-constitutive, insofar as they make sense conceptually only through recourse to each other.

Yet tasting 'acidity' is not a preternatural 'function' of the human sensorium that happens the same way for everyone everywhere (Mol 2012)—it is a particular composition of understanding taste experiences partly shaped by categories of scientific knowledge. When David, and the fermenters he addresses, taste 'acidity', their experience has been shaped by pH meters, titrations, research on ion channel receptors, and the larger apparatus of physiology, whether they themselves are using a pH meter in that specific instance or not. This is a deeper sense in which scientific and craft knowledges are co-constituting: tasting acidity and measuring acidity are historically and materially bound up with each other. The same is true for many of the taste categories the team commonly uses: whether umami, codified in a Japanese laboratory (1.2.1), or paraphyletic categories like 'Lactic Acid Bacteria' and 'Acetic Acid Bacteria', ways of grouping organisms not by phylogeny, as is standard in taxonomy, but by their relevant and tasteable metabolic product (5.0). This latter type of term has gained usefulness in culinary labs and kitchens because it enables fermenters to know microbes in a way that performs scientific rigour yet requires no kit beyond a sufficiently trained palate. While STS scholars have established how integral the senses are and have been to the production of scientific knowledge, they have only recently begun to acknowledge the reverse: how scientific knowledges in turn shape the act and experience of sensing (Lahne and Spackman 2018; Laurent and Langen 2017; Spackman and DeLaet 2017b, 2017a). Consipience offers a useful conceptual tool to this emerging programme of research.

This co-constitution of scientific and culinary knowledges in how fermenters taste is somewhat more nuanced than the claim that microbes can be known through the 'unaided' senses, as the microbiologist John Ingraham makes a spirited argument for (Ingraham 2010), as if these 'unaided' senses were somehow entirely untouched by scientific culture. The danger, as O'Malley notes in her review of Ingraham's book, is that then 'all mention of how the science was done is subordinated to the actual microbial activity, to the point of eclipsing the practices that revealed such activity' (O'Malley 2010: 184). While it is tempting to appeal to the senses as 'unmediated' conduits for sensing microbes, such a move is impossible, and elides a more interesting and important point: that scientific and other knowledges are already imbricated in sensory phenomenology.[168] How exactly they have become imbricated in different contexts is an important question, and one that further research might address.

5.4.2 TASTE, LANGUAGE, AND TASTE AS 'LANGUE-AGE'

As emerged in the discussion of inter- and intraspecies consipience, many of these fermenters have an ambivalent relationship with terminology in general, not just the

[168] While it would have been common to know beings now called microbes through epistemologies other than science in pre-Pasteur (and certainly pre-van Leeuwenhoek) Europe and pre-colonial societies elsewhere, nowadays it is less so. Giraldo Herrera (2018), for example, takes a different approach to similar epistemological terrain, arguing that indigenous Central American cosmologies and associated shamanic techniques like entoptic vision provided the epistemological foundation for later European microbiology. Though his study has little to say about smell and taste.

scientific kind, in tasting and smelling. Many (though certainly not all) chefs, including many of those I interviewed, become attracted to cooking in the first place because thinking and working with their senses and bodies appeal more to them than excessively language-based scholastic endeavours.[169] Luke at Noma described how for him language can easily get in the way of understanding how products, including fermentations, should taste:

> When I'm tasting certain things, I know hey this is the flavour we're going for… If you get too technical into words or things like that, I lose it, and I don't understand it. But if I'm tasting it, I can taste the development, and I understand ok this is the direction it's supposed to go, this has gone too far, this is exactly what we want.

As production sous-chef, Luke worked with the whole range of ingredients that come through the restaurant, and he recognised how David and Jason, as fermentation specialists, would be even more finely attuned to the gradations of fermentations as they develop: 'they're there constantly, they smell it, they see it, they touch it, part of their daily mise-en-place[170] is checking this at this time, checking that at that time, so they have a rolodex in their mind of yes this works, this works, this doesn't.' In Luke's account of a chef's sensory epistemology, one can gain knowledge simply by tasting and smelling.

At the same time, taste and language do not exist as independent categories, but, as with science and 'craft' knowledges, shape each other co-constitutively in practices. Luke may find language distracting in the moment of tasting, preferring to conceptualise standards as sensory gestalten rather than clusters of linguistic signifiers, but even his tasting capacities and tendencies are not preternaturally untainted by linguistic discourse. For other chefs

[169] This fact could conceivably have posed a minor challenge for discursive ethnographic methods such as interviews, but this possibility was overcome by observing and participating in these non-linguistic sensations and exchanges in action, paired with descriptions in interview of the ineffability of these activities.
[170] That which is 'put in place', referring in the argot of professional kitchens to the prep work before service. The term is French.

and fermenters, as illustrated, language is a limited but nonetheless useful tool to aid in becoming attuned to senseable differences, and becoming consipient with human and nonhuman others. While the specific relationship between language and the senses varies according to the individual, the social context, and the specific task at hand, overall, for the fermenters I came to know, smell and taste are both shaped by and exceed language.

This may seem a banal point to make, but with respect to the geographical and STS literatures, it seems to occupy an interstitial, underdeveloped, even novel position. Many scholars seem to want either to place smell and taste (and indeed all the senses) entirely beyond linguistic access, or else to reduce all sensory attunements to linguistic metaphors. Thrift, for example, finds that 'aromas, though readily detected and differentiated, are not easily described in language,' that 'they are difficult to "read"' and 'are not easily made specific in ways which lend themselves to written categorization.' (Thrift 2003: 10) Yet Thrift's argument proceeds using a rather undifferentiated first-person plural:

> Aromas seem to escape our cognitive consciousness. They belong to a realm of "peripheral" psychomotorial actions, an insistent substrate of incessant movement that makes up so much of what we are, but which we so often choose not to register as thought, even though the stamp of the impressions of this movement constantly influences us. (ibid.)

This approach is a clear expression of his non-representational agenda,[171] but makes one wonder whether there might not be exceptions to this 'we'—experts in food, drink, and perfume, for example, for whom smells and tastes *are* representable, and with high (but of course not 'perfect') fidelity. When Thrift writes that 'we seem unable to say much about [smell] that isn't either trite or obvious,' (ibid.: 12) it seems more clear that he is referring

[171] At least one relevant paradox of non-representational theory is that it can only instantiate itself through representation. It seems to yearn to be something *sui generis*, like art, but cannot because a) its practitioners are not artists, and b) it will/can not entirely relinquish all its scholarly conventions, such as the imperative to explain.

to cultural geographers, whose '"vocabulary"… is too restricted to encompass anything other than certain dogmatic ways of thinking which arise from a scholastic way of life.' (ibid.) But then it becomes questionable to base general claims about smell (and taste) on the relatively unexpert capacities of most scholars. If 'we' know less about smell, it is not because smell itself, as Thrift has it, is 'unruly' (ibid.: 13), but because the 'we' in question might not be sufficiently trained. Here is another sense in which tasting difference always involves tasting differently (2.2). The 'olfactory verbal gap' that Thrift cites thus becomes somewhat less remarkable (ibid.: 11)—both because it can be narrowed and bridged with training, and, more generally, because the 'gap' between the signifier and signified is not specific to olfaction, but general to language (Saussure [1916] 1986).

Meanwhile, other scholars aim for the opposite move—to extend language as a metaphor to make all manner of more-than-human semiotics universally legible (at least to language-fixated scholars). As Hinchliffe, Whatmore, and colleagues become attuned to 'the footprints and other marks that water voles leave or make as they go about their business', they call these 'traces' '"water vole writing"' (Hinchliffe et al. 2005). They immediately acknowledge that 'writing is a risky term,' and clarify their motivation:

> to unsettle the sense that nonhumans are always merely written up. In ceding at least some of the writing action to water voles and other characters in this story we can hint at their contributions to what Deleuze and Guattari (1988, page 141) call the material processes of writing. (Hinchliffe et al. 2005: 647)

While I am sympathetic to this purpose, the danger of making everything potentially 'write' is that it implicitly universalises language, and written language at that, both blunting what makes language contingent and particular and, more gravely, impoverishing the plenitude of other-than-linguistic not-fully-commensurable ways that different actors make and understand signs. Drawing again on Deleuze and Guattari, Hinchliffe et al.

propose 'diagramming' as a preferable alternative to 'representation…to grasp this complex of activities and interactions…which, for [them], conveys a sense of "writing around" water voles. Field guides, for example, write around rather than write up, once and for all, their object.' (ibid.: 648) While such a move aims to turn away from the sense of finality and certainty that can come with certain styles of academic writing, it may be that the problem lies in the verb itself, and not its preposition. Hustak and Myers, meanwhile, in their 'involutionary' re-reading of Darwin's work on mutual attraction between orchids and pollinators, do not privilege the written word, but nonetheless also reach for language metaphors, framing recent scientific work on plants communicating through gas exchange as '*volatility* [being] read as a kind of *vocality*, a way of speaking in a chemical vocabulary.' (Hustak and Myers 2012: 100; original italics) Language may shape smell and taste, but understanding smell and taste as 'languages' per se is, as the fermenters here illustrate, both unduly limiting of and somewhat insensitive to the co-constituting yet incommensurable relationships between linguistic and more-than-linguistic ways of knowing. Taste, while not a language, may then be a form of 'langue-age'.[172]

5.5 GENERALISING CONSIPIENCE

Consipience is a tool to aid ethnographers in making sense of the chemical senses. It helps make smell and taste reliable modes of knowing about the world, for those, like many scholars, who are largely not experts in them. It contributes to the thesis' fourth aim (1.4.1), and addresses my second subsidiary research question—how New/er Nordic

[172] My rhetorician colleague Erika Szymanski cleverly suggests that 'taste is as much a "langue-age" as human speech is, in a way.' (pers. comm. 23.7.21) This may be true insofar as they both involve tongue-ing, but this feature alone hardly makes them equivalent epistemic modalities—even while, as discussed, they may entwine deeply. I borrow Szymanski's quip here to name the relationship between taste and language I describe, in which the former is neither fully legible through nor fully beyond the latter: 'taste as langue-age'.

fermenters come to know their microbial partners, and how these knowledge practices enact taste. Consipience happens both across and within species. Human fermenters subjectify their microbial partners, learn to be affected by and to affect them, and navigate the spatial differences that shape what kinds of relations with microbes are possible. These fermenters also become consipient with each other: convergently, calibrating their tastes to shared linguistic signifiers and interpolated, sometimes imagined standards to reduce consistent variance and achieve coordinated intersubjectivity; and divergently, embracing variation between tasters and kinds of palate to know a product as deeply as possible in their pursuit of comprehensive intersubjectivity. The epistemology of consipience, general to both, involves co-constitutive scientific and craft knowledges, and is both shaped by and exceeds language—a form of 'langue-age'.

While I have developed the concept of consipience here with ethnographic material from a rarified context of novel fermentation among culinary innovators, it might be used to illuminate any inter- and intraspecies encounters where knowledge is co-produced through smell and taste. Humans need not be involved here—biology and ecology are replete with examples of nonhumans becoming attuned to each other, within and across species, through chemical exchanges.[173] Understanding these relationships as consipient does something more than most biology and ecology does, or is willing to do: extending not just attunement, but desire, pleasure, and appetite to nonhumans turns consipiants into fellow subjects, opening up the possibility for intersubjectivity not only between humans but among more-than-human kin. This is one of consipience's key contributions.

[173] See, for but a few examples, Morgan (2008) on ants; Goward (2011) on lichens; Hustak and Myers (2012) on orchids and pollinators; Kohn (2013) on trees.

Consipience also suggests many fruitful avenues for research among diverse human groups, to investigate what happens when they manage or fail to taste things together: for example, how taste and smell shape the politics of food acceptance and social exclusion (Yamin-Pasternak et al. 2014); how variation in human gustation and olfaction, not to mention preference and diet, shapes public health and food aid efficacy (Bartoshuk 2000; Drewnowski et al. 1999; Feeney et al. 2011; Rolls and de Waal 1985); or how tasting and smelling together impact nutrition, sociability, and enjoyment for medical patients (Mol 2011). Along these lines, consipience might also find rich engagements with work in crip theory and critical disability studies (Breckenridge and Vogler 2001; Garland-Thomson 2011; Goodley et al. 2019; McRuer 2006; McRuer and Johnson 2014; Serlin 2017), as well as suggest new connections between taste, pleasure, embodiment, and complicity in addiction studies (Courtwright 2019; Pelchat 2002; Pollan 2018).

Consipience allows human fermenters to sense microbes' presence, and enables their mutual flourishing. In the next chapter, I examine how fermenters gain knowledge of their microbes in the absence of consipience, by making 'propositions' (Stengers 2008) in the form of experiments.

6 EXPERIMENT

> We became more independent, and started to explore our idiosyncrasies and special skills. We were beginning to understand how to cook without reference to other cultures, instead from paradigms developed through research and experimentation.
>
> - René Redzepi, *A Work in Progress* (2014: 42)

6.1 CULINARY EXPERIMENTS

Throughout Redzepi's diary, experiment emerges as key to Noma's process. Though it is probably not the case that 'research and experimentation' categorically exclude 'reference to other cultures'—Redzepi here has in mind that rudimentary crème brûlée with sea buckthorn (Ch4), rather than, say, translating Japanese fermentations into the Nordic culinary lexicon—the above passage reveals experiment's importance in Redzepi and team developing their identity and purpose. This theme occurred throughout my ethnography. My participants conducted experiments of many kinds, at many scales—controlled ones, open-ended ones, and everything in between. And they frequently narrated them as such.

It was clear that experiment was a key concept, knowledge practice, and multispecies relation I had to account for.[174]

While scholarly works tend to portray cooking as tacit, embodied, habitual, craft-based knowledge (2.3.2; Arvela et al. 2012), the culinary practitioners I studied, and their experiments, suggest that cooking can also comprise a systematic set of methods for assembling new, explicit knowledge of the material world. In this rudimentary sense cooking is comparable to science, and to experimentation specifically, and not only because of the recent incursions of technoscience into the culinary world (Borkenhagen 2017; Roosth 2013). Bringing literatures on cooking and experiment in geography, food studies, and STS into dialogue with fermentation R&D practices, I develop the concept of a 'culinary experiment', which contributes back to these literatures in turn.

Culinary experiments establish kitchens as understudied 'truth spots' (Gieryn 2006, 2018)—spaces that shape knowledge production in particular ways (see also Livingstone 1995; Shapin 1998). To literatures on cooking, culinary experiments illustrate how multiple styles of cooking, not only modernist cuisine, blend routinised recipe and habituated skill with more explicit and systematic forms of knowing and tasting—without relying on metaphysical distinctions between 'science' and 'art' (cf. Borkenhagen 2017; Paxson 2012). To literatures on experiment, complementary to STS having shown how science is often done less systematically than conventionally thought (Latour 1987; Latour and Woolgar

[174] That a chapter on experiment should be rather un-experimental in its form and style feels somewhat incongruous. While the virtues and vices of various 'form–content' reflexivities have been debated for decades in STS and the social sciences (see Ashmore 2015 for an overview), in this case to write about experiment experimentally would be not only methodologically consistent but might also help address the concept's proliferation and subsequent paralysis (2.3.2). Perhaps elsewhere.

[1979] 2013; Rheinberger 1997), culinary experiments show how certain kinds of cooking are done *more* systematically than often thought.

Culinary experiment contributes to the thesis' fourth aim (1.4.1), and addresses my second and third subsidiary research questions: on how taste structures how human fermenters know their microbial partners, and how human fermenters and their microbial partners shape each other in New/er Nordic translated fermentation. Culinary experiments show how the answers to these questions are co-constituting: to know these microbes through experiment is to shape them—their behaviours, flavours, and natures—and be shaped by them in turn (Ch7).

In this chapter, I identify three of culinary experiments' key epistemics to help analyse how humans and microbes know and shape each other in translated fermentation. These epistemics involve how culinary experiments engage the senses, employ science, and modulate surprise. Each is illuminated by distinct knowledge practices: how these experiments enable and in turn are enabled by consipience; how they are increasingly 'more-than-scientific', by 'using' without 'doing' science; and how they and the kitchens that facilitate them are reconfigurable, opening up and closing down according to purpose. I then discuss how these epistemics of culinary experiment contribute to conceptualisations of experiment advanced by Jellis (2012), Lorimer & Driessen (2014), and Rheinberger (1997). Based on this discussion I develop a framework for experiment that can accommodate its heterogeneity while differentiating its kinds, by situating them along common dimensions of openness of goal, unprecedentedness of outcome, and degree of trial. This 'qualifying' approach might address the recent 'deflation' of the term and help overcome the resulting analytic paralysis (2.3.2). Finally, shifting from experiment's epistemology to its politics, I reflect briefly on the degree to which translated fermentations constitute 'convivial experiments' in multispecies worlding, which returns us to the question of whether fermentation has an essential politics.

6.2 SENSES: CULINARY EXPERIMENTS ENABLE CONSIPIENCE

Culinary experiments involve developing sensory knowledge of novel flavours and textures. When pursued among chefs and/or scientists in groups—indeed most of the time—they also involve intraspecies consipience among humans, in an established, embodied, shared culture of sensory standards and practices: both convergent (calibrating to taste things similarly, for 'coordinated intersubjectivity') and divergent (valorising palate differences for 'comprehensive intersubjectivity').[175]

The experiments of culinary modernism (2.3.2; Borkenhagen 2017; Roosth 2013) are largely concerned with physico-chemical transformations, and so rarely involve developing interspecies consipience—knowing and becoming with other species through smell and taste.[176] In contrast, this interspecies consipience is crucial for New/er Nordic culinary experiments with fermentation. In some cases, experiment was also crucial to developing this consipience in the first place.

Early fermentation experiments in the NNC involved simple lacto-fermentation (Ch4). While some of the products, such as lacto-green strawberries, had no precedent, lacto-fermentation exists in countless forms around the world, including the Nordic region, so Redzepi and team already had some degree of consipience with lactic acid bacteria. Yet

[175] Compare with Shapin's 'intersubjectivity' (2012, 2016) and Stengers 'ecology of practices' (2005).
[176] Learning to be affected by (Despret 2004) and to affect them (5.2.2).

when Noma chefs began developing translated fermentations, applying a distinct technique from a specific place or tradition to Nordic products, they had to become consipient with a new range of organisms and ecologies, with which they had no prior relation—such as pearled barley kōji and yellow pea miso or 'peaso' (Prologue).

Lars, the R&D chef who built up Nordic Food Lab's fermentation research (Ch1), ran Noma's test kitchen, and co-created their 'Science Bunker' fermentation lab (Ch4) before co-founding Empirical Spirits (Ch3), was the one who initially figured out how to grow kōji at Noma and who developed the original peaso recipe. Lars' work illustrates a special case of consipience, in which interspecies consipience must be gained in the absence of intraspecies consipience. The only way this was possible was through experiment.

6.2.1 EXPERIMENTING FOR INTERSPECIES CONSIPIENCE: TRANSLATING KŌJI

When Lars began his translated fermentation experiments around 2010, he had never tasted freshly made kōji (though he had tasted some misos). He had not been to Japan as an adult, let alone visited Japanese producers of kōji or miso. He explained how he managed gradually to figure out how to make kōji 'happy' through a combination of trawling Google Patents for technical insights, much trial and error, and constant smelling and tasting. Lars began with a goal in mind but without visceral knowledge of it, judging when his experiments worked by how much they appealed to his palate and corresponded to what he had read online and in books.[177]

> I wasn't under the illusion that I was making brilliant perfect kōji, but the ones that weren't wrong were very different than the ones that were. When it's healthy it's very delicious… it looks healthy, it looks happy, it smells floral and sweet and when it's gone bad it's clearly disgusting, it smells off. It's just sensory analysis.

[177] Further evidence for the co-constitution of taste and language in becoming consipient (5.4.2).

Lars' first encounters with kōji were absent established standards and practices of consipience, inter- or intraspecies. Nonetheless, he speaks of the difference between successful and unsuccessful kōji in nearly the same terms as, for example, Yu Ting, who at first also hadn't grown kōji before but at least learned how within an established culture of intraspecies consipience at the Noma fermentation lab (5.2.2). For Lars, without having viscerally experienced what kōji should feel, smell and taste like, it was sensorially apparent when the kōji was 'happy' and 'healthy' because of its pleasing looks, smells, and tastes. Lars ascribes this self-evidence to 'sensory analysis', which in this context is less the rigorous deployment of a trained panel (A. Mann 2018) and more the use of his highly trained chef's palate (Ch5).

Considering the longer evolutionary history of kōji having emerged through human selections (Prologue), Lars' visceral attraction to successful kōji is neither coincidental nor preternatural. Generations of Japanese kōji makers and breeders have been drawn to kōji's alluring smells and tastes, become consipient with it, and subsequently shaped its flavours, enhancing and diversifying the very traits that Lars interpreted as signs of its 'happiness' (Ch5; Miele 2011).[178] That Lars could recognise healthy kōji is thus the result of kōji's taste shaping nature. His encounter with kōji was not an isolated event, but an instance of the longer 'coevolutionary' story between humans and kōji 'becoming with' each other (Haraway 2008; van Dooren, Kirksey, and Münster 2016: 2). Because Lars hadn't encountered kōji before, he used experiment to make 'propositions' to it to figure out what it liked best (Stengers 2002, on Whitehead; see also Hustak and Myers 2012; Latour 2004b;

[178] Human preferences for sweet and umami tastes, as well as for fruity aromas, seem to be robust across diverse contexts. See Dunn and Sanchez (2020).

Stengers 2008). For the kōji, this encounter was one more instance of its ongoing 'reciprocal capture' of and by human consipiants (Stengers 2010: 35–6).

In this sense, it could be argued that Lars did not figure out how to grow kōji solely through his own process of trial and error, but was guided in this process by the kōji, which already contains directions for becoming consipient with it. Lars was not only 'learning to be affected' (Despret 2004) by and to affect it (Ch5); kōji's entangled history with humans means that the kōji, and through it, its past human breeders, were 'teaching' Lars how to be affected by and affect it.[179] Yu Ting, in contrast, had the added benefit of acquiring this learning in the intraspecific-consipient context of the Noma fermentation lab, taught mainly by David and Jason rather than the kōji alone. She refined her skills through practice, but her method of improvement was more tacit tinkering than the systematic experimentation that was Lars' only available way forward. While background reading offered Lars general indications of growth conditions and substrate preferences, in practice he had to figure out every parameter one by one, controlling other variables through systematic experimentation: which kind of grains, how long to soak them, pH of soaking water, how to cook them, how much to cook them, what to ferment them in, and then how to create stable conditions for growth—which required expanding the technoscientific infrastructure of the kitchen to include tools for the care of living organisms, not just for the physico-chemical manipulations of pure substances and raw materials. For Lars, becoming consipient with kōji more or less from scratch was

[179] See Kimmerer (2013) for an extended discussion of how nonhumans 'teach' humans in certain Native American cosmologies. Most of Kimmerer's examples, however, do not have extensive domesticatory relationships with humans as does kōji, so the argument is somewhat different. For more on co-evolution and flavour, see Pollan (2002); Dunn and Sanchez (2021).

impossible without experiment: making 'propositions' to become 'attuned' to kōji's subjectivity (Donati 2016; Latour 2004b; Stengers 2002, 2008) and submit to its teachings.

6.2.2 Experimenting for multispecies consipience: translating miso

Once Lars could consistently make happy, healthy kōji, his next experiment was to figure out how to use this kōji to make miso. After growing kōji on pearled barley, 'a more native grain to Scandinavia' than rice, Lars searched for a comparable 'substitute for soybean'. He started by looking up 'all the different legumes that were common or native to Scandinavia,' and compared their nutritional composition to that of soybeans. A variety of yellow pea, already traditionally used, was the closest match. It also had the highest protein content of all the Scandinavian varieties he searched—ideal for an umami-oriented fermentation like miso.

Once Lars sourced the yellow peas, there were more parameters to investigate and adjust: how to cook the peas and how long, the ratio of peas to kōji, the salt concentration, the fermentation vessel and environment. After some trials, Lars settled on 'a relatively traditional' ratio of 3 parts peas to 2 parts kōji. The salt content, on the other hand, was at 'the extreme low end of what's possible.' Japanese misos range in salt content from 5.5% to 13% (Shurtleff and Aoyagi 1983: 31–2). Higher salt content 'allows you a different flavour range because you can age it much longer,' but lower salt content makes it 'much more usable as a product in the kitchen.' Through systematic experimentation, Lars learned that 4% was the lowest he could go, as 'anything below 4% ... goes lactic very, very fast, and the proteins start to, like, decay instead of [ferment].' All these trials and adjustments took more time than figuring out the kōji, as kōji ferments in 1.5-2 days, whereas the peaso takes 3 months. But without an established culture of miso-making, and short of apprenticing with a miso-maker, Lars' only option was to experiment with each variable, smell and taste, and experiment further, gradually developing knowledge of how to consistently create a miso using the ingredients and equipment he had available.

Experiment was also the only way Lars could become consipient with the miso. But this process was different from how he became consipient with kōji, or how brewers at Empirical like Daniel became consipient with yeast (5.2.3). Unlike kōji and yeast, which these chefs and fermenters understand and work with mainly as single species, miso is an ecology, comprising various bacteria and fungi that cooperate and compete, rising and falling in succession over the course of the fermentation. Developing the first peaso required Lars to become consipient with microbes other than kōji—ones he could now only get to know through smell and taste. He noticed that the lower the salt concentration (down to 4%), the fruitier the misos smelled as they developed. These sensory observations, combined with a couple pieces of microbiological and chemical knowledge—that salt inhibits most fungi, so lowering the salt concentration would allow more yeasts to prosper; and that the fruity smells come from esters, which he knew (from Arielle, his flavour chemist colleague) to be produced when alcohols produced by yeasts react with the acids produced by bacteria (Figure 43)—enabled Lars to infer that these fruity smells were likely the result of the increased presence and activity of flavourful and innocuous yeasts.

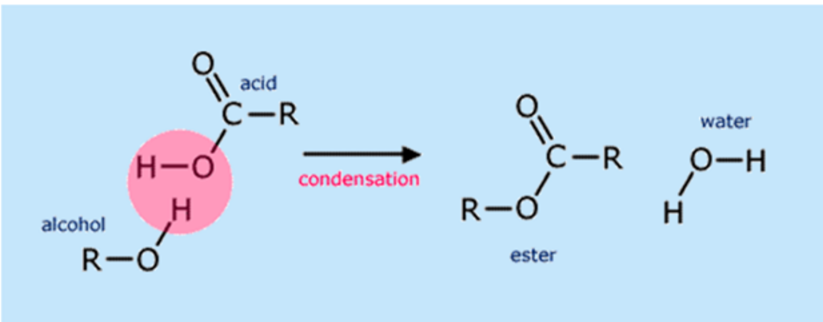

Figure 43—Diagram of ester formation (credit: https://byjus.com/jee/formation-of-esters/).

This is but one example of how Lars became consipient with the peaso's ecology, and illustrates a further type of consipience not discussed in Chapter 5. It is more complex than bilateral interspecies consipience, between a human and nonhuman species; it is multilateral, between humans and multiple nonhumans in ecological interaction. It is 'multispecies consipience'.

6.2.3 Co-constitution of kitchens & labs

Lars' experiments with translating kōji and miso illustrate two key points: the role of the senses, especially smell and taste, in driving culinary experiments; and the role of experiment in developing interspecies and multispecies consipience in the absence of an established intraspecific-consipient culture. Conversely, subsequent culinary experiments with kōji and miso at Noma, for example producing them with varied substrates, and further iterating them into products like clarified miso water, miso water reduction, lacto-fermented kōji water, or lacto-kōji water reduction, relied upon interspecies consipience with kōji, multispecies consipience with peaso, and subsequent intraspecies consipience among the R&D chefs. Experiment is necessary to develop consipience (when it does not exist already), and consipience is necessary to iterate experiments (especially when species other than humans are also involved). This reciprocal relationship between experiment and consipience persists throughout the R&D process—but in the case of translated fermentation wouldn't have been possible in the first place if not for Lars' initial experiments in the absence of consipience.

This section has highlighted these experiments' reliance not only on culinary skill and sensory engagement, but also scientific knowledge and practice—for example through Lars' systematic control of variables and experimental design in learning to make kōji, and his knowledge of ester formation shaping his development of the peaso recipe. Lars' experiments for interspecies consipience with kōji and for multispecies consipience with miso exemplify part of the argument developed in the previous chapter (5.4.1), that science and craft/sensory-driven knowledges do not just 'interact' as such, but co-constitute each other—conceptually (cf. Ingold 2000; Ingraham 2010; Mol 2012; O'Malley 2010; Paxson 2012), and materially (Redzepi and Zilber 2018; cf. Paxson 2012). The discussion presented here extends this argument spatially: that laboratories and kitchens are not a priori categories that come to 'interact' or 'hybridise', but the opposite—that the historical emergence of laboratories as a particular kind of epistemic space has happened gradually and contingently in contradistinction to and exclusion from other 'truth spots', such as kitchens, museums, technicians' workshops, hospitals, and other spaces whose craft-based roots they share (Haraway 1997; Latour 1987; Shapin 1988; Shapin and Schaffer 1985). In this sense, it is not at all surprising that kitchens and laboratories should now more recently be 'hybridising'—they are not developing a mutual affinity, but remembering the affinity they have already always possessed (2.3.2; Fitzharris 2017; Guerrini 2016).

6.3 SCIENCE: CULINARY EXPERIMENTS ARE MORE-THAN-SCIENTIFIC

In culinary experiments, sensory and scientific knowledges co-constitute each other conceptually, materially, and spatially. Yet science shapes not only how chefs use their senses, but also how they conduct culinary experiments in general. Some scholars have begun to identify and even contribute to this movement of scientific knowledge into culinary discourse and practice, particularly on the culinary vanguard (Borkenhagen 2017; Brenner, Sörensen, and Weitz 2020; Roosth 2013; Tan 2020; 2.3.2). Lars' experiments for becoming consipient with kōji and miso, and his peers' subsequent experiments with translated fermentation, demonstrate a new wave of this movement: where the experiments of culinary modernism have been predominantly physical and chemical, the NNC has, through fermentation, extended culinary experiments to the biotic realm, incorporating knowledges, practices, and tools from biology, ecology, and evolution.[180]

To analyse these culinary experiments' employment of technoscience, I draw on and modify geographer Thomas Jellis' concept of 'extra-scientific experiments' (2012), a concept he develops to theorise practices at the intersection of art, research, and public engagement. Jellis is wary of his own characterisation, which he fears might wrongly 'position everything in relation to science' (ibid.: 212). Given his aim to 'reclaim' experiment as a mode that does not inherently belong to science, his ambivalence toward the history of the concept emerging in the seventeenth-century Scientific Revolution is understandable (ibid.: 15). For my purposes, however, what is interesting is precisely how scientific practices, knowledges, and tools migrate into other fields, and so experiment's scientific history poses no concern.

In contrast to scientific experiments, Jellis' 'extra-scientific experiments' are 'exploratory', in that they do not involve testing hypotheses; 'processual', in that they are 'more concerned with process than product'; and 'ambiguous', in that they are rarely about success or failure (ibid.: 207–9). The culinary experiments described here differ in every respect: they are more or less exploratory, but always with some goal in mind; they value the creative process but are ultimately product-oriented; and while success and failure can come in gradations, it is always ultimately clear whether they are worth pursuing further—

[180] While long-standing practices such as culinary breeding and flavour-oriented agriculture might also be framed as such biotic culinary experiments, their different history and geography require a discussion of their own. Furthermore, while the life/nonlife distinction is useful for analysis here, it is not self-evident; see Tallbear (2012); de la Cadena (2015); Povinelli (2016).

does Redzepi like it?—or should be dropped, where failure is not a judgment to be avoided but a crucial and everyday part of driving the creative process forward (Tan 2020). The goal may vary in its degree of openness and specificity, but it is never absent. Even deliciousness is not alone sufficient for an experiment to succeed in the context of the restaurant—the deliciousness must be replicable at scale to be consummated. As I once observed David quip to Jason in the fermentation lab, when discussing an idea for a particular experiment: 'what's the point of a concept you have no way of recreating?'

These culinary experiments, then, are not 'extra-scientific', but what we might call 'more-than-scientific': rather than being in counterpoint to or outside of science, each, in their own way, takes up the tools, knowledges, and practices of various technosciences, and redeploys them for gastronomic ends. This section shows how scientific knowledges of microbiology, ecology, and evolution have been drawn into and made part of culinary practices and discourses, over and above modernist cuisine's focus on physics and chemistry, and further illustrates how these more-than-scientific culinary experiments mix different forms of expertise—abstract scientific knowledge, sensory observations, technological tinkering, and culinary craft. The following subsections describe how culinary experimenters employ microbiological knowledge in both practising and narrating their fermentation experiments, and suggest how these examples contribute to the STS literature on expertise.

6.3.1 Employing scientific knowledge in narrating experiments

As Lars and his colleagues at Noma delved deeper into fermentation, translating further techniques into the Nordic culinary lexicon and hybridising them with each other, they gradually learned more about the microbiology involved in their fermentation experiments. In the early days of these fermentation experiments, around 2010-2014, this knowledge was developed under the rubric of 'microbial terroir', as it helped to construct a distinctive Nordic microbiogeography (Ch4). Humans were present here, but mainly as a passive source of microbes (eg. in lactofermentations). Though Lars' initial experiments to develop the peaso were geared toward producing new flavours and sources of umami, rather than new microbial ecologies, positing that unique if not novel ecologies were involved in these taste-oriented experiments became part of narrating fermentation's role in Noma's constant innovation: as an engine for assembling and reassembling New/er Nordic nature (4.4).

By the time Redzepi and Zilber published *The Noma Guide to Fermentation*, in 2018, Noma's idea of where microbiological differentiation came from in their translated fermentation had shifted. There, instead of microbial terroir, they emphasise human agency and taste as actively shaping microbial natures: 'Our affection for the tastes those microbes produce has allowed them to evolve and stay in our company.' (Redzepi and Zilber 2018: 28) The *Guide* then connects these past selections with translated fermentation's ongoing experiments, for example in developing novel kombuchas:

> The first time we tried making kombucha from black garlic stock, the kombucha took [around] 20 days to acidify properly, more than twice as long as other varieties. We'd overlooked the garlic's natural chemical defense mechanisms. It contains a sulfur-based compound called allicin, which gives garlic its aroma and also fights off fungi. We suspect that the allicin in the stock was interfering with the replication of the yeast in the SCOBY. Fortunately, however, some of the yeast took hold. By the time we started the following batch, we had a healthy SCOBY specialized in fermenting in the presence of allicin. Fermentation is evolution in real time, and it's a fascinating process in which to take part. (ibid. 118).

David and his fermentation lab colleagues did not conduct extensive microbiological, metabolic or genetic analyses to confirm their hypothesis, or identify the exact mechanisms responsible for the suspected 'adaptation' of the kombucha SCOBY to allicin, whether a reconfiguration of the SCOBY ecology, metabolic adaptation to a new substrate, or evolutionary adaptation of existing taxa. Regardless, their empirical observations of the relatively rapid accommodations microbes can make to new circumstances, combined with a basic understanding of ecology and evolution, were sufficient to cultivate the suspicion that their experiments might be yielding not only gastronomic but also biological effects. Yet here, their scientific knowledge remains a framing device—shaping how they narrate and speculate about their fermentations, but not how or why they make them.

6.3.2 EMPLOYING SCIENTIFIC KNOWLEDGE IN PRACTISING EXPERIMENTS

Fermenters at Noma have been accumulating observations of such microbial differentiation for years, which has occasionally led to attempts to deliberately cultivate it. It was first with kōji that the explicit intention to cultivate microbial difference shaped material practice. As soon as Lars was able to make consistently happy kōji, he realised he could grow it not only to use in products like miso but also to let it go to spore, to produce further batches of kōji. He 'stumbled on something on the internet about someone growing their own koji spores,' immediately appealing because it was 'a better solution than having to buy it all the time'. At this point there were not many, if any, commercial producers of kōji spore in Europe, so procuring spore required placing orders to Japan. Yet, in addition to saving cost, Lars had another, more speculative motivation:

> I really liked the idea of having something that would evolve [from] being in a different place… my thought was the koji would evolve being in Scandinavia, would slowly become something quite different, in its own right.

Lars imagined this evolution might happen as a result of growing the kōji both in a different place and 'on different products', as he was 'originally using a yellow koji that wasn't a barley-specific strain.' He noticed that 'it always seemed like the second generation was like a little bit happier' in terms of how 'quickly' and 'robustly' it grew, and 'it would always seem increasingly strong until something was not good.'

> To be honest in the beginning we just didn't realise you could have an issue with going into multiple generations, so I think we were probably into 8 or 10 generations at the point where it started getting weird… It started getting a lot of black growth on it. [such as in Figure 44]

Figure 44—Black growth on passaged kōji, from my collaborative experiment.

This issue first arose in 2013. 'I did some more research, and at that point we had a few more connections in Japan… I talked to a couple sake guys, and they were like, ah yeah, of course, you can only use it like 3 or 4 generations!' From then on, 'we would only… go 4 generations and then start from a fresh batch. At the amount we were growing, it was quite easy to have a lot of kōji-kin [sic; tane-kōji, spores], because we'd make 3 or 4 kilos of just starter, and that would last us for months and months.' After a few attempts, Lars stopped his experiments in trying to facilitate kōji's evolution; but his curiosity about what was going awry, and whether it would be possible to help a Scandinavian variant emerge, remained.[181] Though his experiments didn't quite succeed, Lars' attempts to facilitate kōji's evolutionary variation provide an illustrative example of his scientific knowledge shaping his experimental practice. These experiments were more-than-scientific, in that they employed scientific knowledge (basic evolutionary theory), practices (culture passaging, inoculation, cultivation, sterilisation, etc.), and tools (incubators, cleaning ethanol, latex gloves, etc.) for gastronomic ends. But this is not necessarily to say that Lars was 'doing' science.

6.3.3 'Using' science without 'doing' science

The fermenters I came to know used scientific knowledge, tools, and practices in their culinary experiments, but, for the most part, they were not trying to do science or be scientists. They didn't care whether their experiments were seen as science or not, and technoscience was not central to how they narrated and valorised their culinary style.[182] They did not need to seek that sort of authority (Gieryn 1999), which they already possessed as cutting-edge culinary experts. Their interest in science was not about producing knowledge as an end in itself or making knowledge claims in scientific discourse, but in cooking and culinary distinction: using scientific knowledge to develop new culinary products, flavours and dishes. For them, science's value is instrumental, in service of their culinary goals. This use of science is similar to SSK's 'Mode 2' of 'Applied Science' (M. Gibbons et al. 2010)—but it differs in that it is unconcerned not only with

[181] Lars' experience became the basis for my collaborative experiment with kōji, to investigate whether and to what extent such effects were present (Ch3, Ch7, Appendices G & H). Lars' curiosity is now shared by the brewing team at Empirical, who have conducted similar experiments with passaging yeast to ferment new batches of wort; similarly, around the third generation, they usually go awry, becoming, as one brewer put it, 'pukey'.
[182] In contrast to culinary modernism, for which technoscience and scientism are the main agenda and a key part of the 'brand' (1.1.2).

basic research but even with being perceived as scientific altogether (for 'Mode 2' the same is certainly not the case).

Before proceeding, we should probably acknowledge 'science''s contingencies. Despite the attempts of mid-twentieth-century positivism, and after decades of critical work in science studies, it is probably safe to say that science has no universally coherent metaphysics; it is not 'unified' (Dupré 1995, 2016). Similarly, its boundaries are not fixed, but constantly negotiated and renegotiated, socially, culturally, and politically (Gieryn 1983, 1999). The disunity and contingencies of science, however, are entirely compatible with culinary experiments being more-than-scientific; what matters is that chefs and fermenters are using science for other ends. In short, these experimenters were 'using' science but not 'doing' science (Hodson 2014; Jiménez-Aleixandre, Bugallo Rodríguez, and Duschl 2000; M. Williams and George-Jackson 2014).[183]

This distinction between 'using' and 'doing' science may sound rather regressive against the robust strand of STS concerned with the political implications of perpetuating simplistic distinctions between knowing 'experts' and ignorant 'laypeople' (Callon 1999). Many scholars in this field have worked to reconceptualise expertise (S. Lane et al. 2011; Wynne 1992) and fiercely debated the relationship between technical expertise and public participation in making science policy (Collins and Evans 2002; Jasanoff 2003; Wynne 2003).[184] The distinction nonetheless seems to best describe the attitude these culinary practitioners have to their own experiments. New/er Nordic fermenters value science as a distinct kind of knowledge they can use, but do not give it special status among the many

[183] A distinction I develop from the science education literature, which finds it expedient to distinguish 'doing science' from 'learning science', 'learning about science', and 'doing the lesson'.
[184] Some scholars even argue that anyone who participates in practising science, in the broadest sense, is equally involved in enacting it (Szymanski 2020)—an intriguing though perhaps somewhat extreme position.

knowledges at their disposal. They may occasionally use science and its aesthetics as a way of securing cultural capital—but, unlike in culinary modernism, no more, and often less, than the other knowledges they employ. These culinary innovators often have professional relationships with various practising scientists, but do not pretend to participate as technical peers in the scientific communities who make the knowledge they use.[185] They implicitly distinguish between 'using' and 'doing' science (cf. Secord 1994), and do not feel the need to be recognised as 'scientists' for participating in data collection or other citizen science projects (cf. Eitzel et al. 2017).[186] Their attitude toward science—for them, a method for systematic experimentation yielding replicable results—is catholic, pluralistic, agnostic, utilitarian. Just as 'more-than-human' approaches to research recognise human agency but deny its de facto primacy (Whatmore 2006), 'more-than-scientific' experiments acknowledge the value of science without making it the point.

6.4 SURPRISE: CULINARY EXPERIMENTS OPEN AND CLOSE

Throughout the preceding discussion of culinary experiments' relation with consipience and being more-than-scientific, the experiments and their spaces exhibit an ambidextrous quality. Unlike Kohler's shifting 'border zone' between 'laboratory' and 'field' sciences across which nineteenth- and twentieth-century biologists 'shuttled' (Kohler 2002), or Gieryn's and Guggenheim's complications of lab–field spatialities (Gieryn 2006; Guggenheim 2012), or Latour's proposal of worldwide 'collective experiments' that abolish

[185] This attitude is not shared by all culinary practitioners. In contrast to the NNC, culinary modernism tends to explicitly, even staunchly, support the primacy of science as a way of knowing. Correspondingly, modernist chefs are increasingly interested in actually 'doing' science as well as using it. See for example the *Journal of Culinary Science and Technology*, *Flavour Journal*, and the *International Journal of Food Design* for many articles co-authored by professional, often renowned, and predominantly modernist chefs.
[186] Indeed, to be too explicitly aligned with technoscience would have compromised Noma's New Nordic ideology (Ch1).

the distinction entirely (Latour 1998, 2004a, 2011), these kitchens and fermentaries function fluidly as more 'laboratory' or more 'field' according to their needs. They facilitate both open-ended experiments in R&D and controlled, replicable experiments for production; they can be tightly structured for certain tasks, or opened up to the rambunctious microbial fray for others.[187] They are cell-like: semi-permeable, selectively porous, and reconfigurable according to purpose.

In short, these kitchens modulate their experiments' relation to surprise (Lorimer and Driessen 2014; Rheinberger 1997).[188] Lorimer & Driessen's account of 'wild experiments' in environmental science and conservation helps characterise how. Drawing on Lane et al. (2011), the authors use capitalised 'Experiment' as a 'theoretical caricature' of its positivist ideal, a 'useful heuristic' to show how wild experiments differ (Lorimer and Driessen 2014: 170; Table 4).

Table II Key properties of two models of an environmental science experiment

	Experiment	*Wild experiments*
Ontology	Transcendent order of Nature and Society	Immanent and indeterminate world of humans and nonhumans
Epistemology	Hypothetico-deductive method	Designed to generate surprises
Politics	Delegative: science creates facts, politics decides what matters	Dialogical: emergent collectives for generating and deliberating knowledge
Location	Laboratory (and occasionally the field)	The 'wild'

Table 4—Comparing 'Experiment' & 'wild experiments' (Lorimer and Driessen 2014).

Culinary experiments mix both, as examples throughout the thesis illustrate, and which this section will develop. Like wild experiments, their ontology is an immanent and indeterminate mix of humans and nonhumans, but like Experiment, tracing agencies sooner or later circles back to human orchestration (Ch2, Ch7; Evans and Lorimer 2021).

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[187] This configurability of kitchens and fermentaries is contrasted and qualified by some microbes' specific spatial needs (5.2.3).
[188] And, conversely, to replicability.

Their epistemology oscillates between more 'open' (pursuing the unprecedented in R&D) and more 'closed' (pursuing established replicable standards in production), akin, respectively, to generating surprises and testing/reproducing hypotheses (Rheinberger 1997: 80), though always with the goal of deliciousness that is replicable at scale (6.3). Their politics shift from dialogical during development, in which human team members give each other feedback (5.3.2) and human and microbial fermenters learn to affect and be affected by each other (5.2.2), to delegative when it comes time for experiments to be evaluated, and variations to be selected amongst and iterated further, as these selections are ultimately made by the (human) leader of the team (5.3.1); at Noma, for example, as an experiment moves from fermentation lab to test kitchen to production to service, authority to select moves with each section leader, under Redzepi's ultimate arbitration. Their location, of course, is kitchens, fermentaries, and other spaces of food production, which selectively combine elements of 'laboratory', 'field', and the 'wild' (Ch2, Ch4) into ever-shifting configurations, according to the task at hand.

Lorimer and Driessen note this 'ambiguity' of experiment, citing the OED's two rather opposing definitions: an 'operation undertaken… to illustrate some known truth', and 'a tentative procedure… adopted in uncertainty' (Lorimer and Driessen 2014: 169–70). These definitions map easily onto 'Experiment' and 'wild experiments' respectively. This chapter builds on their efforts, by opening up these two poles into a continuum of surprise and replicability. How kitchens and culinary experiments open and close according to purpose is perhaps their most significant epistemic feature, which will provide one of the dimensions along which we might situate experiments in general. In this section I describe how fermenters modulate their experiments throughout three successive stages: in planning and exploring, they try ideas out in principle and in practice; in iterating and selecting, they manage consistent variance and enhance desirable variance; and in codifying, they revisit and resist recipes.

6.4.1 Planning & Exploring: trying things out, in principle and in practice

Early in my fieldwork, I witnessed an encounter between different approaches to experiment in the Noma fermentation lab. The test kitchen had asked the team if they could figure out a way to preserve the flavour and texture of fresh vegetables and fruits, fennel for example, without the acidity and other transformations that come with fermentation. Jason wanted to try it out, and was attempting to engage David in planning a protocol (he thought a few minutes in pH 8 water, before being packed in sterilised 6-8% salt brine, might do the trick). David, however, insisted, based on a combination of scientific theory and his own experience, that the idea was impossible, because some transformation—microbial or otherwise—would always occur. Jason responded that it is worth trying, because even if it doesn't work it might illuminate why, which in turn might lead to some other new product or technique. David replied that 'the question is not whether it is possible—the question is whether it is possible to do here in a way that does not compromise the point of why we cook here,' implying that some experiments, like translated fermentation, are more appropriate to Noma's mandate than, say, hardcore chemical embalming.[189]

David and Jason's negotiation between thought experiments and practical ones involved adjudicating between different knowledge practices, different modes of trying things out: deduction from general scientific principles, or craft-based tinkering with specific

[189] Another instance of 'house style' shaping the kinds of experiment that are pursued (Tan 2020).

materials. These two modes are not inherently in conflict—in fact any culinary experiment relies on some degree of both. Trying things out in principle can help avoid wasting limited time and resources on experiments that are likely to fail, while trying things out in practice can yield surprises, sometimes productive ones, that principle would not predict. In this sense, thought experiments involving principled deduction help close and focus the field of variations, and practical experiments help open it up.

Knowing how things work in principle, though alone insufficient in the epistemic and working culture of the kitchen, is increasingly important as a complement to craft-based tinkering in the iterative culinary experiments of R&D (Johnson and Williams 2016: 98). Nonetheless, most of the culinary experimenters I observed ultimately favoured trying things out in practice, because practice, for chefs and fermenters, is what ultimately matters. Principle predicts one could grow kōji on starchy seeds like quinoa or buckwheat, but only practice will yield a suitable technique (ibid.). Principle is there to guide, not to dominate: Lars told me how, when first developing novel vinegars, he asked a microbiologist if it would be possible to make a celery vinegar; the microbiologist said probably not, but Lars' trials yielded successful and surprisingly delicious results. The devil is in the details, and the details need tinkering with.

Culinary experiments' practical orientation is not surprising—it is the only way in the end to be sure that a process works, as well as chefs' main source of authority when claiming knowledge of a process or technique. This tendency is found in other craft-based practices and echoed in the literature, for example, by Abrahamsson and Bertoni (2014), in their 'experiments with togetherness' through vermicomposting. Culinary experiments contribute to this literature (see also Paxson 2012) by framing the negotiation between knowledge from principle and knowledge from practice not as an epistemological zero-sum game, but as complementary co-production: the former are the abstracted accretion of the latter, the latter a material manifestation of the former.

This bivalent understanding of experiment dovetails with but ultimately diverges from the prevalent etymological conception of experiment, as articulated by Stengers and others. They coincide insofar as experiment can be understood, succinctly, as a medium of trial: the Latin root of 'experiment' and 'experience' is the verb *experior*, to try or test (Perseus Digital Library, n.d.); by extension, experience, from *experientia* in turn from the present participle *experiens*, is that which is acquired through trial; experiment, from *experimentum*, is the medium of trial; and expert, from the past participle *expertus*, is one who has tried and/or been tried.

Stengers (2008: 109, note 1) notes that 'experiment' and 'experience' are indistinguishable in the French ('expérience'), and employs the former neologistically as a transitive verb in her (English) exposition of Whitehead's *Process and Reality*. This intervention aims to dissolve any 'separation between the experimenter and what she is experimenting on or with', and 'to signal a practice of active, open, demanding attention paid to the experience as we experience it. For instance, a cook would be said to experiment the taste of a new dish.' While Stengers' use of a culinary example is apt, and her relational-ontological motivations sympathetic, her account of experiment leans so far into the open, practical side of experiment that it precludes culinary experiment's other, equally valuable dimensions, including its more closed, theoretical, deductive side. While David, Jason, and Lars would surely appreciate Stengers' championing of culinary work, they might wonder where she would locate their in-principle thought-experiments that happen before, after, and around the practical ones. Culinary experimenters certainly valorise practice for opening things up, but increasingly rely just as much on principle for closing things down.

6.4.2 ITERATING & SELECTING: CONSISTENT VARIANCE & DESIRABLE VARIANCE

Whether more open and practical or more closed and deductive, culinary experiments are not just, per Rheinberger, 'capable of generating and detecting difference,' (1997: 24) but are employed to generate this difference deliberately, producing variations to select from. As chefs make selections and gradually codify successful iterations into recipes, and as the product or technique shifts from development to production, it becomes less of an experiment as variation becomes less and less desirable. For many kitchens like Noma, this process of 'recipification' of experiments is integral to how their production and service function.[190]

Other, often smaller kitchens, such as Ernst in Berlin, view recipification with suspicion. 'There's no thought really behind each individual application of the 2%' salt in lacto-fermentation, Dylan Watson-Brawn, chef and founder and former Noma stagiaire, tells me, his fellow chef and founder Spencer Christenson nodding. Dylan goes on: 'I like variance. I do. Like I like it a lot. I think it's very important.' His purpose in cooking is to identify and draw out these variations in ingredients to attune guests to the conditions—breed, soil, season, agro-ecological practice—that give rise to them.

For example, several of their farmers grow fennel, but different varieties, environments, and treatments yield markedly different results. 'And I think that's amazing,' Dylan says, 'I don't want them to be the same.' One producer grows fennel that, when left in the ground

[190] Comparable to how 'reproducibility' and 'replicability' are seen by many scientists as crucial parts of good science—however easily much research with living organisms flouts them (ATCC 2017).

until late in the season, gets 'less anisey, less one-dimensional, it's more citrussy, it's got levels to that anise aroma and fennel flavour.' Dylan and Spencer have decided to salt it at 3.5%, because they have discovered it helps bring out these different flavours in the fermentation. They arrived at this level of salt through experimentation—first closing the process to focus just on salt-based lacto-fermentation, and on a fixed range of salt levels to try out. 'We can't ferment all fennel the same way. Because the results will be so [accidentally] different. That, for me, is a very important thing to note. And that's why the recipe is such a dangerous idea': because it forecloses the process by which a chef attunes themself to the specific variations of a product that make it special.

Experiment not only helps generate this variation, and helps a chef attune to it—it also helps to draw it out in the taste. Salting all the fennels at 2% might have let some of these differences emerge to some degree, as Dylan suggests above, but only accidentally; to illuminate these differences to their utmost requires developing different treatments tailored to each product. A standardised approach won't be 'inedible, but it won't be the best possible way to get the quality of that fennel which you want out of it.' Much of the STS literature on experimentation discusses its relation to standardisation: how the former variously relies on, enables, and works to transcend the latter, in different circumstances (eg. Gieryn 2006; Kohler 2002; Rheinberger 1997). Culinary experiments are no different, in that any experiment is open to some types of variance and closed to others; what is distinctive about them may be how human palates are the main instruments for detecting these variances.

Experimenters also have different attitudes to variance in general. Luke at Noma, recognising product variance as inevitable, was required to see it as something to be managed, and used experiment to keep it as consistent as possible (Ch5). For Dylan and Spencer, on the other hand, variance is something to be discerned, cultivated, and enhanced: it is, in Dylan's words, 'desirable variance'. While desirable variance may sound comparable to Rheinberger's account of experiments as designed to generate surprises (1997), they are not quite identical. For Dylan, unlike Rheinberger, the variance is often known beforehand. The function of experiment is to draw out in the preparation that which is already known and sought—the levels of fennel flavour, for example, or the distinct minerality of a prized Franconian apricot grown in clay-rich soil—rather than create the conditions for something unknown—a Rheinbergerisch surprise—to appear. The latter does sometimes happen, but it is not the goal.

Experimenting for desirable variance is not the same as being open to any variance at all. Dylan and Spencer would not welcome other variations in flavour that obscure the particular 'levels' they seek in the fennel, or the minerality of the apricot. It is not 'anything goes.' Still, Dylan's desirable variance is ultimately about change:

> That's where you're going to get your best results, if you work with change, and you celebrate change. As opposed to being like, I want *this* level of consistency, which is impossible. So you're going to create artificial circumstances for it, [yielding] a product which is theoretically full of life [but] which is devoid of life in a way.

For Dylan, excessive recipification, like the blind application of 2% salt in lacto-fermentation, is a tool of mass production akin to monocultural agriculture. It produces fermentations as biocapital (Helmreich 2008); alive with microbes, perhaps, but not 'lively' (Haraway 2008). Here some of the politics and material consequences of culinary experiment become clear: the more committed to generating, detecting, and in Dylan's words 'celebrating' variance in flavour, the more one is required to attune oneself, one's team, and one's guests to, and materially defend, the political-ecological conditions that enable such ingredients' lives—plant, animal, or microbe. Whether to manage consistent variance or enhance desirable variance, culinary experimenters modulate their experiments' openness according to their goals.

6.4.3 CODIFYING: RESISTING AND REVISITING RECIPES

Dylan and Spencer discuss above what they see as the dangers of recipification. While they resist settling into fixed recipes in the first place, using experiment to seek out and amplify desirable variance case-by-case, other chefs use experiment to shake up a codified recipe, reintroducing desirable variance from which new products might emerge.

Jason described to me how, after joining the Noma fermentation lab, he was keen to play with Noma's established recipe for lacto-kōji water—kōji, lacto-fermented in salt brine, blended, frozen, thawed, and strained, yielding a salty, sour, slightly sweet and fragrant liquid seasoning (Figure 45). David told him they had already experimented with all the grain varieties available to them for this application; but Jason just 'did it anyway'. Before coming to Noma, Jason had been working at 'a big distillation agricultural project' in Texas, where he 'became obsessed with wheat and grains.' He had grown kōji on some of the wheats, and had made lacto-wheat kōji water, which he wanted to introduce to the Noma team. Their standard lacto-kōji water at that point, in 2018, was made with fresh barley kōji, blended with 2 parts water, salted at 2%, and let to ferment at room temperature for 7 days. Jason 'had always done it with different amounts of salt, and different grains in the past.' With this specific wheat, Jason knew 'it can't be fermented for 7 days, it has to be fermented to the right specific point to where you get all the flavours of the wheat and then also the lactic acid bacteria and the fruitiness of the koji,' which was only 2 days. Upon tasting Jason's lacto-wheat kōji water, 'René's eyes just lit up.' Not soon after, it had replaced all lacto-barley kōji water on the menu.

Figure 45—Lacto-kōji water (Redzepi and Zilber 2018: 260).

Jason's experience with lacto-kōji water illustrates culinary experiments' dialectical relationship between recipification (closing) and desirable variance (opening). Though Jason was driven to draw out a specific wheat kōji's distinctiveness through desirable variance, in the Noma context its success meant it quickly became codified into a new recipe. What began as an experiment to generate something unprecedented soon became a matter of rote reproduction. Even institutions like Noma concerned with constant reinvention end up generating conventions—indeed, the convention of reinvention itself.[191]

[191] I thank Erika Szymanski for suggesting to articulate this convention explicitly.

Experiment can help attune to difference, but does not necessarily do so if the context prioritises consistency. A recipe, once opened, can easily close back into another.[192]

It must be in this closed, recipised sense that Paxson claims 'artisan cheesemaking' and 'running a series of laboratory-based scientific experiments' to 'have much in common,' or Harvard microbiologist Rachel Dutton that 'every cheese is an experiment in microbial ecology.' (Paxson 2012: 149; 158). Making artisan cheese may be open to a certain degree of desirable variance, certainly more than most industrial production; but Paxson also describes the lengths to which artisan cheesemakers go to prevent wholesale 'surprises', and the cost they bring when they happen. Whether Jason's lacto-kōji water or Paxson's cheeses, recipes tend toward closed experimentation, which culinary experimenters can resist or revisit with more open experimentation according to their style and goals.

6.4.4 Experimental 'borderline' to experimental 'border zone'

Culinary experiments can be more open or more closed. But they always involve elements of both: whether in the planning and exploring stage, by trying things out in principle and practice; in the iterating and selecting stage, by managing consistent variance and enhancing desirable variance; or in the codifying stage, by resisting and revising recipes.

This reconfigurability of culinary experiments expands Rheinberger's influential account of 'experimental systems' in productive ways. Rheinberger's work contributes to a larger tradition of laboratory ethnographies that illustrate how, unlike 'Experiment', laboratory experimental science is often 'practised without theory or even testable hypotheses, is infused with local values and must wrestle with unpredictable and surprising materials,'

[192] Here as well fermentation exhibits a relational rather than an essential politics (Ch1, Ch8).

and thus how these 'labs are much like field sites comprising experiments that are tentative, local and uncertain.' (Lorimer and Driessen 2014: 170). For Rheinberger, experimental science is speculative, powered by 'tinkering' rather than hypothetico-deduction (Rheinberger 1997: 186):

> An experimental arrangement must be sufficiently open to generate unprecedented events by incorporating new techniques, instruments, model compounds, and semiotic devices. At the same time it must be sufficiently closed to prevent a breakdown of its reproductive coherence. It has to be kept at the borderline of its breakdown. (ibid. 80)

For Rheinberger, experiments function optimally at this 'borderline', a singularity where maximum openness and sufficient closedness meet. This borderline, however, is predicated on the notion that any experiment is always trying to be as open as possible. The diverse culinary experiments described here, however, paint a more multidimensional picture. They can be more or less consipient, more or less scientific, and/or more open or more closed according to their purpose—and still be experimental. Rather than a 'borderline', they suggest a 'border zone' (Kohler 2002)—a richer conceptual space in which experiments, of all kinds, may be situated.[193]

6.5 SITUATING EXPERIMENTS IN THE BORDER ZONE

Bringing together works on experiment and cooking in geography, food studies, and STS to help address the thesis' fourth aim (1.4.1), I have developed the concept of 'culinary experiment' to make sense of the knowledge practices through which chefs and fermenters develop, refine, and circulate novel fermentations (Table 5). I identified three distinctive knowledge practices of culinary experiments—how they engage the senses, employ science,

[193] See also Hinchliffe et al. (2013) for a comparable topological shift 'from borderlines to borderlands' in their multispecies analysis of biosecurity and zoonoses.

and modulate surprise—through examples from New/er Nordic translated fermentation. I noted the co-constitutive relationship between experiment and consipience, drawn out from Lars' initial translations of kōji and miso and subsequent products. I described these experiments as more-than-scientific, and how by incorporating basic knowledge of microbiology, ecology, and evolution into culinary discourse and practice these culinary experimenters came to recognise and attempted to cultivate microbial differentiation. And I illustrated culinary experiments' reconfigurability, through which they open or close according to purpose—trying things out in principle and in practice, managing consistent variance and enhancing desirable variance, and resisting and revising recipes.

Knowledge practice	*Function in culinary experiments*	*Implications*
Engaging senses	Culinary experiments enable (and then are enabled by) consipience	Kitchens and labs co-constitute each other
Employing science	Culinary experiments are more-than-scientific	Culinary experimenters 'use' science without 'doing' science
Modulating surprise	Culinary experiments can open and close	Experiments can be situated across a 'border zone'

Table 5—Epistemics of culinary experiments and kitchens as truth spots.

As much of the literature bemoans, invocations of 'experiment' have become ubiquitous (2.3.2). The knowledge practices I characterise make it possible to relate different types of experiment to each other along common dimensions, situating them across the experimental 'border zone'. Two dimensions of this border zone might be called 'openness of goal' and 'unprecedentedness of outcome' (Figure 46). Experiments can also vary along a third dimension, which could be called 'degree of trial', the amount of trying required. This dimension relates to the experience and skill of the individual experimenter; the same experiment can be extremely trying or not at all depending on who is doing it. The diagram below controls for degree of trial by plotting the first instance of each experiment; other diagrammings might employ this third dimension.

Openness of goal has been discussed above; it relates to the experiment's purpose. Unprecedentedness of outcome is relative to the audience and context; the extent to which something is 'experimental' (in the novel sense) is related to the extensiveness of the audience for whom it is unprecedented—or alternatively the degree to which the audience is 'networked' (Latour 2005). For example, recreating a certain chemical reaction may justly be an 'experiment' for students who have not witnessed it before, even while the frontier of global scientific research is far elsewhere. Because an experiment's unprecedentedness is not essential to it but relational, negotiating its status can quickly become political, as much can hinge, as discussed, over how new different publics accept it to be. The rise and fall of 'experimental' discourse and its problems are thus comparable with the current obsession with 'innovation', and its motivation to downplay knowledge, or remain willfully ignorant, of what has come before. There are rich but insufficiently plumbed intersections here between STS work on experiment and agnotology, the study of ignorance and its construction (Proctor and Schiebinger 2008), which the current analysis might help illuminate (see Gross 2010 for a pioneering example).

In the border zone of the culinary experiments discussed here, the experiments are situated relative to NNC fermenters, at the time of each experiment's initial occurrence (naturally unprecedentedness decreases over time). I will discuss each kind of experiment moving along 'openness of goal', from more closed to more open.

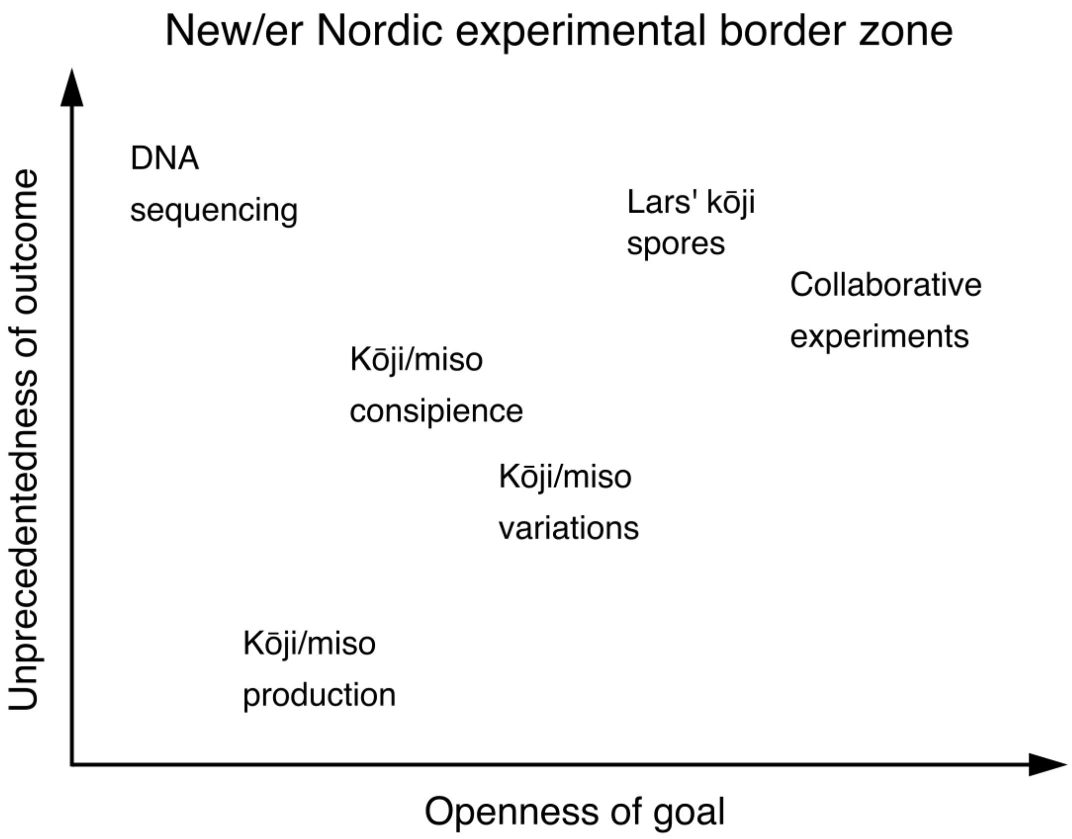

Figure 46—A diagram of the border zone of New/er Nordic culinary experiments, by openness of goal and unprecedentedness of outcome (relative to NNC fermenters, at the time of each experiment's initial occurrence).

The DNA sequencing of the collaborative experiments (Ch3, Appendices G & H) is one of this project's most closed experiments. It was not open to surprise; on the contrary, in order to work reliably, tinkering had to be oriented toward ensuring the protocols were followed and the instruments functioned as reliably as possible. In this sense, using the laboratory to do 'natural history' (Gan, Tsing, and Sullivan 2018) rather than 'reveal causality' (Kohler 2002: 2) makes the laboratory in fact the least experimental space discussed here. In contrast, the data these experiments generated constituted perhaps the most unprecedented outcome, as the microbiomes of these products had never been sequenced before. Similarly, the production of translated fermentations like barley kōji and peaso, once the recipes had been figured out and scaled, relies on precedent, and has little room for surprise; the range of acceptable or desirable variance is narrow. DNA sequencing and reproducing recipised fermentations at scale may still be considered ‘experiments’, insofar as they involve ‘tinkering’ and some degree of trial, however minimal. Yet the more closed experiments tend, the more they turn ‘into devices for testing, into standardized kits, into procedures for making replicas.’ (Rheinberger 1997: 80)

Moving toward the middle of this experimental border zone we find Lars’ initial consipient experiments with kōji and miso, whose results were quite unprecedented in the Nordic context. Though Lars did not know exactly what the outcome would be like, he had some idea from his research, and the ultimate goal was quite specific: making successful kōji and miso. The various iterated culinary experiments with kōji and miso, such as the lacto-waters and reductions, had slightly more open goals, as in development they were meant to produce desirable variance. On the other hand, these novel products were less unprecedented than Lars’ initial consipient experiments, though still more unprecedented than making them for production once the recipes were codified.

Moving further toward the more open end of this experimental border zone, we find culinary experiments for cultivating microbial difference, such as Lars’ initial experiments with growing kōji recursively for spore to see if it would adapt to its new context. Such experiments have been carried out in Japan for generations, but were quite unprecedented in the Nordic region. Even more open in goal might be the collaborative experiments to investigate possible microbiological change in translated fermentation (Ch3, Ch7, Appendices G & H), as they were simply interested in observing what might be happening, rather than producing a new ecology or strain for use. Though as they were based on participants’ previous experiments and observations, they were not as unprecedented.

Opening up experiment from a borderline to a border zone, in which experiments can be situated according to their openness of goal, unprecedentedness of outcome, and degree of trial, allows for experiments' differentiation and for adjudicating their typicity. This 'qualifying' approach offers a framework that might help characterise and compare diverse kinds of experiment in many contexts beyond culinary ones (Figure 47). Revisiting Rheinberger, it is not that a well-designed 'experimental system will be capable of generating and detecting difference, [as opposed to] confirming what is known' (Rheinberger 1997: 24). It is rather that the more closed an experimental system, the better it is at confirming or reproducing what is known (sometimes useful), and the more open an experimental system, the better it is at generating and detecting difference—up to the point of the experimental system's breakdown, where detectable difference becomes incoherence: difference whose source is no longer certain.

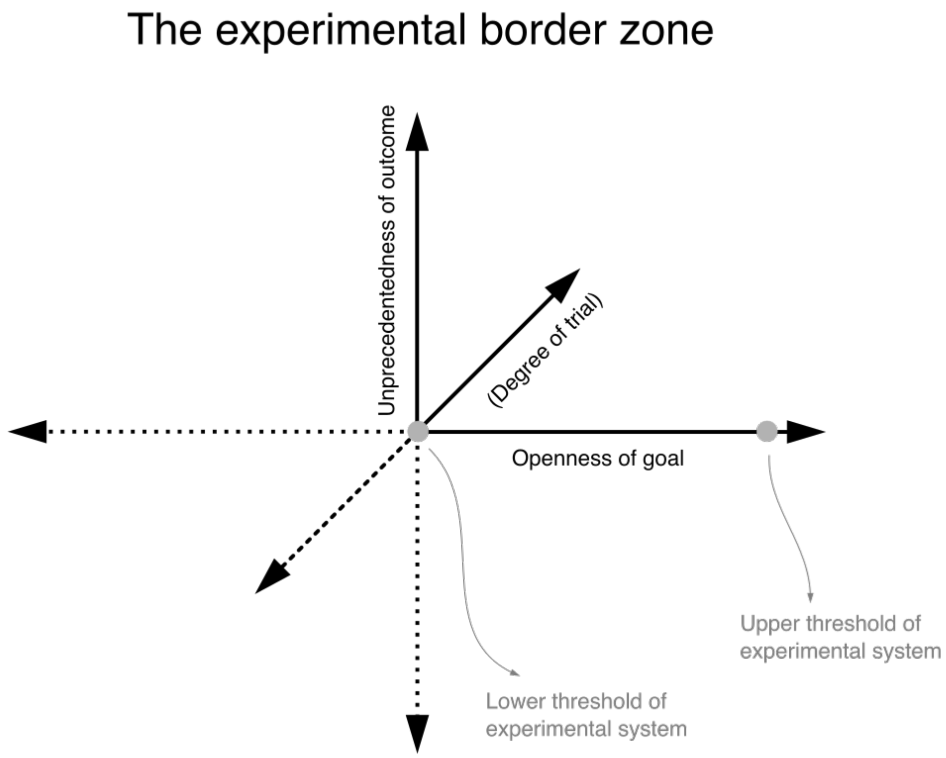

Figure 47—Model of the experimental border zone in three dimensions.

The experimental border zone does not just offer an account of how experiments work epistemologically; it also suggests how these epistemics are inflected politically (eg. Latour 1987, 2004c; Ch7). It further clarifies, for example, why fermentation has no essential politics (1.2.2). A fermentation's microbiopolitics varies according to the goal, scale, space, regulation, specific practices, and other contextual factors (Paxson 2008, 2012). The more open the experiment, the more space for microbes (and any nonhumans) to exhibit agency (Ch7). Yet much fermentation also occurs in a highly closed mode, particularly in large-scale industrial contexts, approaching and even crossing the lower threshold of sufficient openness beyond which it ceases to be experimental—becoming a 'device for testing', a 'standardised kit', a 'procedure for making replicas.' (Rheinberger 1997: 80) These replicas of course can and do still go awry when microbial agency diverges from human will. But it would be a mistake to ascribe to fermentation itself an essential potential to shift the more-than-human social order. Such a dream might be better located in experimental approaches to fermentation specifically—approaching Despret's understanding of experiment as 'transformation', as 'creating a becoming' rather than 'revealing a pre-existing reality.' (2004: 121) The more open the goal and/or unprecedented the result, the more such experiments might facilitate, though not necessitate, more response-able, care-full, convivial, interesting and interested multispecies relationships with microbes and other kin.

7 INTEREST

Edith Salminen is not a picky eater. A Swedish-Finnish food professional who grew up in Vietnam, she has lived in seven countries, speaks six languages, and has traveled widely. She vocally celebrates openness to new flavours and different deliciousnesses. So it's significant that, as a research intern at Nordic Food Lab, she encountered fermentation experiments being valorised she thought utterly inedible.

It was in the houseboat's bottom floor, in a cool room half below the water line, window propped open. The then-head of R&D, Ben, was leading a team tasting of long-term fermentation experiments, some with grains and legumes based on shoyu (soy sauce), some with fish based on garum. These experiments were, as Edith recalls, 'very ambiguous', barely 'structured or controlled or analysed'; 'everything was very spur of the moment… and the weirder the better.' Many had 'various types of moulds' growing on the surface.

Ben began tasting. Edith was 'very impressed'. She thought, 'if they're eating this, then you know, I can eat it too.' She joined in. But her 'whole body was just, not agreeing.'

Meanwhile, Ben 'was being very verbal about' how 'cool' and 'interesting' the experiments tasted.

> He kept on talking, being very assertive… It was a performance… I remember looking at him and [thought], I need to find some sort of reaction… that he's actually just wanting to puke… Cause it was not interesting, it was not funky cool, it was just bad. It had just gone.

For Edith, the whole situation was about being 'interesting':

> I have never used the word 'interesting' as much as I did at the lab. It was always 'this is interesting' and 'let's see where this can go'. It was like, this [being interesting but not necessarily palatable] is how it's supposed to be… From that day on I felt like, this is just not right. There are certain things that it's ok to say, this is actually rotten, and it's rotten to a point where it's not interesting.

Something more complex than 'de gustibus non est disputandum' seems to be at work here.[194] If for Ben 'interesting' meant something like 'novel and attention-worthy', for Edith it was not only an aesthetic judgment—being sensorially remarkable—but also an ethical one: that this remarkability, when it arises, is the result of appropriate and normative human involvement.

I will argue, as Edith implies, that in fermentation, the aesthetics of taste are bound up with an ethics of involvement. To be interesting is to be between the raw and the rotten (cf. Lévi-Strauss 1983);[195] between the lower and upper thresholds of the fermentation's experimental system (6.5); between total domination of microbes and environment, and total submission to the microbial fray; between rule-bound 'tradition', as Edith recounted from her gastronomic education in Italy, and the 'rule of no rules' she encountered on the

[194] 'There is no disputing taste', an ancient Roman maxim frequently cited in food discourses.
[195] Fermentation, and its absence in Lévi-Strauss' famous 'culinary triangle' (Lévi-Strauss 1966), further question the latter's logic.

bleeding edge of restaurant cookery in Copenhagen. To be interesting, and interested, is, in short, to be in between.

7.1 INTRODUCING INTEREST

Throughout my ethnography, it was impossible to separate the aesthetics, ethics, knowledge practices, and politics of translated fermentation experiments. I needed a way to discuss them together, without washing everything into blandness.

'Interest' kept appearing in my ethnographic data, explicitly and in cognates, as an aesthetic-ethical concept that promised new relational terrain, different from control and domination but not more innocent, for understanding translated fermentation practices, their more-than-human politics, and their material consequences. For many of my participants, as for Edith, interest meant sensory remarkability resulting from suitable human involvement—an aesthetic of novelty entailing a being-in-relation. Concurrently I noted it invoked throughout the STS literature, though never receiving systematic analysis. My empirics and the literature called out to each other, asking me to develop this concept they held in common in ways that might be useful to others.

Interest is not new, but it has somewhat fallen out of use (2.3.3). In this chapter I aim to recuperate interest as an analytic, and to demonstrate the possibilities it still offers scholars in multispecies studies, STS, more-than-human geography, and related fields. Interest has at least three theoretical advantages over related concepts. First, interest addresses shortcomings of 'co-' configurations like 'collaboration', 'conviviality', and comparable metaphors of 'togetherness', which in championing relationality can flatten out or ignore asymmetries (2.3.1). Mere togetherness matters less, and is less 'interesting', than how actors become interested, how they come to be or are put in between. Second, interest obviates the issue of intentionality often debated in domestication studies. Agencies can be distributed and differentiated without recourse to deliberation. Third, interest is species-agnostic: it works as well for humans as nonhumans, and thus apt for multispecies use. These features make interest a useful concept in discussing domestication (Ch8).

Interest also places the preceding analytic chapters in new light. It frames the social and institutional impulses that led Noma to shift from the New to the Newer Nordic as a combined aesthetic, ethical, and political matter (Ch4); it helps explain how and why consipience works (Ch5); and it situates all experiments between the two ideals of total control and total openness (Ch6). In bringing together discussion of how fermenters come to know and shape their microbial partners, and with what consequences, this chapter addresses the second and third subsidiary research questions on taste and modes of shaping, and helps fulfil the thesis' fourth aim (1.4.1). In developing this concept of interest, I offer four contributions: (i) a differentiation of the interesting as an aesthetic category, through an articulation of the 'culinary interesting'; (ii) development of the concept of 'micro-governmentality', a complementary, inverse concept to Paxson's 'microbiopolitics'; (iii) an illustration of the mutual necessity of evolution and involution; and (iv) the figure of the rolling torus for thinking interest topologically.

I begin the analysis with the 'interesting' as an aesthetic category. I build on Sianne Ngai's work to sketch a complementary concept of the 'culinary interesting', whose material consequences I discuss with DNA sequencing results from my collaborative miso experiment. Being interesting requires becoming interested, and in the following section I discuss methods of becoming interested across the main stages of fermentation practice—

what I term 'Initiating', 'Guiding', 'Halting', and 'Embodying'. I draw on Callon, Paxson, Foucault and others to sketch this 'ethics of involvement' and outline some of their political implications. Interest—being interesting and becoming interested—does not just shape intimate, dyadic encounters; it also structures the differentiation of life across deep time. In the final section, I frame interest as the co-constitution of involution and evolution. I illustrate their mutual necessity with DNA sequencing results from my collaborative kōji experiment, and develop the figure of the rolling torus for thinking interest topologically. To conclude, I identify interest's complementary values of 'betweenness' and 'both–and'-ness, and suggest how this concept might be useful to others.

7.2 THE IMPORTANCE OF BEING INTERESTING

Interest's commonest form might be 'interesting': an aesthetic, affective category describing how something draws us closer, invites further consideration. I aim to show how this aesthetic dimension is bound up with interest's epistemological, ethical, and political dimensions (2.3.3). First, I must discuss what kind of aesthetic, affective category interest is. In this section, I draw on literary theorist Sianne Ngai's discussion of the interesting, and its relation to the beautiful and the new. Setting Ngai's understanding of the interesting in dialogue with ethnographic material from Noma's R&D kitchen, I note important differences, which leads me to suggest the complementary concept of the 'culinary interesting'.[196] I conclude with why the aesthetics of the interesting matter: I discuss the material consequences of the culinary interesting, with DNA sequencing results

[196] Though I develop the 'culinary interesting' in this elite, professional context, in principle it can act wherever cooking does, including domestic kitchens. I thank Anna Sigrithur for this note.

from my collaborative miso experiment. We will then be able to discuss the connection between aesthetics and ethics.

7.2.1 AESTHETICS OF INTEREST: THE INTERESTING AND THE DELICIOUS

Ngai traces the interesting to the nineteenth-century German Romantics, for whom it represented a new aesthetic category distinct from the beautiful: if the latter was 'objectively rule-bound, universal, and disinterested', the former was 'restlessly subjective and idiosyncratic' (Ngai 2008: 782; 2.3.3). The interesting thus constantly shifts in pursuit of novelty.

As this pursuit has become ambitious restaurants' driving force in recent decades (Leschziner 2015; Pearlman 2013; Tan 2020), it is not surprising that those on the culinary vanguard mobilise a comparable distinction, between the 'interesting' and the 'delicious'. In a New York-based focus group tasting of Empirical's products, an anonymous participant compared Empirical's appeal to that of 'tasting menus at progressive restaurants': 'I've always had a course where I'm like 'Gross' but it was interesting, like "Oh, this challenged me" and I'm not bummed out by that idea.' If the delicious is about pure gustatory pleasure, the interesting is about pleasure of another kind: to be challenged, to be tried (6.4.1), to try something one has never tried before.

These two pleasures are not mutually exclusive, and the interesting can also come to shape one's sense of the delicious. Each also varies between people (unlike the nineteenth-century beautiful). Most notable is how eaters and cooks in the experimental culinary milieu understand this relation differently. For many eaters, as above, something may be interesting and delicious but need only be one of them to be worth eating. For cooks at

Noma, and producers at Empirical, something must be both interesting and delicious (to them) to be servable.[197]

Junichi Takahashi, a chef at Noma since 2012 and in the test kitchen for the most recent years, described many examples of this requirement. He described how at Noma 2.0 René tasked the test kitchen with cooking a lobster dish Noma had served a decade before, as part of the R&D process for creating a new one. 'It was delicious… very good. It just [snapped his fingers] didn't have that "Woww", you know? … Maybe we can serve at any bistro, but we can't serve at Noma. It's still good, very good, but it's just a bit boring to eat.' For Jun and the test kitchen team, the purpose of R&D is not just to make things delicious, but to 'make a new flavour, new cooking techniques'—to 'make crazy interesting things,' he told me with a laugh.[198]

These examples do not just point to different relations of the delicious and the interesting. They also suggest a new interesting that departs from Ngai's.

7.2.2 DIFFERENT INTERESTINGS: DISTINGUISHING THE CULINARY INTERESTING

Ngai develops her aesthetics of the interesting from specific works in literature and art, so it is not surprising that her characterisation 'make[s] the interesting more aesthetically central to the history of some artistic genres'—and entire media—'than to others' (Ngai 2008: 790).[199] For the same reason, observing how the interesting functions among Noma's

[197] This is also the ideal of many critics, like Lisa Abend (Ch4): for dishes to be 'interesting and delicious at the same time'.
[198] This 'interestingness imperative' seems to exist for many objects of connoisseurship (I thank Erika Szymanski for suggesting to make this explicit). The relationship between interestingness and connoisseurship would be a worthy topic for further study.
[199] Ngai's analysis might also be fruitfully extended to, and rearticulated through, the modernisms and avant-gardist movements of the early twentieth century.

culinary innovators suggests a somewhat different aesthetic category.[200] If the former is a 'literary' or 'artistic' interesting, we might call the latter the 'culinary' interesting. Here I outline five points of divergence between the literary-artistic and culinary interestings, and an additional feature of the culinary interesting not present in Ngai's analysis.

The culinary interesting is not wholly different from Ngai's, however. They have at least two characteristics in common: historicity and contentlessness.

1. *historicity*

   Ngai argues that 'far from being an ahistorical abstraction, the interesting is a specifically modern response to novelty and change (which is a noticeably irrelevant issue when it comes to the beautiful)' (ibid.: 789). The same is true for the culinary interesting, just that its historical emergence is more recent (the delicious has also changed over time but that is another matter).

2. *contentlessness*

   Ngai outlines that the literary-artistic interesting is 'semantically blank' (ibid.: 787), or 'what Hegel would call its lack of content' (ibid.: 789). The same is true for the culinary interesting—it does not refer to a specific sensory feature, taste, aroma or look, but rather to an affective feature of being arresting, inviting attention. It is an aesthetic judgment, but one not inherently tied to any particular quality. It is relational.[201]

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[200] While the 'interesting' is also invoked by eaters, as above, I develop the culinary interesting based on culinary innovators, because they are the ones whose taste shapes microbial natures. Whereas Ngai distinguishes between the artist and the critic, in this case these chefs and fermenters are both. If developed from eaters, the culinary interesting might look different.

[201] Though not quite in the same way as 'relational aesthetics', 'which take as their theoretical and practical point of departure the whole of human relations and their social context, rather than an independent and private space.' (Bourriaud [1998] 2002: 113) This relationality is neither as specific as that of the interesting, nor as radical as that of social theory, in which relations precede relata.

From here the literary-artistic and culinary interestings diverge, in at least five ways. While the former, for Ngai, is ambiguous and provisional, ambivalent, 'mere', repeatable, and universal, the latter is the opposite: clear and final, definitive, absolute, momentary, and contextual.

1. *ambiguous & provisional // clear & final*

   Ngai argues that 'interest begins as a feeling of not knowing exactly what we are feeling.' (ibid.: 789) This feature 'makes interesting so useful as a syntactic placeholder, enabling critics to defer more specific aesthetic judgments indefinitely. Interesting thus becomes particularly handy as a euphemism, filling the slot for a judgment conspicuously withheld.' (ibid.: 787) Culinary innovators at Noma and Empirical, however, know exactly what they feel—that something is notable, not only delicious but worth pursuing further, worth attending to, and ultimately worth serving. For them, the interesting is not a 'placeholder' or 'on the way' (ibid.: 800) to an aesthetic judgment, but an aesthetic judgment itself. It is not a point of departure, but a destination striven for.

2. *ambivalent // definitive*

   For Ngai, 'the wavering between the boring and interesting seems internal to the interesting' (ibid.: 788). For culinary innovators, as Jun demonstrated, the interesting is the boring's definitive antithesis.

3. *mere // absolute*

   For Ngai, 'interesting always seems to come with this merely attached to it, as if to highlight its indeterminacy' (ibid.: 789). 'The feeling at its root' is 'a feeling so low in intensity that it can even be hard to say whether it counts as satisfaction or dissatisfaction, feels good or bad to feel (in contrast to the unequivocal feelings of pleasure/displeasure that give rise to judgments of the beautiful/disgusting)' (ibid.: 788). If Ngai's interesting has 'low affect' (ibid.: 788, 794), the culinary interesting has high affect. A dish or product is never 'merely' interesting—it is interesting absolutely.

4. *repeatable // momentary*

For Ngai, 'interest has the capacity for duration and recursion' (ibid.: 785): 'the object we find interesting is one we tend to come back to, as if to verify that it is still interesting. To judge something interesting is thus always, potentially, to find it interesting again.' (ibid.: 786) The culinary interesting, meanwhile, is guaranteed to be no longer interesting at some point in the future. A culinary concept can be updated to be made interesting again—such as a classic Noma serving of musk ox tartare with wood sorrel from c.2010, eaten with the hands (Figure 48), revisited with reindeer tongue in 2018 (Figure 49)—but then, it becomes something new.

Figure 48—Musk ox tartare, c.2010 (credit: winelab)

Figure 49—Reindeer tongue tartare, 2018 (credit: Foodle)

5. *universal // contextual*

For Ngai, 'to call an object interesting is to claim that it is *objectively* interesting. Indeed, to judge an object interesting is to claim that everyone who encounters it *will have precisely this feeling*' (ibid.: 787, note 32; original italics). This position is based on her interesting's being a 'placeholder', a constant deferral of judgment. But, just as the culinary interesting is not a placeholder but a definitive judgment, it is tied both to a specific moment in time and to a specific subject or group with a common understanding of what is not interesting. The culinary interesting is contextual—for Noma, not only in relation to more conventional cookery or the broader culinary vanguard (as social distinction would predict; Bourdieu [1979] 1984), but especially in relation to their own repertoire of dishes and flavours once interesting but no longer. Noma's culinary interesting is relational mainly to its own history.

In addition to these differences, the culinary interesting mobilises an extra feature that does not figure in Ngai's discussion: the aesthetic value of work.

6. *aesthetic value of work*

The culinary interesting is about not just novelty but challenge. Jun described how the test kitchen won't use many typical fine-dining ingredients that are 'very tasty' but also 'not interesting'. They forgo turbot, for example, instead working with more 'difficult', 'challenging' ingredients like cod bladder (5.3.1). 'It's not as tasty as the turbot, actually, you can say. But we can make it better than the turbot.' The culinary interesting thrives on making deliciousness where it might not have been before. There is a special aesthetic value in work, in having worked, in being challenged, in having tried (Ch6), that cannot be claimed otherwise.

Having identified the culinary interesting and distinguished it from Ngai's, I must note that the culinary interesting, like the delicious, is a necessary but not sufficient condition for a product or dish to be approved for production and service.[202] It must also conform to and advance 'house style' (Tan 2020). Jason named innumerable products and servings he had developed—enzymatic scallop sauce, chili pastes, spice blends—which everyone in R&D thought 'interesting' and 'delicious', but 'not for Noma'. Often this was because the product tasted too close to an existing cuisine—Japanese, Korean, Vietnamese. The task was to create in the space where the delicious and the interesting not only coincide, but where their coincidence has no reminiscences: where it lies in between established tastes. Novelty is a norm embedded into Noma's house style, and that of many vanguard restaurants. This feature of the culinary interesting bears some relation to Ngai's observation that 'the judgment of interesting is underwritten by a realization that the object is meaningfully different from others of its type' (Ngai 2008: 789). Here, however, the culinarily interesting is that which is sufficiently different to claim a new type unto itself.

Ngai's literary-artistic interesting and the culinary interesting I develop here share some features, including historicity and contentlessness. They then diverge across five dimensions of clarity/finality, definition, affectivity, temporality, and extension. The culinary interesting also involves a new dimension: the aesthetic value of work. Its importance is often modulated by house style. Taken together, these differences suggest that though the interesting may have been 'invented expressly by and for literary critics'

[202] At least at Noma and Empirical, though I suspect it holds for similarly exacting restaurants and producers.

(Ngai 2010), constituting Ngai's 'we' (Ngai 2008), this aesthetic category has both spread into other domains and changed as a result.

7.2.3 INTERESTING MATTERS: THE MATERIAL CONSEQUENCES OF AESTHETICS OF INTEREST

The search for the culinary interesting is what drives Noma's R&D, and, along with the delicious, is a necessary (but not sufficient) condition for something being servable. Contrary to Ngai's, the culinary interesting is not 'cool', detached, 'merely' so, or 'trivial' (Ngai 2010: 950–1)—it is charged, involved, crucial, and consequential. The pursuit of interesting novel misos, for example, doesn't just make new flavours—it also materially shapes their microbiology. The DNA analysis from my collaborative miso experiment data suggests that varying the miso's proteinous substrate shapes its microbial ecology (see Appendix H for a thorough discussion of the following findings). These data also show more diversity in miso ecology than currently exists in the miso literature (in English; ibid.), which suggests there is a broader range of microbes involved in making miso, especially novel ones, than currently understood.

Additionally, 'treatment' (factors of human involvement, eg. choice of substrate, nixtamalisation) seems to have more influence on microbial composition than mere geographic location, at least at the level of genus (ibid.). For example, misos made with yellow peas and barley kōji, using the same ratio and recipe, at Noma in Copenhagen and at Noma's then-sister restaurant Inua in Tokyo, had comparable ecological compositions (ibid.). This finding supports the shift in fermented food microbiology around 'microbial terroir', from positing unique place-based microbiota to emphasising patterns of human involvement (Wolfe et al. 2014; Ch1, Ch4).

These findings suggest how the aesthetics of the culinary interesting matter. Yet the interesting does not emerge equally in every fermentation—some practices, values, and contexts bring it forth more than others. To be interesting requires becoming interested, which operates through an ethics of 'involvement'.

7.3 BECOMING INTERESTED: ETHICS AND POLITICS OF INVOLVEMENT

The interesting is an aesthetic sometimes coincident with but distinct from the delicious. It has diverged from its literary-artistic sense and taken on new meaning in the culinary world.[203] And it has material consequences. Yet it is not only an aesthetic, in which a subject apprehends and considers an object's appearance (Kant [1790] 1951) but neither is necessarily changed as a result. Interest not only attracts—it involves. Just as when Stengers, Despret, and Latour say that science must be interesting, they mean not only that it fascinates or draws close but that it involves, implicates, and forces one to risk being changed (Stengers 1997; [1993] 2000; Despret 2004; Latour 2004b; 2.3.3), so the culinary interesting leads not to mere 'disinterested' apprehension of flavours but to 'involving' oneself (Hustak and Myers 2012) in nonhumans' lives and livelihoods. This is an ethics which is impossible to separate from aesthetics (Wittgenstein 1922: entry 24.7.16; 1969: 6.421; Collinson 1985; Ch4). It is not an ethics calculated systematically based on utility (Bentham 1879; Mill [1863] 2002), deduced from first principles of virtue (Aristotle 2000), or guided by a categorical moral imperative (Kant [1785] 1998); rather, it emerges in contingent, messy, day-to-day demands of production and decisions of care (Puig de la

[203] That cooking be interesting (i.e. innovative for its own sake) is a relatively new norm, prefigured by the Nouvelle Cuisine (and one might argue by Marinetti's *Futurist Cookbook* ([1932] 2014)) but only emerging explicitly with culinary modernism (Ch1).

Bellacasa 2017) not always deliberated upon. Here I trace how this ethics of involvement manifests through the aesthetics of the interesting, over the main stages of the fermentation process: in what we might call Initiating, Guiding, Halting, and Embodying.

7.3.1 INITIATING: INTEREST AND INTERESSEMENT

Human fermenters vary their degree and kind of involvement in initiating fermentations. Some types, like lacto-fermentations, welcome human inoculum through hand contact; others, like kōji, prefer stricter conditions of sanitisation to thrive. These relations are all post-Pasteurian, in that they are discerning (Paxson 2008, 2012). But discernment alone does not explain fermenters' different modes of involvement in initiating fermentations.

Taste also matters. 'I feel like I have a very delicious biome,' Kim Wejendorp, R&D chef at Restaurant Amass, told me playfully. In preparing lacto-fermentations, he was 'aware of trying to get [him]self in contact with the things that are fermenting, to provide the culture.' In such cases, as Kim says, 'you are your own deliciousness'. On the other hand, some fermentation processes can go most desirably with more distance. Kim as well as Hiro Takeda, then head of R&D at Empirical, both noted how gloves are a useful tool for anonymising hand taste—for when individual variations are less desired than a consistent house style, as well as when the risk of introducing undesired microbes is high, such as in making kōji. Sanitisation is also useful here, preparing equipment to receive a desired culture and help it predominate.[204]

[204] Beyond considerations of how to introduce the microbes, Jia Hao in the Noma fermentation lab identified how even seemingly small decisions, like whether to peel one's vegetables and how to cut them, also affect the taste (and perhaps also the ecology).

These different modes of initiating involvement can be framed by comparing interest and interessement (Callon 1984). When Kim or Hiro use gloves to withhold hand taste's effects, or sanitise surfaces to help kōji flourish, they are 'interessing' the ecology or species: they are keeping other actors, microbial or otherwise, from defining the nature of the system differently. When they welcome hand taste in lacto-fermentation, they are opening up the possibility of it being more 'interesting'. It is risky, but worth the potential result.

If interessement is hierarchical, competitive, authority-seeking, interest is more heterarchical, open, provisional. They are not a logical binary but gradations on a scale of involvement. Their difference is clarified by their different object relations and prepositions. Interessement features an active subject and passive object, which must be 'captured' from other competing subjects; it takes the preposition 'from', as in 'Kim interessed the growing kōji from the *Bacillus subtilis* bacteria.' Interest involves both active subjects, which can mutually interest and be interested in or by something, as in 'Kim interested the kōji in growing on rye by cracking the grains first' and in turn 'the kōji interested Kim by producing some distinct banana aromas.' This difference corresponds to Stengers' (1997) description of 'faire écran' (make a screen, a block) and 'faire lien' (make a link, a relation). But whereas Stengers, and Despret and Latour in turn, seek to reclaim the latter as interest's primary sense, fermentation practices here demonstrate the importance of each, in respective contexts.

Sometimes, interest and interessement are both engaged to manage consistent variance (Ch5) and the risk of the not-delicious. Kim described to me the risk involved in making Amass' fermented potato bread. 'When stagiaires peel the potatoes for the potato bread, [sometimes] you'll get batches that are bad,' and 'a week's worth of potatoes', sometimes two or three, has to be thrown out. 'That's just how it is,' but 'everybody gets a go, because you don't know [whose biome is delicious or not] until afterwards.' The potatoes' lacto-fermentation initiated by the staigiare doing the peeling is what enables the potatoes to become interesting; though if the result is interesting but not delicious and/or not conformant to house style, the process must then be interessed away from the staigiare in question. 'Either they're incredibly unclean, or they just don't have a good biome,' Kim joked, but quickly realising the implications of such a statement, soberly clarified: 'I mean I don't mean a "good" biome, just not particularly delicious.'

A politics of hand taste emerges here. Some people were discovered to have more 'delicious' biomes than others (relative to the intraspecific-consipient context; Ch5). Once this 'deliciousness' became apparent, it did not index to any obvious social category (race, gender, age, class, nationality, etc.). But, in this ambitious restaurant kitchen, the deliciousness of one's microbiome became consequential as a new category of social differentiation. It came to shape whether a stagiaire could make the potato bread again, improve, and gain knowledge and skill in lacto-fermentation. It may have shaped their access to subsequent learning opportunities and experience. It certainly inflected their social position in the kitchen.[205]

7.3.2 Guiding: governing the 'micro-society' with 'micro-governmentality'

> There's a thin line between rot and fermentation, and that line might best be understood as an actual line, like the kind you'd find outside a nightclub. Rot is a club where everyone gets in: bacteria and fungi, safe or unsafe, flavor enhancing or destructive. When you ferment something, you're taking on the role of a bouncer, keeping out unwanted

[205] To my knowledge, these chefs have not made attempts to see whether 'delicious' microbiomes are associated with specific microbial communities (yet).

> microbes and letting in the ones that are going to make the party pop. (Redzepi and Zilber 2018: 29)

Being involved is what distinguishes fermentation from rot. Being involved demands making decisions about how the fermentation party develops. To extend Zilber's metaphor, it means being not only the bouncer, but the promoter, bartender, sound engineer, and DJ.[206] To gain any specifically desired balance of taste, and often even for the process to succeed, a fermenter must guide the process accordingly.

These guiding practices are frequently conceptualised by fermenters and scholars alike in terms of human 'control', often implied as an all-or-nothing proposition (eg. Chera 2012; Maroney 2019).[207] Yet 'control' means different things, and exists in gradations (Spackman 2017). Building on interest and interessement as complementary strategies in initiating fermentations, here I outline the politics of two prevalent notions of control, think through their relation to interest, and discuss their implications.[208]

Wine emerged for many participants as a useful case to think with. Louise Beck Brønnum, a 'gastrophysicist' then working in R&D at Restaurant Alchemist in Copenhagen, pointed to more extreme instances of so-called 'natural' wine, wine made with minimal intervention from the winemaker, as a good example of 'how important humans actually are [in the fermentation process], because if there's no human trying to control to create the balance it doesn't become a nice wine'. Louise stated her love for many natural wines, crafted by the winemaker with discernment, involvement, and care. But as she said, her

[206] The club metaphor is also apt because it reflects how fermentation, and thus any of its politics, rely on exclusion as well as inclusion (1.2.2).
[207] See also 'control and confinement' as common indices to domestication (eg. in Clutton-Brock 1989; critiqued by Lien 2015; Swanson, Lien, and Ween 2018; 1.3).
[208] There is kinship here between the ethics of involvement and STS work on 'ontological choreography' that draws in performative, embodied, and rhythmic qualities to offer an alternative metaphor to control (Thompson 2005; Haraway 2008: 65–7).

'problem sometimes with nature wine' is the occasional producer's attitude that 'I just leave it there and it will just do its own shit. But you can't just do that, it's a society, and if people just could do whatever they want, it wouldn't work.'

Multiple participants framed fermentation in human social and political terms, which I will revisit shortly. For now I want to focus on Louise's ambivalence about the word 'control'. After discussing how 'good craftsmanship' involves 'controlling the fermentation in a nice way,' she immediately reflected that 'I don't want to use the word control, but [rather something like] understanding [how] to create a beautiful product in the end.' When asked why she didn't want to use the word 'control', she returned to this idea of 'balance'. 'Control can be a good or a bad thing… It's a matter of degree.'

Louise and others' ambivalence towards 'control' seemed to stem from 'control' referring simultaneously to quite different ways of being involved in the fermentation process. If control often connoted an impossible ideal of absolute, dominating, hypermasculine mastery (Plumwood 1993), it also denoted a range of practices of involvement, of becoming interested, of partial agency, of acknowledging one's necessary implication in the fermentation process and at the same time refusing mastery's dream. Even if I might be inclined to move away from 'control' in analysis entirely, its multivalence was ethnographically significant and must be accounted for.

Edith spoke at length on this ambivalence of control and mastery. Her research project at Nordic Food Lab focussed on *viili*, a Finnish fermented dairy product, which, when made in its older, pre-industrial style, can develop a desirable, crinkly white layer of *Geotrichum candidum* mould on top.[209] After much background research and experimenting, Edith

[209] The same mould present on many small-format, Loire Valley goats' cheeses.

managed to get the fuzzy mould to reliably appear. 'You do get a high when you realise that you somehow quote-unquote "master" such a complex process in nature,' she confessed with performative brio. She then quickly undercut herself, explaining how as soon as she 'thought [she] had full control,' she would always be 'surprised' by another factor she hadn't taken into account. Even such seemingly small details as which side of the houseboat she kept the viili on relative to the sun's rays came to make a difference.

In contrast to mastery, Edith used the word 'maneuvering' to describe the 'ontological choreography' (Thompson 2005), the ever-unfolding 'dance of becoming-with' (Haraway 2008: 27) she was engaged in.[210] This other sense of 'control' might also be articulated by 'symbiopolitics': 'deliberate interventions that aim to modulate symbiotic relationships to deliver ecological functions and services' (Lorimer 2020: 83) in response to 'the unavoidable politics of responsible multispecies living' (Lorimer 2020: 230; after Helmreich 2009).[211] Fermentation might be understood as a set of symbiopolitical practices, and doing so moves us beyond 'control''s analytic crudeness—but it wouldn't sufficiently account for aesthetics' role in the ethics of involvement. 'Ecological functions and services' typically refer to effective and desired geophysical and metabolic transformations that enhance multispecies flourishing, priorities compatible but not quite coincident with fermenters': the production of 'delicious' flavours in specifically calibrated configurations.[212]

[210] For related forms of attunement and 'maneuvering' cast out to ecological and climatic scales, see eg. Choy (2011); Choy and Zee (2015); Knox (2020). I thank Emma Pask for sharing these.
[211] See also Keulartz' 'controlled decontrolling of ecological controls' (Keulartz 2012) and Lorimer's use of it in his discussion of rewilding and 'going probiotic' (Lorimer 2020). The droll phrasing further points to 'control''s underdetermination, and the need for more articulated concepts for analysis.
[212] On the other hand, conceptualising 'deliciousness' as an ecosystem service might also be possible. Thanks to Erika Szymanski for this observation. A thought to pursue further elsewhere.

Thinking with interest instead can account for the relations between different fermentation practices and different aesthetics of taste, and how they reinforce each other. Jia Hao, then stagiaire in the Noma fermentation lab, described a difference in fermentation aesthetic between Noma 1.0 and 2.0 (4.4). While fermentations at old Noma were maybe more 'rustic' and 'rough', those at new Noma were more 'clean', more 'strictly correct', with a more 'consistent', 'not as wild flavour'. 'It tastes sometimes... like they were made by a machine,' or 'by artisans' but 'in a factory'. These differences were of course also shaped by different spaces and infrastructure. But these were proximate causes; the ultimate causes were different people with different values and tastes (Lars led the former, David the latter), and to some degree the difference between the New and Newer Nordic culinary ideologies (Ch4). These different aesthetics are both the result of the different approaches to fermentation, and in turn their cause. Symbiopolitics can account for how the difference in approach shapes the fermentation process and ecology, but not how the difference in aesthetic does. This is not to say that politics cannot involve aesthetics, or that an aesthetic cannot be made a political principle—but that symbiopolitics, and politics generally, are rarely cast as such, with aesthetics made necessary and internal to them, rather than a contingent, external feature added on when appropriate. Rather than stretching both to fit my purpose, I find interest does more and better work.[213]

We can now return to how some participants framed this difference in fermentation practice in human social and political terms. Louise discussed fermentation as a form of governing what she called 'the little society' or 'micro-society'. Natural wine was again a useful case. Louise described how

[213] Another instance of the limitations of categorical category expansion (8.4.1).

> who is in control, no who is in charge [she smiled] in this micro-society… decides what products come out in the end. If it's acetic bacteria, then the final product will be a vinegar. But if it's… yeast… you have alcohol, and we would get a wine.

Different microbial populations function as different demographic groups in the 'micro-society'.[214] In this model, who is 'in charge' is ultimately governed by the fermenter, as a kind of sovereign (7.3.3). There are microbes here, and there are politics, but their relation suggests something different from 'microbiopolitics' (Paxson 2008; 2012). If microbiopolitics, after biopolitics (Foucault [2004] 2008), concerns the governance of human subjects through microbes (2.3.4), we need a complementary and inverse concept for the governance of microbial subjects (5.2.1) sometimes through other humans. Echoing Paxson's modification of biopolitics, and drawing on Foucault's other primary mode of biopower (Foucault [2004] 2008, 2009), we can call this new complementary concept 'micro-governmentality' (2.3.4). If microbiopolitics always directs back to human governance of other humans, micro-governmentality helps keep human governance of microbes in the frame—not only as a means to the former but as an end in itself, to which the former can also be enlisted.[215]

The different 'control's that fermenters identify, and different modes of involvement generally, mobilise not only different microbiopolitics, but also different micro-governmentalities. These micro-governmentalities can be arranged on a spectrum. If one extreme, the (impossible) dream of mastery and standardisation, is a kind of totalitarianism, the other extreme, the (equally impossible) totally 'hands-off'/'laissez-faire' approach, might be a form of (neo)liberalism, libertarianism, or anarchism—depending on

[214] Related notions of microbes revising the broader concept of the 'body politic' have recently entered posthumanities and social theory (Fishel 2017).
[215] Some scholars have argued to move beyond the sovereignty–biopolitics–governmentality distinction entirely (Povinelli 2016). Thanks to Emma Pask for this point.

what other inadvertent and/or nonhuman 'governing institutions' exist.[216] Notably, both extremes assume a prior separation between fermenter and microbes—different ethics, same metaphysics.

Between these extremes is a range of micro-governmentalities. Some are relational—in which human fermenters are implicated but not dominating, response-able (Haraway 2008) but not masterful, 'controlling' but not 'controlling', involved, interesting, interested: a parliamentary micro-governmentality, perhaps, after Latour's 'parliament of things' (1993: 142-5). Here would lie Louise's favoured natural wines, where 'natural' does not mean 'without humans', but where many other agencies are allowed to express themselves, which the fermenter 'facilitates'.

This way of conceptualising the spectrum of micro-governmentalities is not the only one. Depending on which agencies one thinks can guide the fermentation, or 'govern' the 'micro-society'—only humans, or other nonhuman persons as well—the second extreme could be either (neo)liberalism/libertarianism/anarchism, or a kind of democracy. For many Indigenous fermentation practices, for example, humans and other animals, microbes, sun, and climate are all seen to shape the outcome, sometimes with no necessary hierarchy among them, no Prime Minister or House Speaker.[217] This is still not to say that 'anything goes'—judgments of appropriateness for eating are still made, just according to a different rubric.

[216] Eg. ambient conditions like temperature, oxygen exposure, etc. This is not to equate neoliberalism's individualist rejection of regulation and anarchism's consensus-based self-regulation—only to say they each represent different visions of reducing or eliminating governance from above. There is a lot more to say about how this spectrum of micro-governmentalities works; perhaps in future research.
[217] I am indebted to my Greenlandic-Inuk microbiologist colleague, Aviaja Lyberth Hauptmann, for these insights.

Whatever the micro-governmentality, all (except the second illusory extreme) rely on different 'onto-norms' (Mol 2013)—notions of who 'should be' there, based on what kind of society (i.e. product) the desired fermentation must cultivate. A fermenter with no onto-norms, who is completely agnostic and hands-off, is in effect a rotter. If totalitarian mastery, in its pursuit of a singular inflexible onto-norm, constrains and represses, a 'hands-off', (neo)liberalist/anarchist tendency to 'push the boundaries' and create ostensibly 'new' onto-norms easily commits 'conceptual colonialism' by ignoring existing micro-societies—for example, when some natural winemakers valorise excessive amounts of spontaneously occurring acetic or lactic acids as edgy and ground-breaking, but in doing so essentially create vinegar or pickle juice. These considerations of micro-governmentality and onto-norms are crucial in translated fermentation especially, for deciding how and how much to guide a fermentation experiment, and toward what, play a key role in shaping its appropriateness and desirability for eating, with consequences for its taste and its microbiological nature.

7.3.3 HALTING: ULTIMATE SOVEREIGNTY

While guiding a fermentation can involve different micro-governmentalities, deciding when a fermentation is finished is ultimately a sovereign decision. To yield a product at its best, the fermenter must decide when and how to halt the process. They must consider how best to store the product to maintain its optimum point, or encourage appropriate aging to reach its optimum later. Products vary widely in their optimal periods—from hours to decades—and producers also vary in their optimal tastes. At Noma, the house style prefers fermenters halt the fermentation when it tastes both of 'the essence of the raw product' and its microbial transformation (Redzepi and Zilber 2018: 66)—the '5' on Luke's scale (5.3.1). Deciding when to halt the fermentation forms both a key part of a fermenter's aesthetic and the resulting microbial ecology. It is simultaneously aesthetically, ethically, and ecologically consequential. It is interested; it is involved.

Edith identified a useful counterpoint to the experiments she tasted in Nordic Food Lab's houseboat basement. Surströmming, an 'infamous' northern-Swedish delicacy, is Baltic herring fermented in salt brine in a can. The can expands under pressure from the fermentation, and the herring gain a quite pungent aroma. For many who did not grow up with it or learn to love it, surströmming smells putrid. But those who love it understand its discernment.

Edith, a Swedish Finn, has tried it, but is not part of its culture. She recalled that some of the 'fermenting' fish sauces in the basement of the houseboat had some similar smells. Nonetheless, she saw them as different processes. The main difference was not the kind or degree of 'control'; both were subject to similar gentle controls of a light salt brine and a cool temperature. It was that with surströmming those who make and eat it have an onto-norm in mind. 'Where [fermentation] ends is ambiguous', so deciding when a product is finished is a necessary condition of fermentation over rot. 'There's not one way to do surströmming,' Edith said; 'there's a range of acceptability,' from the earliest to the optimum to the latest point of palatability. But even a range constitutes decisiveness. Lacking this decisive sense of completion is what doomed the basement fish experiments to remain, at best, merely 'interesting' (*sensu* Ngai, perhaps, but not *sensu* Salminen).

Sometimes, this decisiveness is sufficient involvement for the product to be good to eat, even without human guiding or initiating. A Greenlandic-Inuk microbiologist colleague of mine, Aviaja Lyberth Hauptmann, shared with me some enlightening examples from Indigenous Greenlandic fermentation practices. While with the delicacy *kiviaq*—a seal skin filled tightly with hundreds of entire little auks, sewed shut, sealed with seal fat, and fermented under rocks for some months, made in the north (*Avanersuaq*)—the human fermenter may be said to play a central role in 'choreographing' the process, other foods involve a different understanding of who or what does the guiding. Caribou stomach contents (*tuttup aqajarua*)—what Aviaja, nodding to the Inuit's animal-based traditional diet, calls 'the most popular Inuit vegetable'—are lichens, indigestible to humans when raw, but nourishing once fermented by the caribou. Some walrus, when hunted, have bellies full of mussels they have fermented, also a great delicacy in Avanersuaq. Certain capelin, a small North Atlantic fish (*ammassat*), sun-drying and lightly fermenting at the shoreline, are claimed as perfectly ripe and delicious to eat (Hauptmann et al. 2020), particularly in the west (*Kitaa*).

A common colonial response to these foods is that they are not 'controlled' at all—that they are not fermented but merely rotten.[218] Aviaja begs to differ. She acknowledges that these fermentations do not exhibit the same degree of 'control' or 'involvement' as many industrial ones. Nonetheless she deliberately uses the word 'control' to describe these fermentations in her research and stories[219] as a political intervention into Greenland's ongoing colonial history—framing them as definitively fermented rather than rotten, and as differing from industrial products in degree rather than kind. For Aviaja, 'control' means neither mastery nor even close human involvement. It simply means the food is safe and good to eat, produced in a reliable way, not totally arbitrary. Who does the controlling can vary. If in control as mastery the human aims for sole authority, a totalitarian micro-governmentality, and in control as involvement the human aims for something like a

[218] Eg. Kjærgaard 2006: 494.
[219] Eg. www.youtube.com/watch?v=n_uCjgg3-BA.

parliamentary micro-governmentality, with its checks and balances of power, these Inuit examples extend micro-governmentality in even further more-than-human directions. The caribou rumen lichen and the walrus stomach mussels might be understood as truly multispecies parliamentary micro-governmentalities, in which the animal plays the central role, and the human only enters the coalition in halting the fermentation by taking the animal's life and preparing the fermentation for eating. The capelin at the shore is not fermented by another animal's microbes and bodily processes, but by its own microbes and some from the environment, shaped by salt, sun, waves, and wind—what could be called, for example, an autarchic-abiotic parliamentary micro-governmentality.[220] When these more-than-human fermentations are harvested, whatever is not eaten immediately is halted, by freezing, for future use.

Just as distinguishing 'fermented' from 'rotten' is political (1.2.2), deciding what counts as control, and whether halting alone suffices, are also political acts. Aviaja and her colleagues articulate how Danish colonists' inability to recognise Greenlandic Inuit fermentations as such let them assume the Inuit simply left seals to 'rot' on the shore, giving rise to the racialised stereotype that Inuit are 'wasteful'.[221] This attitude persists to this day, structuring colonial policies of natural resource management and impeding Greenlandic food sovereignty (Hauptmann, Olsen, and Seiding, in Review).

However involved the ethics, fermentation requires the fermenter ultimately deciding when the fermentation is done. In many cases, this decision results in enclosure, and possible disposal of microbes, for example through pasteurisation, to stabilise the product.

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[220] These examples do not even go into the range of nonhuman fermentations, in which humans never become involved (1.2.2).
[221] See eg. Müller (1906): 231-2.

While guiding can involve different micro-governmentalities, halting is inherently sovereign: 'the right to take life or let live' (Foucault [1976] 1990: 136). The sovereign nature of halting exemplifies how, while fermentation can be practised relationally, these relations are ultimately asymmetrical. This does not require that we move beyond relationality as a theory (cf. Giraud 2019)—simply that we articulate asymmetries and exclusions as different relations internal to it. Interest is suited to the task.

7.3.4 EMBODYING: MICROBES' INVOLUTIONARY MOMENTUM

This section has focussed so far on how human and nonhuman fermenters involve themselves in microbial life. But microbes also come to involve themselves in their fermenters' lives and bodies—and not only by being eaten. In previous chapters I have detailed reciprocal relations between human fermenters and their microbial partners as they 'learned to be affected' and to affect in the process of becoming consipient (Ch5), sometimes through experiment (Ch6). The relationship Yu Ting in the Noma fermentation lab developed with kōji—sensitive, care-full, affectively charged—is exemplary here (5.2.2). Louise described developing a similarly close, 'caring', 'respectful' relationship with *Rhizopus* spp., in her Master's project on tempe. Such closeness is not always pleasant: Réka Almási on the Empirical production team described how whenever the kōji went wrong, which it frequently did during the trial-and-error process of figuring out how to scale the production up, 'it hurt—it seriously hurt.'

Sometimes, the embodied involution of microbe and fermenter was even more physical. Priyanca, then kōji maker at Empirical, noticed that she began to smell like kōji, even when away from work—especially when sweating during exercise. 'I really think,' she confessed, 'that's it's infiltrating my system.'[222] Here too this physical involution was sometimes unpleasant and debilitating. Anna Loraine Hartmann, a cook and food scientist, told me how after working with *Rhizopus oligosporus*, a tempe fungus, almost every day for a year, in her thesis project with Louise followed by a large sensory science experiment in Indonesia, she started having 'phantom pain' in her head and in her joints, 'weird stitches', and 'tingling' sensations, which doctors could not explain. She became 'much more sensitive to mould' of many kinds. She could recognise it 'in the air' in a way she never did before; when eating mouldy cheese (which she loved), or working with kōji, she would get a pronounced 'tingling sensation' on her tongue. Anna acknowledged that some of these symptoms might have been conditioned responses to the stress she was under during that year; but she also wondered whether it might have been something more involved. As she put it, 'at some point I felt overdosed… like I *was* a fungi'.

These examples of microbes involving fermenters sketch some of the more difficult, unexpected, and unruly dimensions of 'involutionary momentum' (Hustak and Myers 2012). 'Becoming-with' is not always lovely.[223] It is not only, as Hustak & Myers show, animated by mutual desire and affect, but also by unequal and less-desirable relations of predation, parasitism, and pathology. Interest allows us to account for these diverse relations of involvement even when, as is often the case, actors are not symmetrically interested.

Through these four stages of fermentation—Initiating, Guiding, Halting, and Embodying—humans and microbes involve themselves in each other. These ethics of

[222] See also the two-way exchange of microbes between professional bakers' hands and their sourdough starters (Reese et al. 2020).
[223] I thank Erika Szymanski for this phrasing.

involvement involve interest and interessement, microbiopolitics and micro-governmentality, sovereign power, and reciprocal involutionary momentum. Each has political implications. The next section investigates the material consequences of this ethics of involvement, by developing interest as the co-constitution of involution and evolution.

7.4 INTEREST = INVOLUTION + EVOLUTION

Interest is an aesthetics with consequence, and an ethics that emerges in aesthetic involvement. Yet it is not only a relation between two actors at a given moment; it is extended and differentiated across time and space. Interest conjoins involution and evolution as mutually necessary, co-constituting forces in life's differentiation and propagation. In this section I unfold some implications of this relationship, illustrated with results from my collaborative experimental evolution trial with kōji. From here, building on the logic of the 'reticulated tree' (2.3.3), I develop the mathematical figure of the rolling torus for thinking interest topologically, and offer folded flexagons as a way of playing with this figure materially and conceptually.

7.4.1 ROLLING IN AND ROLLING OUT

The all-the-way-down entanglement of involutionary and evolutionary momenta is illustrated by results from my collaborative experiment with kōji (Ch3; see Appendix H for a thorough discussion of the following findings). At Noma and Empirical, the three populations gradually changed in spore colour and aroma, transforming from white fuzz and aromas of tropical fruit and fresh champignon (Figures 50 & 51) to long black-grey fur and aromas of fresh dough, stone fruit and almond (Figures 52 & 53).[224]

[224] For full results, see Appendix H.

Figure 50—Noma kōji generation 1, at 24h.

Figure 51—Empirical kōji generation 1, at 48h.

Figure 52—Noma kōji generation 25 population 2, at 72h.

Figure 53—Empirical kōji generation 25 population 2, at 72h.

These results corroborated Lars' and David's earlier observations. The DNA data suggested that all three populations at both Noma and Empirical had by generation 25 become dominated by *Rhizopus delemar*, a close relation to *R. oryzae* used in tempe (Appendix H).

The practices I used were for growing kōji for production, not for spore (the latter often uses lighter pearling, and adds ash). That *R. delemar* came to predominate in all six populations was likely the partial consequence of not using the ideal practices for the goal, of not being sufficiently and appropriately involved. Kōji has become with us such that human interest is now necessary to its life and livelihood. Without our sufficient and appropriate involvement, without kōji being sufficiently interessed from other actors, other organisms take kōji's place, ones better suited to the swirl of advertent and inadvertent conditions.

This change was not arbitrary contamination, but unfolded according to other actors' interest. This is why the six populations did not each go awry in their own way, but all became predominated by *R. delemar*. This fungus not only thrived in the conditions we had inadvertently created, but continued to genetically diverge between some populations at Noma and Empirical (ibid.). It was involving us in its ongoing evolution—an outcome different than expected, but equally interesting and significant.

The reliable appearance of *R. delemar* in all populations at Noma and Empirical might also be explained through human involvement in kōji's history. By my participants and I relaxing our involvement, the kōji 'reverted' to earlier and earlier evolutionary stages (ibid.)—not only to earlier colours of sporulation (white, green, black), but even earlier, back before it was a 'pure' culture, when, as in kōji's Chinese and Korean progenitors, species of *Aspergillus* live alongside those of *Mucor*, *Monascus*, and *Rhizopus*.

Meanwhile, the laboratory populations also exhibited interesting-interested involutionary-evolutionary dynamics. In one of the generation 25 lab populations, though it had been grown in controlled conditions to favour *Aspergillus oryzae*, a bacterial symbiont, *Bacillus amyloliquefaciens*, became co-dominant (ibid.; in the other two populations, it also became the most prevalent non-Aspergillus taxon, though not co-dominant). The 'pure' commercial spore contained traces of other cultures symbiotic to *Aspergillus oryzae* (ibid.), and for some reason this population, but not as much the others, allowed ecology to bloom. Even at its maximum, human interest is never the only; full and permanent interessement is never possible. As kōji's involutionary-evolutionary partners, we were interested, involved—neither fully apart nor fully dominant.

Though at Noma and Empirical other actors had a greater ability to interesse, laboratory conditions also shaped evolution. In contrast to Noma and Empirical's *R. delemar* continuing to diverge, to roll out into different forms, the laboratory *Aspergillus oryzae* also evolved but toward each other, rolling out into similar forms. Compared to the first-generation populations grown on plates, generation 25 were more genetically similar (ibid.). It is not unprecedented that in such stable and enriched conditions the populations should converge, possibly through negative/purifying selection (losing unneeded genes). It also offers further illustration of the necessity of involutionary and evolutionary momenta in all life's ongoing becoming.

7.4.2 FIGURING INTEREST: ROLLING TORI & FOLDING FLEXAGONS

While the kōji experiment illustrates involution and evolution's co-constitution empirically, figuring interest illustrates it conceptually. The reticulated tree (2.3.3) gets us partway there, but in that model, organisms alternate between evolving and involving. Yet evolution and involution are happening all the time, everywhere, for everyone.

What kind of figure rolls out and in simultaneously?[225] One example is a rolling torus. We can visualise how this form can emerge from a simultaneous rolling out and rolling in. Let

[225] This is a topological question. Thinking topologically here, in the mathematical sense, is appropriate: mathematics and geography have a long entwined history and shared interest in topology as the study of 'spatial properties of an object or network that remain true when that object is stretched' (Paasi 2011, citing Harris 2009).

us start with a simple sphere. If, at any place on the surface of the sphere, two or more adjacent points begin to move away from each other ('roll out'), other points from below will have to rush up to fill its place, as with tectonic divergence. This movement means that, eventually, at the opposite side of the sphere, two or more adjacent points on the surface will have to move toward each other, falling into ('rolling into') the inside, as with tectonic subduction. Correspondingly, if the movement starts with two points moving in toward each other, it will entail two points on the other side moving out and away. The order doesn't matter, because each entails the other. In short, this is convection.

Now we can imagine that, as this involutionary-evolutionary momentum increases along an axis between the two 'poles', and more points are drawn into movement, the sphere begins to turn into a ring, a torus turning along the central interior axis of its circular cylindrical prism—just as Earth's geologic movements (convection currents of molten metal in the outer core, combined with planetary rotation) give rise to the toric form of its magnetic field (Figure 54; Ulmer 2016).[226]

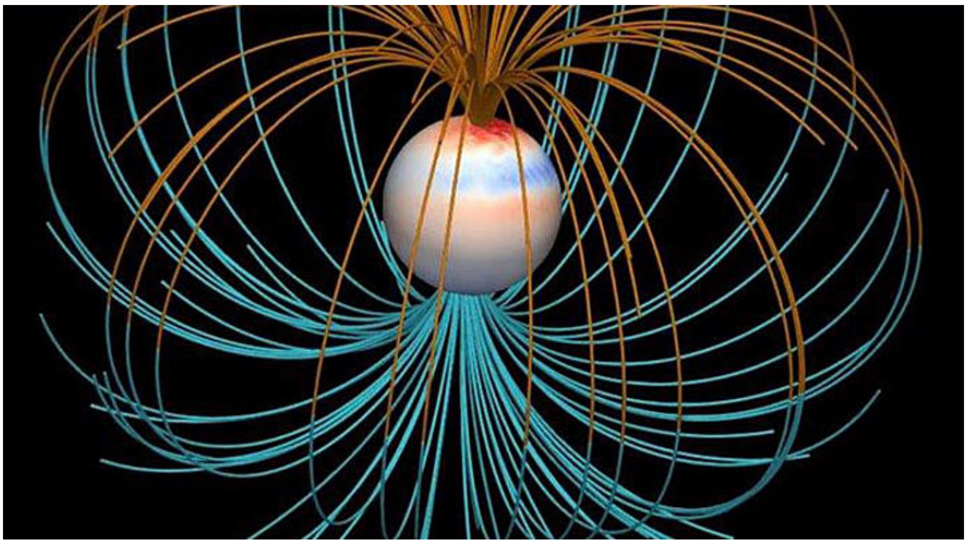


Figure 54—Model of Earth's magnetic field (Ulmer 2016).

[226] Here too, the movement, the relation, gives rise to the form, the relata.

Thus interest—co-constituting evolutionary-involutionary momenta—yields a torus. In society, however, interests exist not in the singular, but the plural. If interest can be figured as a torus, then multiple interests can be networked, just as rings can be linked into chains and ultimately 'meshwork' (Ingold 2017)—not a mesh of lines, but a mesh of interlocked rings, like mail. And as in the reticulated tree everything is connected to everything else but not in the same way, this meshwork of interests' interlinked rings is not even, but 'patchy' (Tsing, Mathews, and Bubandt 2019)—less like armour than lace.

This ring form is what enables interests to relate to each other, to link together. These interlocking rings can open up and close down, widen and constrict, gain links and shed them, depending on the circumstances that govern the interests of their networked actors. It is important to reiterate that these rings are not the actors themselves—they are sets of relations between actors, interests which themselves can be interested into networks.[227]

Figuring mentally has its limits. As a supplement I can recommend making a flexagon. Flexagons are folded hexagons that can be 'flexed' or 'rolled' into multiple isomorphic forms (Figure 55; Fowler and Guest 2005). For an introduction to flexagons, I can recommend the work of mathematician Vi Hart.[228] Flexagons are easily made with paper, yielding an infinitely rolling ring that 'rolls in' and 'rolls out' at once. They model the rolling torus, offering an embodied sense of how interest works. Figuring the rolling torus with a flexagon also materialises both Hustak and Myers' 'inward foldings of involution' (ibid.: 97) and Haraway's 'infolding' as a 'dance of world-making encounters' (Haraway

[227] Cf. Latour's 'chains of associations' (1990).
[228] See 'Hexaflexagons' (www.youtube.com/watch?v=VIVIegSt81k), 'Hexaflexagons Pt. 2' (www.youtube.com/watch?v=paQ10POrZh8), and 'Hexaflexagon Safety Guide' (www.youtube.com/watch?v=AmN0YyaTD60). The tone may be peppy; the mathematics are rigorous. Note in 'Hexaflexagons Pt. 2' how flexagons circling through their isomorphic states, when diagrammed, also form rings—that 'turn out' into other linked rings, and eventually 'turn back in' where they began.

2008: 249). 'What happens in the folds,' Haraway reminds us, 'is what is important.' (ibid.) Deleuze would probably agree ([1988] 1992). And as Hart and other flexagonists remind us, a flexagon only rolls as well as its folds are folded.

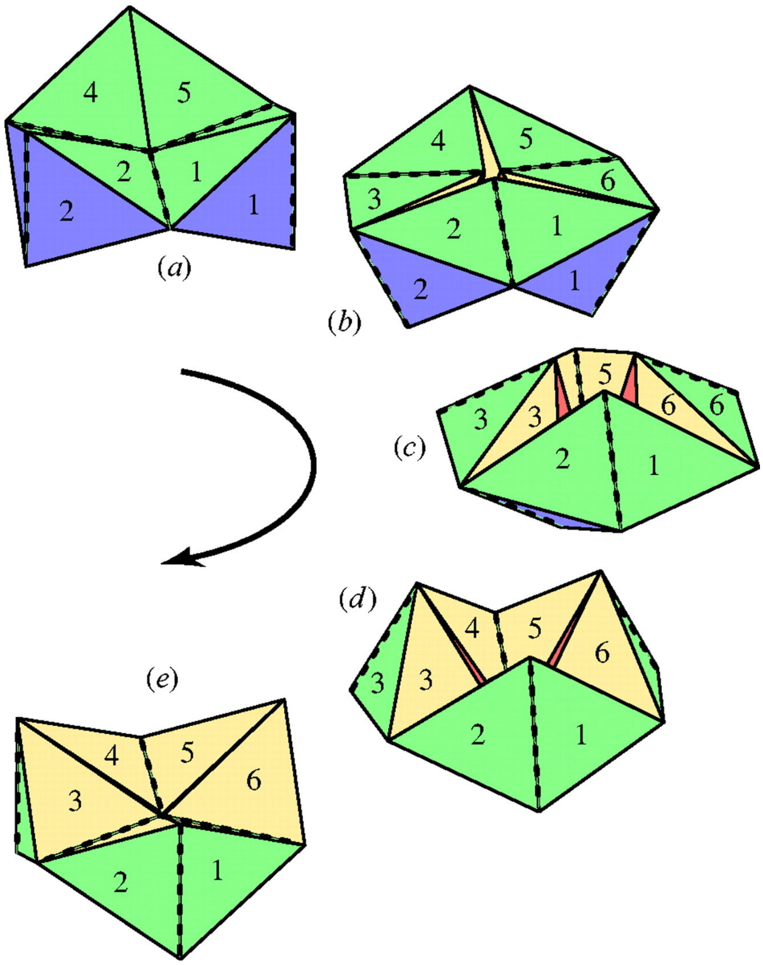


Figure 55—A folding tetrahexaflexagon (Fowler and Guest 2005).

This recommendation could sound frivolous. Fortunately, an established body of work exists as justification. From Natasha Myers' 'Dance your PhD' project (Myers 2012) and her ongoing kinaesthetic-artistic research 'Becoming Sensor' (Myers and Liberona, n.d.), to the branch of multispecies studies devoted to producing knowledge through art practice (eg. Antonsen and Bencke, n.d.; Kirksey 2014), to Haraway's material–conceptual 'string figures' (Haraway 2016)—STS, multispecies studies and environmental humanities are developing a robust and growing tradition of engaging materiality and the body to do theory.

At the end of this chapter, I include a template with instructions for making one's own tetrahexaflexagon (Figure 56).[229] It will help illustrate the material simultaneity, mutual necessity, and co-constitution of involutionary and evolutionary momenta, situate the aesthetics of the interesting and the ethics of involvement in their broader context, and begin to suggest interest's world-making power.

7.5 INTEREST: BOTH 'BETWEEN' AND 'BOTH–AND'

Interest—being in between—draws together aesthetics, ethics, and politics with epistemology and material consequence, and helps fulfil the thesis' fourth aim (1.4.1). The aesthetics of the culinary interesting shapes fermentation practices and consequently microbial worlds. The ethics of involvement in fermentation involve humans, microbes, and other actors in different and uneven ways, with more-than-human political implications. If becoming involved is a rolling in, and evolution is a rolling out, interest accounts for both, from the most intimate encounters to their expansive, patchily joined-up becomings. In figuring these interested relations, reticulated trees are a start; a lacy meshwork of rolling tori gets us further.

Valorising betweenness is no new idea. Calls from feminist theory and Indigenous and post-colonial scholarship have held up the necessity and promise of being in-between, of always already being-in-relation (Irigaray [1977] 1985, [1994] 2000), of studying 'betweenness' (A. Watson and Huntington 2008), of drawing power from residing and

[229] Instructions can also be found online: www.instructables.com/How-to-Fold-an-Origami-Flexagon/

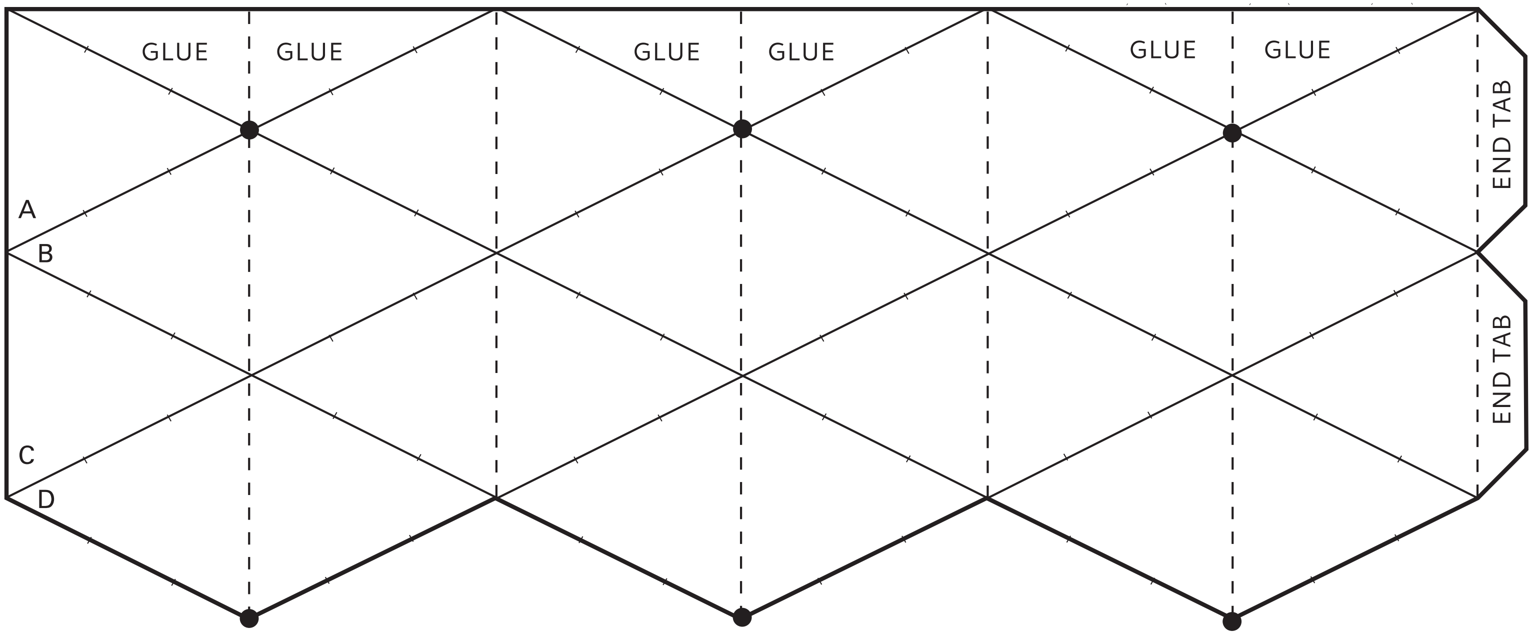
remaining 'in between worlds' (Larsen and Johnson 2012).[230] To these traditions, interest might suggest a way of considering aesthetics, ethics, and politics together, also when they sometimes do not sit easily alongside one another—for example, in food systems, art practices and theory, and activism.

Alongside betweenness, interest also suggests the value of 'both–and'-ness. Rather than weighing questions of 'either–or', in which only one answer is assumed to be best or possible, interest is more interested in a discerned 'both–and': articulating the conditions within which multiple arguments and explanations are possible. Both–and is not anything-goes relativism, but a simple reversal of the burden of proof: pluralism is assumed, specified in certain bounds, and possibly proven otherwise. This value of 'both–and' echoes Swanson's argument for the possibility and necessity of using natural science methods for multispecies ethnography, while also 'holding critiques of scientific knowledge claims in the frame' (Swanson 2017; 3.4.1)—a methodology I also employed here to justify the different forms of data I used to theorise interest itself.

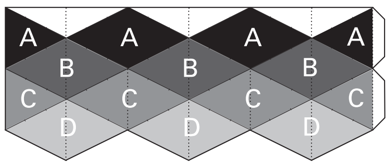
Such an 'interested' approach—both in-between and both–and—allows one to entertain multiple conceptions of domestication, suggests a way of navigating between them within certain thresholds, and shows the fruitfulness of each approach—final contributions I sketch in the last chapter, and use to gesture toward future work.

[230] And, as Réka at Empirical articulated, of moving between different cultures of knowledge.

Flextangle Template



Pattern Guide



Instructions:

1. Draw different designs in each row of triangular sides. Refer to Pattern Guide for row layout. Be sure to connect the designs at the tick marks.
2. Cut along bold line.
3. Crease dashed lines face to face. Unfold.
4. Crease diagonal lines back to back. Unfold.
5. Gently fold paper to match dot to dot and form a tube.
6. Add glue on tabs marked GLUE and press together.
7. Add glue on end tabs and tuck into open end of tube. Press to seal.

Figure 56—Template and instructions for making a tetrahexaflexagon (credit: Babbledabbledo).

8 FERMENTATION'S DOMUS

> Fermentation is domesticated decomposition – rot rehoused.
>
> - Merlin Sheldrake, *Entangled Life* (2020: 299)

Charismatic microbes like kōji are making history in Copenhagen. Drawn by these microbes' power to create 'deliciousness' and shape taste, high-profile chefs have helped drive a probiotic, post-Pasteurian turn in cooking (Lorimer 2020; Paxson 2012)—both in their own kitchens and far beyond them, to those of professional and home cooks around the world. They are making new spaces for novel ecosystems (Hobbs, Higgs, and Hall 2013), enhancing plant, animal, and microbial diversity, while generating new sources, forms and quantities of economic and cultural value. Kōji and its charismatic microbial kin are domesticating more people as chefs translate domus-sharing relations long established in East Asia, through a mutual multispecies 'microbiology of desire'.

This glocal probiotic turn of translated fermentation represents a new chapter in the history of human–microbial relations, and likely, at some point, of microbial evolution. Now armed with scientific tools for microbial identification, industrial techniques for microbial propagation, and marketing techniques for microbial popularisation, chefs like Lars, Jason, and David have become agents of microbial proliferation. Kōji is taking over the world, in a new global domus of translated fermentation (Landecker 2015). With its topology of nodes and networks, and its flows of highly mobile chefs, cookbooks, Instagram posts and spores, this domus is far from the Neolithic hearth. And yet, as with that hearth, kitchens and fermentaries of all kinds remain key spaces of emergent biogeographic, ecological, and coevolutionary novelty among humans and microbes.

In this final chapter, I revisit the thesis' central theme of domestication, and what might be gained by thinking it microbially. First, I review each chapter's contributions, and how they come together to answer my research questions and fulfil the thesis' aims. I then return to and expand the discussion I opened in Chapter 1 around fermentation politics. From here, I take up the domestication question, outlining some of the underpinning conceptual contributions I will only be able to detail in full elsewhere, before discussing what microbes and fermentation offer to studies of domestication, regarding taste, space, scale, and method. Broadening out, I then offer some general reflections that have emerged in my study, for theory, for society, and on method, and close by pointing to directions for further research.

8.1 CONTRIBUTIONS, RESEARCH QUESTIONS, AND AIMS

Following the Prologue in which I introduced kōji and miso and how they are made at Noma, in the first chapter I introduced my project's broader context. I proposed how the pursuit of flavours in novel fermentations might be having larger biological consequences, and discussed why it might matter. I offered background on Noma and the New Nordic Cuisine, its historical and geographical context, its critical reception, and its shifts into what I have called the 'Newer Nordic', described the culture and political economy of fine dining, and outlined some of the scattered scholarship on cooking. I then described Noma's 'translated' approach to fermentation, considered the definitions, politics, and metaphors of fermentation generally, and situated the rise of fermentation in popular practice and scholarly work within the current 'microbial moment'. Returning to the question of biological consequence, I introduced domestication as a central concept in considering how humans and nonhumans shape each other over time, reviewed some of its extensive literature, and identified the potential of rethinking domestication through microbes, fermentation, and taste. I concluded by outlining the thesis' aims, research questions, key contributions, and chapter structure.

To investigate the connections between food and taste, human–microbe relations, and fermentation, in Chapter 2 I brought together critical studies of nature, more-than-human geographies and multispecies studies, theories of taste, and STS into a concept I call 'taste shaping natures'—natures shaping and shaped by taste. I began by acknowledging the fraught analytic status of 'nature', and its material-semiotic multiplicity for New/er Nordic practitioners for whom it denotes an ontology, invites a mixture of epistemologies, suggests certain ethical and political norms, and functions as a source of cultural and economic value. I then developed an analytic framework combining wilderness/wildness and pastoral/postpastoral pairs to make sense of how the New/er Nordic has mixed different natures, as imaginaries and materialities, for different ends: what I call 'multinatures' (after multinaturalism). As part of this framework, I suggested 'wilder' as a derived adjective for 'wilderness', as distinguished from the 'wild' for 'wildness'. In this chapter I also developed a conceptualisation of taste as multiple, that retains rather than explains away its multivalence: both preference and sensation, gustation and degustation, physiological and phenomenological, already always multisensory, intersubjective and multispecies. Having conceptualised natures and taste, I then turned to modes of how they shape each other. In my ethnography I identified and investigated three—experiment, interest, and micro-governmentality—which I conceptualised here. In conclusion I reflected on other practices and domains where the concept of taste shaping natures might be useful.

Having developed my conceptual framework, in Chapter 3 I turned to the methods I needed for conducting the research. To study the taste shaping natures of New/er Nordic translated fermentation I had to engage multiple sites, senses, species, and methods within the framework of ethnography—an approach I shorthanded as 'multiplied ethnography'. Studying taste shaping natures in their complexity requires integrating natural- and social-science methods, and my methodology brought together multispecies ethnography, sensory ethnography, sensory science, microbiological experiment, and DNA sequencing. After briefly justifying my choice of sites and outlining my fieldwork, I introduced these methods and justified three novel components of my methodology. 'Culinary discourse analysis' is a method for analysing culinary aesthetics as a material discourse, which I then used in Chapter 4 to listen to what dishes themselves have to say. 'Collaborative experiment' is a method for designing biological experiments with participants and based on their existing culinary experiments, but not quite participatorily. 'DNA agnosticism' is an approach to working with DNA ethnographically that takes DNA seriously but without naïve realism or necessary causal priority—one form of an emerging approach within the social sciences and STS of using natural science methods for different epistemological ends. I then reflected on my analysis of the data, my standpoint, positionality, and the project's ethics, and concluded with a discussion of some challenges and limitations I faced, and what changed between plan and practice.

From here, I set out on my four analytic chapters, addressing natures, taste, and modes of shaping in turn. In Chapter 4 I traced how and why New/er Nordic natures, as imaginaries and materialities of 'Time & Place', have shifted over time, their differing implications for New and Newer Nordic translated fermentations, and their corresponding shifts in taste. Drawing on the 'multinatures' framework I developed in Chapter 2, I identified two kinds of postpastoral: a 'timeless postpastoral' that valorises cultivated products whose historicity is obscured, and a 'historical postpastoral' that valorises cultivated products whose historicity is celebrated. In contrast to most scholarship in the geographies of nature, my analysis of the Newer Nordic also suggested an altogether different kind of nature, one that celebrates rather than conceals its constructedness—what I call an 'unnatural nature'. Anticipating Chapter 7, I introduced the concept of 'culinary interest'—a derivation of interest to describe the conjunction of aesthetics and ethics in culinary practice. The New and Newer Nordics' respective multinatures also illustrated the conceptual point made in Chapter 2 that the relation between taste and nature works both ways.

Drawing on the conceptualisation of taste as multiple I developed in Chapter 2, in Chapter 5 I introduced the concept of 'consipience' to account for how humans and microbes, or any nonhumans, co-produce knowledge within and across species by tasting and smelling together. First, I justified the need for such a concept. I then identified its kinds: 'interspecies consipience', consipience between species; and 'intraspecies consipience', consipience within species. In the practice of New/er Nordic translated fermentation I illustrated how both are happening all the time. I discussed how interspecies consipience involves subjectifying microbes, learning to by affected by and learning to affect them, and navigating their differentiating spaces. I then identified two kinds of intraspecies consipience among my human participants: 'convergent consipience', in which they calibrate their palates to align tasting and achieve 'coordinated intersubjectivity'; and 'divergent consipience', in which they engage different palates to gain different taste perspectives and achieve 'comprehensive intersubjectivity'. In the ethnographic analysis I identified 'consistent variance', which describes a product's expected material-sensory variation, often seen at Noma as something to be managed, and 'imagining consipience', a tool for achieving convergent consipience when shared tasting isn't possible. After describing how consipience works I turned to a general discussion of its epistemology, including its use of and co-constitution through scientific knowledge, and the relation between taste and language. In the latter I described taste as 'langue-age': conceptualising a relation between taste and language that neither reduces the former to the latter nor places the former wholly beyond the latter, but frames them as both distinct and co-constituting. In conclusion I considered the broader applicability of consipience to other domains.

Drawing on the geographic and STS literature on experiment I outlined in Chapter 2 and the concept I developed there of a 'culinary experiment', in Chapter 6 I analysed New/er Nordic translated fermentation to draw out three key epistemic dimensions of culinary experiments: how they engage the senses, employ science, and modulate surprise. In discussing how these experiments enable and in turn are enabled by consipience, I developed the additional concept of 'multispecies consipience', consipience among humans and multiple nonhuman species at once, and identified how kitchens and labs are conceptually and materially co-constitutive. Noting how culinary experimenters employ scientific knowledge in both narrating and practising experiments, 'using' science without 'doing' science, I suggested how culinary experiments are 'more-than-scientific': they engage (rather than disavow) science while not giving it epistemological priority among other knowledges, and redeploy technoscientific tools, techniques, and knowledges for other ends. In describing how culinary experiments modulate surprise, I introduced the concept of 'desirable variance', describing a product's distinctive or distinguishing variation: in contrast to 'consistent variance' (Ch5), 'desirable variance' is sought out and cultivated. In culinary experiments' modulation of surprise, I also indicated how they and the kitchens that facilitate them are reconfigurable, opening up and closing down according to purpose. I discussed how these epistemics of culinary experiment engage and contribute to existing conceptions of experiment, and proposed the 'experimental border zone': a novel framework for accommodating the heterogeneity of 'experiments' while adjudicating their typicity, by 'qualifying' them and situating them along three dimensions: 'openness of goal', 'unprecedentedness of outcome', and 'degree of trial'.

Drawing on the STS literature on interest I mobilised in Chapter 2, in Chapter 7 I developed 'interest' as an aesthetic-ethical concept that promises new relational terrain, different from control and domination but not more innocent, for understanding translated fermentation practices, their more-than-human politics, and their material consequences. I first noted some of interest's theoretical advantages compared with related concepts. I began the analysis with the 'interesting' as an aesthetic category, from which I developed the 'culinary interesting' that draws on and departs from established accounts, and illustrated its material consequences through a discussion of the DNA sequencing results from my collaborative experiment with miso. From 'being interesting' I shifted to a discussion of 'becoming interested', in which I described how fermenters 'involve' and 'interest' themselves in microbes' lives across four main stages of fermentation practice—

what I termed 'Initiating', 'Guiding', 'Halting', and 'Embodying'. Here I illustrated and developed the concept of 'micro-governmentality' I introduced in Chapter 2—a complementary concept to Paxson's 'microbiopolitics' that inversely describes how the governance of microbes is 'threaded through' human bodies and socialities. Zooming out from the intimacies of fermentation encounters to their implications for the differentiation of life across deep time, in the final section I framed interest as the co-constitution of involution and evolution, and illustrated their mutual necessity using DNA sequencing results from my collaborative kōji experiment. Based on this discussion, I developed the figure of the rolling torus for thinking interest topologically, and proposed flexagons as a way to model interest materially. To conclude, I suggested how this conceptualisation of interest might be useful to others, highlighted how it allows for both 'in between' and 'both–and' approaches to epistemology and ethics, and anticipated how it might offer an alternative to established domestication concepts.

Taken together, these contributions help answer my main research question—How do taste and natures shape each other in New/er Nordic translated fermentation?—and its subsidiaries. The New and Newer Nordics have each enacted different natures, as imaginaries and materialities, for different ends. These different natures have valorised different tastes, and have shaped the practice and taste of translated fermentation in different ways. These tastes in turn structure how human fermenters know their microbial partners, and their sensory knowledge practices enact taste as a productively multivalent phenomenon. Through these feedback loops linking natures and tastes, New/er Nordic fermenters and their microbial partners shape each other through experiment, interest, and micro-governmentality, with consequences for microbial biogeography, ecology, and evolution, and with theoretical implications for fermentation and domestication.

In the course of answering my research question, I also fulfil the thesis' five aims: (i) to develop a conceptual framework for 'taste shaping natures'; (ii) to assemble a methodology for integrating multiple sites, senses, species, and methods into ethnography; (iii) to provide a critical account of the 'New/er Nordic Cuisine' that places it in social and political context and assesses how and why it has changed over time; (iv) to develop concepts that account for the enmeshed aesthetics, ethics, epistemics, and politics of how humans and microbes know and shape each other in New/er Nordic translated fermentation, with applicability to STS, more-than-human, and multispecies scholarship; and (v) to consider the implications of these microbial taste shaping natures for current debates about domestication. This fifth aim I turn to shortly. While the specific contributions of Chapters 4 to 7 address aims (iii) and (iv), my three overarching contributions—'tasting shaping natures', 'multiplied ethnography', and 'domestication revisited'—align to aims (i), (ii), and (v). 'Taste shaping natures' describe how taste, in the broad sense, shapes and is shaped by multispecies relationships and environments. 'Multiplied ethnography' is a methodology that integrates multiple sites, senses, species, and methods—in this case, analysis of culinary aesthetics, biological experiments, and DNA sequencing—into ethnography. 'Domestication revisited' is a contribution to domestication studies: for parsing its multiple meanings; weighing calls to expand or retain its dominant narrative; proposing an intermediate, partly expanded and partly thresholded approach; and noting what thinking domestication microbially offers domestication studies in general. This final contribution has multiple parts, not all of which I can present here in full, but I begin to sketch them in 8.3. First, I return to another of the thesis' central themes: the question of fermentation politics.

8.2 FERMENTATION POLITICS: SPECIFICS OVER ESSENCE

Beyond the transformation of food and drink, fermentation has captured the imagination of practitioners and scholars as a metaphor for social and political change. For such scholars, fermentation provides 'cues for agitating the social order around us' (Hey and Ketchum 2018a), 'a valuable tool for thinking and enacting change' (ibid.), and 'a new metaphor for the complex, messy politics of today [that] may… help provide new narratives of social change' (DuPuis 2015: 147). Fournier's 'ten ways in which fermentation is a ripe framework for approaching transinclusive, antiracist, countercolonial feminisms' (2020) cited in Chapter 1 is part of this larger seam of work. Other examples abound.[231]

This bubbling conversation originates in fermentation's recent global revival and popular discourses around it. Sandor Katz, a queer American community homesteader and one of this revival's key figures, has since its early days made this political parallel explicit: 'As you watch your fermenting food bubble away as bacteria and yeast work their transformative magic, envision yourself as an agent for change, creating agitation and unrest, releasing bubbles of transformation in the social order.' (Katz 2003: 56)

While appealing to many, there are reasons to be sceptical of this idea that fermentation has an inherent, categorical politics. As many of the examples I've discussed—such as the production of kōji, yellow pea miso, lacto-fermented plums, and many other fermentations at Noma and Empirical—have shown, it is not the case that fermentation necessarily 'subverts established paradigms in the food industry and beyond' (Desjardins 2018a) or 'is antagonistic to increased acceleration' (Desjardins 2018b). Much of the work of Noma

[231] Countless projects at the intersection of art, activism, and scholarship have similarly ascribed a particular politics to fermentation: see eg. 'food feminism fermentation' (www.foodfeminismfermentation.com) and 'Fermenting Feminism' (www.laurenfournier.net/Fermenting-Feminism-Publication).

fermentation lab has involved optimising fermentation experiments to yield consistent results at production scale (Ch5, Ch6). Though it is not always easy to accomplish, and some microbes are good at resisting, many fermentation processes generally can be and have been fitted to modernist, capitalist, and Pasteurian paradigms of rationalisation, profit, and control—not only recently in restaurants but also in methods of industrial production of food, medicine, and other goods over the nineteenth and twentieth centuries.[232]

A visit to most any industrial fermentation facility shows how fermentation can just as easily close down possibilities for thinking and living otherwise as it can open them up (Brice 2014; Chera 2012). Widespread instances of fermentation facilitating social distinction (Bourdieu [1979] 1984; Brumberg-Kraus and Dyer 2011; Paxson 2012), blithely reproducing appropriative cultural relations, (Chan 2021; Sangbae 2018; BBC 2020), and relying on underpaid, forced, and/or child labour (USDL 2021; Verité 2012), for but a few examples, show how fermentation can be used to exclude and oppress just as it can to include and emancipate.

Fermentation can have no categorical politics because it is practised in such a variety of ways: at different scales (home, artisanal producer, global multinational), for different purposes (health, flavour, profit, prestige, sustenance), and with varying relations of microbial 'involvement' (wild, inoculated, or backslopped; raw or pasteurised; more or less 'controlled'; Ch7).[233] These diverse practices are each guided by different goals and timeframes, shaped by different spaces, subject to different sets of regulations, and offer

[232] See eg. Latour (1988) for a discussion of Pasteur. See Lee (2021) for a similar story in Japan.
[233] These different forms of microbial involvement might also be understood as different conditions of nonhuman labour (Besky and Blanchette 2019).

different affordances and possibilities to the microbes and humans involved. The humans and microbes in each context encounter different challenges, promises, and dangers, and develop through different relations of agency and power. In short, while every fermentation has a politics, different fermentations have different ones.

This might be a rather mundane point to make. Yet amid the current enthusiasm for fermentation, as a practice and a metaphor (Katz 2020), among popular and academic worlds alike, it seems somewhat glossed over. Certain approaches to fermentation might offer glimpses of a different, more vibrant, more diverse, more just world. But what matters is the specific kind of fermentation and the context that enables it, not fermentation categorically itself (6.5).

Beyond this practical reason that fermentation cannot have a categorical politics are two others. The second reason is microbiological: though fermentation is often held up as a model of multispecies 'collaboration', both between humans and microbes and among microbes of various kinds, fermentation involves at least as much competition among microbial taxa, and microbial death by human hand, as it does co-operations or 'collaboration', if such a term be appropriate (Evans 2021). In making miso at Noma, for example, making kōji requires selecting for *Aspergillus* against most other taxa (other than those the kōji itself enlists). Then, when the kōji is ready, mixing it with salt and compacting it with the crushed peas to limit contact with air kills it off, in favour of lactic acid bacteria (LAB) and salt-tolerant yeasts to take over. These taxa then produce carbon dioxide, lactic acid, and other metabolites, to produce an environment favourable to themselves and unfavourable to others. Over time, and with sufficient resources, the LAB will eventually outcompete the yeasts, by producing more lactic acid than the yeasts can tolerate. At a finer grain of resolution, different species and strains of LAB and yeast may have particularly co-operative or antagonistic relationships, but they are taxon- and context-specific. The same principles of overlapping, nested co-operations and competitions, in different compositions, structure the ecologies of any mixed fermentation, such as kombuchas (Coton et al. 2017) or sourdough starters (Landis et al. 2021). The overall point here is that, while some fermentations are more open and some more closed (Ch6), no fermentation allows for the flourishing of all microbial taxa—every fermentation, even totally open 'fermentation' i.e. rot, is for some taxa and against others. Every fermentation involves multispecies politics, and each has a different one. While fermentation is always 'interested', every fermentation is interested in its own way (Ch7).

A third argument against categorical fermentation politics is epistemological: that seeking to derive a normative, categorical politics from fermentation relies upon naturalising the stories microbiological science tells about the world. We can recall Stefan Helmreich here, as cited in Chapter 1: that 'Biology does not speak for itself' (2014: 59). An analogous and perhaps illustrative example of this problem can be found in the long, varied cultural history of honeybees. Since classical antiquity, honeybee colonies have been used as models to naturalise diverse political-economic ideologies: from classical democracy to medieval feudalism, early modern monarchies, nineteenth-century revolutionary republicanism, as well as both twentieth-century socialisms and capitalisms (Wilson 2004; Preston 2006; Seeley 2010; Nimmo 2013). Honeybees are undeniably social; but describing this sociality inevitably says at least as much, if not more, about the human society describing it as it does about the bees themselves. The same is true of fermentation. In this way fermentation is but one site of the larger ongoing debate between new materialisms (eg. Bennett 2010;

Hird 2009; see also Kimmerer 2013) and critical STS (eg. Helmreich 2014; Paxson and Helmreich 2014) over whether the material world ever 'speaks for itself'.

I sense the many visionary, caring, committed scholars and practitioners who have developed fermentation-as-metaphor—and many of whose work has enabled and informed my own—must already be thinking of precisely such specific forms when they invoke 'fermentation' in their various works: DIY fermentation, artisanal fermentation, a fermentation practice in which one cultivates close, care-full connections with microbes and other people. I hope to offer a small, yet I think important, addition, that these attributes are not inherent to fermentation as a category, just some of its many kinds. Rather than fetishise fermentation and wonder why social and political transformation doesn't follow, scholars and fermenters might instead articulate the specific conditions under which such transformations bloom.[234] In short, it is a familiar problem with a familiar solution: articulating and pursuing specifics over essence.

Fermentation does not have a categorical politics—but every specific fermentation does. This is for practical reasons—fermentation is practised in such different ways—as well as microbiological and epistemological ones: any fermentation already involves many kinds of more-than-human social relations, and even if it didn't, the bare materiality of the world, even if it were immediately accessible, is not enough to offer a normative vision for society. As suggested in Chapter 1, these political questions are undergirded by definitional and ontological ones—how expansive the definition should be, what is at stake, and who

[234] Murray (2020) is one of the few scholars I have seen argue something like this position so far. In popular discourse, Katz seems to be exploring something similar, for example in his most recent work *Fermentation as Metaphor* (2020)—but still somewhat ambivalently. There is not space here, but I will be able to go deeper into this discussion elsewhere.

gets to decide.[235] While fermentation and rot are both forms of 'human–microbial performance' (Ingram 2011), and the boundary between them varies in space and over time (Ch1, Ch7), they are not equivalent. Fermentation is not just any microbial metabolism (cf. Katz 2020); that is rot. Fermentation is a subset of this: somewhat 'controlled', socially significant, culturally appropriate microbial metabolism (Evans 2021). In short, fermentation is rot with interest (Ch7).[236] As Sheldrake elegantly puts it: 'Fermentation is domesticated decomposition – rot rehoused.' (2020: 299)

8.3 DOMESTICATION REVISITED

I can now turn to the thesis' overarching theme: that of domestication. 'Domestication' has multiple meanings (1.3). Based on my reading of its extensive literature, I have identified eight dimensions along which these meanings vary: (i) heredity, (ii) symmetry, (iii) intentionality, (iv) human involvement, (v) multispecies involvement, (vi) scale, (vii) teleology, and (viii) universality. While some recent expansive multispecies accounts argue for the heuristic value in this multiplicity, in that it allows different questions to be asked in different contexts (Lien, Swanson, and Ween 2018), other, more critical ones argue for the utility of retaining narrower notions of domestication, to help better attend to histories of human and more-than-human dominations and inequalities (Tsing 2018). Both these positions have tended to elide the hereditary dimension, conflating domestication with mere taming (3.4.2), or using it loosely for the domination of landscapes. Based on my ethnography and experiments, and what they suggest to be the strengths and weaknesses of the literature's recent multispecies expansions, I take an approach somewhere in the

[235] As above, I will be able to go deeper into this discussion elsewhere.
[236] Recall, for example, Lars' threshold of 4% salt distinguishing fermented from 'decayed' in the peaso (Ch6), or Edith's distinction between the insufficiently interested garum experiments and surströmming (Ch7).

middle: more expansive than the dominant narrative along some dimensions (in that it need not involve intentionality, humans, teleology, universality, or even multiple species), but thresholded along other dimensions (in that it does involve heredity, is never fully symmetrical, and acts on organisms and populations but not landscapes). To define this conceptualisation, I begin with geographer Kay Anderson's definition of 'hereditary reorganisation of animals into new forms according to human interests.' (1997: 493) I make a few revisions for species-agnosticism, relationality (though not symmetry), and concision, to yield 'mutually interested hereditary change'. Interest covers all domestications, but in applying just as well to non-hereditary, symmetrical, and ecological/landscape cases, it is also more capacious. Inversely put, domestication is a subset of interested relations—those that are mutual (though not symmetrically) and that involve hereditary change.[237]

8.3.1 THINKING DOMESTICATION MICROBIALLY

In those instances where domestication is useful to retain, thinking domestication microbially highlights limits in the literature. Even Lien, Swanson, and Ween's recent multispecies expansion, which aims to explore domestications' 'marginal and atypical sites' (2018: 19), still only concerns 'plants and animals' (ibid.: 2–3). Given microbes' radically different reproductions, evolutions, and lifeways (O'Malley 2014), it is surprising that seemingly no work has been done thinking with microbes to explore and potentially rethink domestication concepts. I begin to pursue this idea here.

[237] This section is merely a précis to signal the conceptual work on domestication I have done over the course of the PhD, which undergirds the following subsection on the contributions that emerge from thinking domestication microbially. There is not space here to include the above framework, arguments, conceptualisations and definition in the detail they require, though I will be able to do so elsewhere.

Thinking domestication microbially may also have been hindered by the comparable lack, until recently, of archaeological work on microbial domestications. This is not surprising; microbes leave no bones and few residues in the ground. Yet the recent development of next-generation sequencing technologies, in addition to facilitating the current 'microbial moment' (1.2.3) and the use of paleogenomics in domestication studies (3.4.2), has also lit up interest in questions of microbial domestication, past and present. It is worth briefly reviewing some of this work before turning to what thinking domestication microbially can offer.

Much work on the evolutionary history of fermentation microbes centres around *Saccharomyces cerevisiae*, common budding yeast, its origins and spread (Almeida et al. 2015; Drumonde-Neves et al. 2018; Eberlein, Leducq, and Landry 2015; Fay et al. 2018; Gallone et al. 2016; Gonçalves et al. 2016; Legras et al. 2007; 2018; Libkind et al. 2011; Liti et al. 2009; Sicard and Legras 2011). This focus is related to its prominence in Western cultures in the production of bread, wine, and beer. Though *S. cerevisiae* is commonly understood to be a prototypical domesticated microbe, much of this work on its evolutionary history is not strictly concerned with its domestication process. Many microbes, not only *S. cerevisiae*, have also long been favoured as 'model organisms' for laboratory studies, including experimental evolution (Burke, Liti, and Long 2014; Conrad, Lewis, and Palsson 2014; Elena and Lenski 2003), yet such studies involving food microbes have been infrequent and incidental (eg. Bachmann et al. 2012) and rarely framed in domestication terms. Similarly in history of science and STS, multiple works have focussed on the transformation of microbes in laboratory technoscience (Bud 1994; Landecker 2007; Latour 1988), but have not framed these practices and processes in relation to ongoing domestication histories. Only in recent years has a group of food-interested evolutionary microbiologists begun investigating fermented foods as tractable systems for studying past and ongoing microbial domestications across a range of sites, products, and organisms (Bigey et al. 2020; Carbonetto et al. 2018; Colehour et al. 2014; Dumas et al. 2020; Gallone et al. 2016; J. Gibbons et al. 2012; J. Gibbons and Rinker 2015; McLoon et al. 2011; Passerini et al. 2010; Rokas 2009; Steensels et al. 2019). Some of these researchers have even sought to reproduce microbial domestication processes experimentally in the laboratory, and even framed their experiments in such terms (Bodinaku et al. 2019).

In addition to the relative absence until recently of microbes in studies of domestication, the voluminous literature on domestication also rarely features taste as a driver of domesticatory relations (Ch1). Attending to this multispecies 'microbiology of desire' by thinking with tasty microbes and fermentations like kōji and miso offers four contributions to thinking domestication generally: on taste, space, scale, and method.

Taste is an important but neglected aspect of ecological and evolutionary selection. While not every taste shaping nature is domesticatory and not every domestication involves taste in the sensory sense, many are and do. The centrality of taste and consipience in New/er Nordic translated fermentation, and their biological, ecological, and potentially evolutionary consequences, attest to this general importance. Highlighting taste's world-making power, across species, can thus only enrich accounts of domestication, as well as attune us to nonhumans' sensory agencies in shaping their worlds as subjects.

Recognising the more-than-human historical power of taste also draws attention to significant yet understudied spaces of the domus in which consipience—knowing together by tasting together, within and across species (Ch5)—is key: kitchens, fermentaries, and other spaces of food creation. Social scientists have long attended to the spatial dimension of domestication (eg. Hodder 1991; Leach 2003), but even when the hearth has been discussed, culinary transformations and the consipient senses that enable them have been somewhat underappreciated. Thinking domestication microbially, and through fermentation specifically, offers to redress this sensory–spatial oversight.

Thinking through the spaces of the domus—a bounded domain that differentially shapes the evolutions and involutions of its inhabitants—quickly leads to considerations of scale, and illuminates a nested domesticatory structure of domus within domus, from the cellular to the planetary. If endosymbiosis was the original domestication (1.2.3), any eukaryotic cell is already a domus. From cells to cultures, many fermentation vessels and spaces can be seen as domūs in themselves, as they create boundaries between 'inside' and 'outside' that help specific taxa to flourish and certain traits to be selected and enhanced (5.2.3). Certain microbial taxa and communities can even be seen to create their own domus, as with SCOBYs found in kombucha, kefir, and some vinegars. From cultures to bodies, holobionts, by always already involving multiple species and being embodied ecologies before being individuals (S. Gilbert, Sapp, and Tauber 2012), render the corpus a domus (eg. Lorimer 2018). Beyond the conventional domus of the shared hearth, this nesting of the domus continues to expand. The 'shared built environment' of the city becomes a collective domus, for example in structuring mutualist domesticatory relationships between humans and mosquitos in Dar es Salaam (Kelly and Lezaun 2014). And if antibiotics have left an Anthropocene signature in the global microbiome (Landecker 2015), then, as Lorimer argues, 'the domus for our analysis of human–microbial relations and health must expand' from the built environment to the planetary (Lorimer 2018; see also Young 2016).

This global Anthropocene signature is of course not limited to the microbiome. Anthropogenic climate change has by now affected every corner of our earth in some way. This relatively new planetary anthropogenic domus raises a host of new implications and questions. Is any anthropogenic effect part of this domus, or only those that involve us with other species, bring us closer together, rather than ones that sever us, that turn us apart, that change others and us but without shared interests?[238] And what is now the relevant unit of domestication? Typically it has been the evolutionary individual; with the holobiont revelations of microbiome science, in which individual animals and plants are also ecologies, this unit may now be multiple, and, as with the domus, similarly nested.

These considerations of taste, space, and scale also suggest an additional contribution on method. Kitchens, fermentaries, and other microbial spaces of the domus not only facilitate fermentations; they also break down domestication processes into timeframes and spatial scales humans can experience, rather than infer only from artefacts and bones. Fermentation thus offers a tractable system for studying domestication processes experimentally, experientially, and ethnographically. It is not only, per Sheldrake, 'domesticated decomposition' (2020: 299); it is also, enticingly, domestication decomposed.

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[238] Here is another argument in favour of retaining a thresholded conceptualisation of domestication: there already exist words to describe, for example, the adaptation (hereditary or merely behavioural) of nonhumans to anthropic environments, especially when human interests are against or indifferent to it. For example, 'anthropophilia'/'anthropophily', or 'synanthropy' (the state) and 'synanthropisation' (the process')—not so used in Anglo-Saxon literatures, but widely used in French (eg. Guetté et al. 2017) and Central and Eastern European ones (Dončev and Iankov 1989; Malovichko et al. 2021; Olaczek 1982; Zawadzka and Zawadzki 2016). Such terms might better describe some of the cases proposed by recent multispecies revisionists (eg. in Cassidy and Mullin 2007; Swanson, Lien, and Ween 2018). Some domestications likely began as synathropisations, such as that of wolves. They became domestication when interests became mutual.

This ethnographic approach to studying domestication processes as they unfold can 'help to bridge the divide between natural and social sciences in domestication studies' (Payne & Evans 2017).[239] Though these different approaches have recently been converging on similar theoretical conclusions, for example around domestication as gradual and non-teleological (1.3), that they continue to study domestication with different methodologies can end up reinforcing the nature-culture dichotomies which scholars on both 'sides' have worked to overcome (2.1.1). Using fermentation to study domestication experimentally, experientially, and ethnographically can be one way to bring these approaches (back) together.

8.4 REFLECTIONS

Having reviewed the thesis' contributions, answered its research question, fulfilled its aims, and revisited central themes of fermentation politics and rethinking domestication, I now look back on my project, and identify some general reflections for theory, for society, and on method.

8.4.1 FOR THEORY

These reflections for theory are patterns I noticed recurring throughout my analysis and across chapters, which I thought useful to articulate. There are three: criticality as discernment, co-constitution of difference, and the conceptual double-bind.

The first is a pattern that has emerged in my discussions of domestication and fermentation in the thesis, as well as thinking through multispecies 'collaborations'

[239] Some precedents for such a combined methodology exist, eg. Larson's AHRC-funded project 'Cultural and Scientific Perceptions of Human-Chicken Interactions'.

elsewhere (Evans 2021). This pattern is a critique of the apparently common assumption in the social sciences that category expansion, and its related practices of blurring and dissolving boundaries, are categorically desirable or progressive. In my discussions of fermentation and domestication, I have suggested how this is not necessarily the case. Terminological expansion does not necessarily mean political expansiveness—sometimes terminological conservatism can be more politically progressive. The assumption of their alignment we might call the 'category expansion fallacy'. In addition to its misdirected political aims, uncritical category expansion has profound implications for the intellectual economy. Such categorical category expansion is consumeristic. If concepts are always to be expanded, their utility shall always be devalued, which necessitates the creation of new concepts at an ever-increasing pace. No room is left for repair, care, re-invention, re-creation. Of course, I am also not arguing that we ought never make new concepts at all; by now the reader will have sensed my occasional interest in doing so. Instead I argue for discernment: a meta-criticality that encourages us to be discerning about when to expand concepts and when to retain them, at different thresholds along different dimensions for different purposes—and when to make new ones.[240] This ethic of meta-criticality extends the sensory discernment of New/er Nordic fermenters' tasting practices (Ch5) and the epistemological discernment of the 'Stengers–Despret shibboleth' (Latour 2004b; 2.3.3) to criticality: a discerning criticality about when and how to be critical, and how much.[241]

The second pattern is that difference does not imply dichotomy, but emerges through co-constitution. I have discussed how many of the conceptual distinctions engaged in the thesis—'sensory' & 'scientific'; 'science' & art'; 'kitchen' & 'laboratory'; 'material' &

[240] I have developed this argument for domestication and fermentation specifically in more detail, which I have been unable to include here in full, but which I will be able to publish elsewhere.
[241] See also Latour (2004b). It thus contributes to the 'more-than-critical' turn in STS I outline in Chapter 3.

'discursive'; 'principle' & 'practice'; 'replication' & 'surprise'; 'consistent variance' & 'desirable variance', 'evolution' and 'involution'—emerge in this way. This co-constitution might also apply to 'taste' and 'natures' in taste shaping natures—that the relation, in this case the shaping, precedes and gives rise to the relata. This relational co-constitution is figured by interest. As my colleague Erika Szymanski wrote to me in feedback:

> What I appreciate most about this figure [of the rolling torus] and evolution–involution as a necessary pair is that the *pattern* or *shape* is formed by points persistently moving to remain related and to remain separate. This feels like a point that holds together the theoretical developments of every chapter—that making *interesting* shapes requires insisting upon separateness, not dissolving into unity, while simultaneously coming together to sustain relation.[242]

Erika went on to apply this point to fermentation: that fermentation has no essential politics not only for the practical, microbiological, and epistemological reasons I provide earlier, but also

> because not all fermentations generate interesting shapes, and not all interesting shapes interest the same actors – but fermentations at Noma have a politics in terms of the relations they sustain and hold separate, and that politics was different in Noma 1.0 and Noma 2.0.[243]

This leads me to the third pattern, which is that ancient conceptual double-bind I detected in my reading and thinking around experiment (2.3.2), and in work on fermentation and domestication I have made for the thesis but will publish elsewhere: that identifying instances of a general concept requires a pre-existing concept in the first place, but developing such a concept also requires generalising from existing instances of it. For analytic philosophers, this is a plague of circularity; for those more dialectically, relationally, and/or 'continentally' inclined, this mutual reliance of inductive and deductive

[242] Erika Szymanski, pers. comm., 2.8.21
[243] Ibid. I tend to agree with Erika's analysis, and am grateful to her for articulating it so helpfully.

reasoning—or rather, their co-constitution—is simply a matter to be aware of, to ensure one accounts for and engages both approaches in doing conceptual work.

8.4.2 For society

Beyond the thesis' contributions to academic debates, it also suggests some contributions for society: around cooking, agriculture, rewilding, and genetic modification. I only gesture toward these here, though they could be developed at much greater length.

Cooking is a world-shaping power. Rather than restricting it to a secluded domestic realm, recognising its implication and orchestration of larger domains of food production and consumption, political economy and ecology, social relation and difference opens up not only new areas of scholarly inquiry but also a new (and thoroughly old) way of making the world otherwise (Pollan 2013).

Fermentation is a specific form of cooking, and just as fermentation can be practised in many ways, with varying degrees of interest, so can agriculture and any form of cultivation. This variation is a reminder to keep these categories broad and differentiated, as they are in the recent archaeological literature (1.3), yet as so often doesn't happen in, for example, urgent political discussions of land preservation and rewilding, in which agriculture can be categorically vilified (as discussed in eg. Lorimer 2020).

As with cultivation and domestication, rewilding can and does also happen unintentionally—so-called 'passive' rewilding. But landscapes never truly go 'back'—they can only ever turn into something new.[244] Instead of 'rewilding' or even 'wilding', both of

[244] Related to the question of teleology and reversibility in domestication, a discussion I must take up elsewhere.

which suggest return to a prelapsarian state before any kind of human involvement, we might instead think of rewilding as 're-interesting' or just 'interesting': recreating/creating landscapes that interest and are in the interests of many creatures, perhaps as many as possible. This interested approach both moves beyond rewilding's implicit reliance on baselines, and helps describe the danger in how passive rewilding can sometimes make space for one creature, particularly invasive ones, to dominate—Tsing's 'proliferation' instead of 'resurgence' (Tsing 2017; Bubandt and Tsing 2018a; Ch4).

This interested approach might also inform long and heated debates around gene modification, and most recently gene editing with eg. CRISPR/Cas9. In these debates of enormous legal, political, and scientific stakes, much hinges on the degree to which these new techniques are seen as in continuity with or rupturing from longer histories of humans intervening in the evolution of other organisms. What is new is not humans changing genomes, even those of other humans—what is new are the means and power relations of shaping evolution, and, in the case of humans, of related norms about human variation (Kirksey 2020b). The question is not only about whether gene/genome editing is in continuity with or rupturing from longer histories of humans hereditarily shaping nonhuman others, but also whether these methods similarly allow for nonhumans to assent or object, to exert, to some degree, their own agency in these mutualistic processes (Szymanski and Calvert 2018).

8.4.3 On method

In addition to these broader theoretical reflections for theory and society, there are multiple concrete reflections on my methodology and its limitations, especially around the DNA sequencing component, that emerged over the course of the project and which I touch on in Chapter 3 and Appendices G and H. These reflections also suggest areas for future work.

Gaining a finer resolution of the differences among the miso ecologies down to species and strain level would require shotgun metagenomics, a more involved and expensive method than metabarcoding of 16s and ITS genes. Similarly, deeper analysis of potential genomic differences between the different populations of *A. oryzae* and of *R. delemar* would require deeper sequencing for more coverage of the genome. Both would take more time and resources than what I and my collaborators had for this project. I have also not yet documented clear-cut evolutionary adaptation in translated fermentation, as the main changes observed in the kōji experiment ended up being ecological, and the suggestions of evolutionary change I encountered were probably more likely due to genetic drift than adaptation.[245] Further sequencing of more samples and analysis, and perhaps even new experiments, would be needed for this. I also can't yet say anything about causal relationships between specific flavours and specific ecological/evolutionary changes—the 'why' question. This would take much more research using the current methods, additional methods like metabolomics, more structured sensory methods, and of course more time, resources, and researchers. Another dimension is epigenetics. Research in this field is growing, and it would be valuable to integrate this dimension of hereditary change into the research design—but of course this would take further resources and expertise.

In addition to these methodological alternatives, with hindsight there is something else I might have done differently, with potential benefit: to seek a master's student or two to do

[245] These results, and the lack thus far of deeper analysis of potential hereditary changes between the populations of *A. oryzae* and *R. delemar*, also mean I am not yet able to offer my own DNA data, as I am with my ethnographic ones, to contribute to discussions of and support my conceptual thinking about domestication. This is a priority for further work.

their thesis project as a collaborative part of mine, to take on the DNA labwork and sequencing analysis and perhaps further larger-scale sensory analysis. Such extra capacity might have enabled more detailed analyses, and thus further theoretical and conceptual work, and perhaps even begun to suggest some answers to the 'why' question. It would also have created extra supervisory work; so perhaps also fine to have left for the future.

The DNA analyses produced here might not yield ground-breaking findings for ecological or evolutionary theory, but they may offer more modest, empirical contributions to the literature. While DNA sequencing techniques have been used to study a range of fermented foods in recent years, so far very few if any studies (in English) have focussed on miso or kōji. And though the main miso findings are somewhat expected from theory, the kōji data are currently being used as part of larger datasets studying evolutionary and domestication processes in *Aspergillus oryzae*, which might come to make theoretical contributions to the literature.[246] Beyond specific empirical or theoretical contributions, or the methodological contribution of using DNA sequencing as a multispecies-ethnographic method, I also hope that this rudimentary attempt to bring these methods together might even, in the long run and in whatever small way, help make the value of ethnography and that of DNA sequencing more legible to natural and social scientists respectively.

The perfect project for my research question would involve a team of multiple researchers from the social and natural sciences, each with interest in if not some basic knowledge of the other, studying the multivalence of taste shaping natures together. This is a research programme more than a PhD project; one I am now beginning to develop.

[246] By my colleague John Gibbons at the University of Massachusetts, a specialist in kōji evolution, who also helped me with some of the analyses of my experiment data.

8.5 FUTURE DIRECTIONS

Having looked back on my project and offered some broader reflections that emerge from it, in this final section I look forward, and suggest some research directions I and others might pursue further. As suggested above, in many ways the project's central idea of taste shaping natures lays out a research programme rather than a project of appropriate scope for a PhD. Accordingly, many new questions and further directions emerged along the way. Beyond those I highlight at the end of each chapter, here are some further and more general proposals.

In Chapter 1, I introduced from literary translation theory the categories of 'fidelity' and 'freedom', and 'foreignising' and 'domesticating' approaches, for analysing different kinds of translated fermentation based on what they prioritise and how they materialise these priorities. These distinctions did not become so necessary in the analysis here, but I have left them in as I believe they could be worth pursuing in other work.

From Chapter 2, beyond the many situations where 'taste shaping natures' might be useful, the concept could also be applied to aesthetic perceptions and judgments beyond taste and smell—for example in Haraway's aesthetic-sensory transformations in the Camille stories (Haraway 2016), as redescribed by Kirksey in the context of the rapidly emerging reality of human genome editing (Kirksey 2020a).

As discussed in Chapter 3, the participatory dimension of my sequencing plans was impeded by technological and time limitations, but suggests fruitful areas for further work. One set of questions is about the performative dimension of sequencing data: do these new data change anything about participants' fermentation practice and/or their relationship with their microbes, and if so, how? I gathered some preliminary data on this question by sharing the DNA results of the collaborative experiments with some of my participants and asking for their feedback. These preliminary data suggest this new kind of knowledge does impact fermenters' practices and attitudes. For one participant, these findings suggested new avenues for R&D and practical problem-solving, whether using nixtamalised substrates to pursue greater consistency in miso production, pursuing research into the different compositions of commercial kōji spores, or exploring whether a 'reverted' kōji strain could contribute new flavours to existing production processes. For other participants, these findings stimulated new thoughts around microbial terroir, the ecology of 'pure' kōji spores, and why, out of the many fungi present in the original mixed cultures of Chinese *qu*, *A. oryzae* was the one selectively purified in Japan, when *Rhizopus* spp. also produce many enzymes and are used in other products like Indonesian tempe. Overall, the findings reaffirmed participants' 'wonder' in the microbial world: that 'life finds a way', and that while 'humans can bend nature to our will, it is only ever for very limited periods of time—evolution always has its way, generally far faster than it took for us to bend it.' Another set of questions here is participatory: How might these findings be best conveyed to such non-expert audiences? How might such experiments be replicated with sequencing technology participants can deploy themselves in situ (eg. with the Nanopore)? And how might participatory DNA sequencing be used as a method of care, a tool for furthering fermenters' interest, opening up new ways of becoming 'involved' with their microbes?

Further directions also emerge in the analytic chapters. In addition to those outlined at the end of Chapter 4, for example on New/er Nordic natures' performative and political consequences for humans and nonhumans, the multinature framework I developed might also be useful in analysing other biopolitical and sociopolitical processes, such as pasteurisation, domestication, or rewilding. In addition to the further directions outlined at the end of Chapter 5, on other domains, for humans and nonhumans, where consipience could aid research, consipience raises a key political question: how different humans' tasting capacities influence the questions raised in the thesis around consipience and taste shaping natures. And in Chapter 6, the framework developed for accommodating experiment's multivalence might also be applied to any form of novelty, even if not framed as 'experimental'.

Chapter 7 indicates multiple further directions. It draws links between the previous three chapters: for example, how the epistemology and phenomenology of consipience (Ch5) and the success of culinary experiments (Ch6) are shaped by the aesthetics of the interesting (Ch7). As a way of linking aesthetics, ethics, epistemics and politics, in the value it suggests for theory and methodology of 'being in between' and pursuing 'both–and' approaches (Ch3, Ch7), and for its potential in reshaping domestication and rewilding discourses proposed earlier, interest may be widely applicable to other realms. Micro-governmentality, meanwhile, suggests something more general: 'bio-governmentality'. Microbiopolitics and biopolitics are not so different conceptually, other than the former's specific empirical relevance to microbes. Similarly, micro-governmentality suggests that governmentality, in which subjects are formed to be made amenable to governance, happens not only with microbial subjects but with any nonhuman subjects. We might call this general, more-than-human governmentality 'bio-governmentality'. It also suggests a further way of accounting for domestication's asymmetries.

The microbiological part of this project also raises further empirical questions. In the miso experiment, where did the microbes come from? In the kōji experiment, why was it *R. delemar* that became predominant? How might miso and kōji ecologies change in new spheres of the domus, such as space, and what might fermenting in such radically different environments tell us about fermenting on earth?[247] Alongside these empirical scientific questions, there are deeper ethnographic engagements with DNA sequencing to pursue: for example, attending to how different laboratory practices and transformations of working with DNA (after Latour 2000)—the sampling, extracting, cleaning, sequencing, assembling, analysing, and databasing—construct the microbial world in different ways, with far-reaching implications for how microbiological knowledge is deployed beyond the laboratory.[248] More generally, while this study has focussed on changes in the microbiomes of fermented foods, a symmetrical multispecies ethnography of translated fermentation will also attend to how human fermenters' bodily microbiomes are changed through fermentation practice—a priority for further work.

These future directions for translated fermentation, taste shaping natures, multiplied ethnography, more-than-human natures, consipience, experiment, interest, fermentation politics and revisiting domestication all point to an enticing web of questions on 'hand taste': How are human hand microbiomes, human gut microbiomes, fermentation handcraft, and human and microbial taste and appetite connected? How have they shaped and continue to shape each other, and with what consequences for humans, microbes, more-than-human society, and the planet?

Kim Wejendorp, then R&D Chef at Restaurant Amass, recounted to me how when he lived in Hokkaido, Japan, all his neighbours in the village not only made distinctive misos, but preferred their own misos to those of their neighbours. It's hardly surprising that one

[247] A project I have pursued elsewhere (Evans 2021).

[248] I managed to gain some experience with and knowledge of these transformations in this project, but it became clear that properly to follow this 'science in action' (Latour 1987) would be a project of its own, and so a detailed ethnographic discussion of these technoscientific practices will have to wait.

might make one's miso to one's preference, of course. But there might be something more profound happening here: a feedback loop linking one's microbiome, fermentation practice, and taste preferences. We know that an individual's body microbiome can shape the ecology of a fermentation, and that the ecology of a fermentation, through repeated exposure via habitual fermentation practice, can also shape an individual's bodily microbiome (Reese et al. 2020). We know that what we eat shapes our microbiome (Flachs and Orkin 2021), which is shaped by as well as shapes our taste preferences (1.2.3). We also are beginning to learn how one's microbiome shapes not only the fermentation ecology and what one likes, but might also affect how one tastes (Cattaneo, Gargari, et al. 2019; Cattaneo, Riso, et al. 2019; Heys et al. 2021). Therefore, to say 'you are your own deliciousness,' as Kim does (7.3.1), implies not only that our bodies can be the source of microbes that yield delicious fermentations, but also that our sense of what is delicious might also be shaped by these microbes, which in turn reinforces their place in our microbiome, and in the fermentations we make.

These isolated empirical studies are only just starting to emerge, and so far the connections between them—and their implications for taste, individual and planetary health, ecology, and society—remain unplumbed. Yet nowhere might the loopy connections between taste, fermentation, and more-than-human interest be more apparent. Adequately addressing these questions, their connections and implications, is a quintessential case where nothing less than a multi-year, multi-researcher, multi-disciplinary, multiplied ethnography of hand taste will suffice. Such a project is a logical extension of this thesis, and one that I may now be somewhat more prepared to undertake.

APPENDIX A – PARTICIPANT INFORMATION SHEET

SCHOOL OF GEOGRAPHY AND THE ENVIRONMENT
South Parks Road, Oxford OX13QY, UK

Supervisor: Dr. Jamie Lorimer
+44 (0) 1865 275841
jamie.lorimer@ouce.ox.ac.uk

Primary researcher: Joshua Evans, DPhil student
+45 52 22 79 88 (DK) / +44 (0) 7709 773044 (UK)
joshua.evans@ouce.ox.ac.uk

Endless Convivial Experiments:
Domestication and the microbiogeography of translated fermentation practices

PARTICIPANT INFORMATION SHEET
Ethics Approval Reference: R57570/RE001

What is the purpose of this research?
This study investigates the role of flavour in shaping ecologies and organisms in novel approaches to fermentation in the restaurant industry.
The aims of the research are to compare ethnographic and genomic data to investigate the degree to which flavour-oriented selections may be leading to inadvertent hereditary change in the micro-organisms associated with novel fermentation techniques as they are 'translated' from eg. East Asia to the Nordic Region.
This research will help us understand how micro-organisms symbiotic with humans change as they respond to new environments, and how humans and non-humans change each other often without realising it. As such it may teach us something new about how domestication and similar processes work in general.

Why have I been invited to take part?
You have been invited because you have expertise that is relevant to the aim of the project.
The inclusion criteria for interviews are that one is at least eighteen years of age, and is or has been involved with novel fermentation practices in the Nordic restaurant industry to some degree, whether as a chef, cook, front-of-house staff, producer, administrator, writer, journalist, critic, or in some other capacity, and for participant observation that one is also a member of the team at either Restaurant noma or Empirical Spirits.

Do I have to take part?
No. You can ask questions about the study before deciding whether or not to participate. If you do agree to participate, you may withdraw yourself from the study at any time, without giving a reason and without penalty, by advising the primary researcher of this decision. If you should choose to withdraw, your data may be held anonymously until the end of the project, but will not be used in analysis or publication.

What will happen to me if I take part in the research?
If you are happy to take part in the research, you will be asked to participate in an interview with the primary researcher at a mutually agreed time and place, and/or allow the primary researcher to observe and participate with you at parts of your work which you and the primary researcher will mutually agree upon. The interview should take between .5 and 1.5 hours depending on the number of questions asked and your responses. Before the interview and/or participant observation begins, you will have the chance to discuss any potential concerns and to give your written consent by reading and signing a consent form. You may be asked to participate in 1 or 2 follow-up interviews, which you may agree to separately. You will also be asked whether you consent to having your interview audio-recorded for ensuring ease and accuracy of data collection and analysis, and possibly to having your photograph taken, and if so, whether you consent to having this data identify you in subsequent analysis and publication.

You may also be asked if you consent to having your hands sampled for sequencing the DNA of their microbes, if you are involved in the production of the fermented products which are part of the project's experiments.

Are there any potential risks in taking part?
There are no physical or mental risks to you if you choose to take part, nor are there any specific preparatory requirements for participation.

Are there any benefits in taking part?
Your participation will contribute to producing new knowledge about how novel fermentation practices may be changing the microbes and humans involved. This research may also yield information of immediate interest for your work. You may request on the consent form to be kept updated via email with the results of this project.

Payment
There will be no remuneration for taking part in this study.

What will happen to any samples I give?
If you agree to let us take a sample from your hands, we will extract the DNA from the cells present (human and microbial) within 7 days of sampling, sequence it, and use this data in comparison with other samples from the fermentation process to try to shed light on how its organisms and ecologies might be changing. We will destroy the sample after extracting the DNA.

What happens to the data provided?
All data (including interview transcripts, written notes, and/or any personal data such as name, age, email address, audio files, and/or photographs) will be encrypted and stored confidentially on one password-protected laptop computer, and backed up on one password-protected external hard drive.
The interview transcripts and written notes will by default remain unanonymised, but will be anonymised if you so choose, which you may indicate on the consent form. One password-protected copy of an anonymity key will be encrypted and stored on a separate device. All devices belong to the primary researcher. Personal data is not possible to anonymise and will be stored securely on the primary researcher's encrypted hard drive.
Only the primary researcher, supervisor, and other people authorised for monitoring purposes such as members of the Central University Research Ethics Committee will have access to the data. If you give the researchers a sample from your hands, this data will also be accessible to the technician at the Danish Natural History Museum who sequences the sample; they will destroy it once they have transferred it securely to the primary researcher.
We would like your permission to use direct quotes from your interview(s). We would also like your permission to use anonymised data in future research, and to share data with other researchers (e.g. in online databases). All personal information that could identify you will be removed or changed before information is shared with other researchers or results are made public. You may decline these on the consent form.
We would also like your permission to store your personal data securely, only accessible to the primary researcher, for 3 years after publication or public release of the work of the research, in case it will be made into a book.

Will the research be published?
The research will be published as a student doctoral thesis in print and online in the Oxford University archives, and may also be published in the form of academic and/or popular articles. Your data, as transcript excerpts and/or photos, may or may not feature directly in these publications.

Who is organising and funding the research?
This research is organised by the primary researcher. This project is funded through the Mortimer May DPhil Scholarship in Human Geography at Hertford College, Oxford, with supplementary funding through the supervisor's Fell Fund Grant no. ACD12770, and is unaffiliated with specific commercial interests.

Who has reviewed this study?

This study has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee (Reference number: R57570/RE001).

Whom do I contact if I have a concern about the study or I wish to complain?
If you have a concern about any aspect of this study, please speak to the primary researcher (+45 52 22 79 88 / +44 (0) 7709 773044) or their supervisor (+44 (0) 1865 275841), who will do their best to answer your query. The researcher should acknowledge your concern within 10 working days and give you an indication of how they intend to deal with it. If you remain unhappy or wish to make a formal complaint, please contact the relevant chair of the Research Ethics Committee at the University of Oxford who will seek to resolve the matter in a reasonably expeditious manner:

Chair, **Medical Sciences Inter-Divisional Research Ethics Committee**; Email: ethics@medsci.ox.ac.uk; Address: Research Services, University of Oxford, Wellington Square, Oxford OX1 2JD

Further Information and Contact Details
If you would like to discuss the research with someone beforehand (or if you have questions afterwards), please contact:
Joshua Evans
School of Geography and the Environment
South Parks Road, Oxford OX13QY, UK
Tel: +44 (0) 7709 773044
Email: joshua.evans@ouce.ox.ac.uk

Thank you for considering to participate!

APPENDIX B – WRITTEN CONSENT FORM

SCHOOL OF GEOGRAPHY AND THE ENVIRONMENT
South Parks Road, Oxford OX13QY, UK

Supervisor: Dr. Jamie Lorimer
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Primary researcher: Joshua Evans, DPhil student
+44 (0) 7709 773044 (UK) / +45 52 22 79 88 (DK)
joshua.evans@ouce.ox.ac.uk

UNIVERSITY OF OXFORD

PARTICIPANT CONSENT FORM

CUREC Approval Reference: R57570/RE001

Endless Convivial Experiments:
Domestication and the microbiogeography of translated fermentation practices

Purpose of Study: To investigate the role of flavour in shaping ecologies and organisms in novel approaches to fermentation in the restaurant industry.

		Please initial each box
1	I confirm that I have read and understand the participant information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
2	I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, and without any adverse consequences or academic penalty.	
3	I understand that research data collected during the study may be looked at by designated individuals from the University of Oxford where it is relevant to my taking part in this study. I give permission for these individuals to access my data.	
4	I understand that this project has been reviewed by, and received ethics clearance through, the University of Oxford Central University Research Ethics Committee.	
5	I understand who will have access to personal data provided, how the data will be stored and what will happen to the data at the end of the project.	
6	I understand how this research will be written up and published.	

7	I understand how to raise a concern or make a complaint.	☐
8	I understand how audio recordings / photos will be used in research outputs.	☐
9	I agree to take part in the study, by interview.	☐
10	I agree to take part in the study, by participant observation.	☐
Optional:	I consent to being audio recorded.	☐
Optional:	I consent to having my photo taken.	☐
Optional:	I give permission to be quoted directly in the research publication by my name.	☐
Optional:	I give permission for my interview transcript and/or participant observation data to remain unanonymised.	☐
Optional:	I agree for research data collected in this study to be given to researchers, including those working outside of the EU, to be used in other research studies. I understand that any data that leave the research group will be fully anonymised so that I cannot be identified.	☐
Optional:	I agree to my personal data being held securely by the primary researcher for up to three years after the end of the project, in case it will be made into a book.	☐
Optional:	I would like to be kept updated via email with results of this project as they become available (in articles, thesis, or otherwise).	☐

________________________ ____________ ________________________

Name of Participant Date Signature

________________________ ____________ ________________________

Name of person taking consent Date Signature

APPENDIX C – INTERVIEW QUESTIONS

Interview Questions

1. How did you come to be working here?

2. How are you involved with fermentation here?

3. Did you grow up with fermentation? If so, how?

4. How much did you know about and/or practice fermentation before joining the team?

5. How did fermentation figure into why you came to work/visit here?

6. What kinds of fermentations/fermented flavours do you like the most?

7. What kinds of fermentations/fermented flavours do you pursue here?

8. How did you learn what tastes right and what tastes wrong when fermenting here? Were you trained? How?

9. How do you get to know the microbes you work with?

10. Do you have different relationships with different microbes you work with?

11. Has your relationship with making and eating fermented things changed since coming here? How?

12. What is a particularly compelling transformation you have encountered?

13. Do you think this team has a distinctive fermentation style/palate? How would you describe it?

14. Do you think any of these flavours or this style are ‘new’? If so, in what way?

15. How do you decide which fermentation traditions/techniques to explore? How do you combine them, and what considerations do you make when combining? eg. Why did Japanese traditions figure heavily from early on?

16. How do you communicate your fermentation work to others? Who are they?

17. How do you think fermentation relates to the larger shifts in Nordic cooking over the last fifteen years, if at all?

18. Why do you do fermentation, both here and in general?

APPENDIX D – LIST OF PARTICIPANTS

Name	Affiliation, position	Gender	Nationality
Kim Wejendorp	Amass, R&D chef	M	New Zealand, Denmark
Jia Hao Choo	Noma, intern in fermentation lab	M	Malaysia
Priyanca Patel	Empirical, kōji; formerly Noma, intern in fermentation lab	F	Canada
Yu Ting Lin	Noma, intern in fermentation lab	F	Taiwan
Hiro Takeda	Empirical, head of R&D; formerly Noma, intern in fermentation lab	M	Canada, Japan
Chris Stewart	Empirical, distilling, R&D	M	Ireland
Jason White	Noma, deputy head of fermentation lab	M	USA
Sam Hunt	Empirical, sales	F	Ireland
Ni Lenette	chef; formerly Noma, R&D	F	Mauritius, England
Louise Beck Brønnum	Restaurant Alchemist, R&D	F	Denmark
Junichi Takahashi	Noma, R&D	M	Japan
Dylan Watson-Brawn	Restaurant Ernst; former Noma stagiaire	M	Canada
Spencer Christenson	Restaurant Ernst	M	Canada
Johannes Bay	Empirical, sales	M	New Zealand
Andrew Lê	Empirical, production	M	Canada
Daniel de Haas	Empirical, production	M	South Africa, Portugal
Mathias Skovmand	various Copenhagen food & wine	M	Denmark
Jonas Astrup Pedersen	Meyer, Director of Development; various Copenhagen food & wine	M	Denmark
Henry Stevens	Amass, FOH	M	England
Edith Salminen	formerly Nordic Food Lab; various Copenhagen food & wine	F	Finland
Tamara Vega	Noma, FOH	F	Australia, England
Rodrigo Nincao	Empirical, head of production	M	Brazil
Lisa Abend	Time Magazine, journalist	F	USA
Kamilla Seidler	Restaurant Lola	F	Denmark
Anna Loraine Hartmann	formerly Nordic Food Lab; various Copenhagen food & wine	F	Germany, Philippines
Luke Kolpin	Noma, head of production	M	USA
Torsten Vildgaard	Noma, R&D	M	Denmark
Réka Almási	Empirical, kōji	F	Hungary
Lars Williams	Empirical, co-founder; formerly Noma, head of R&D	M	USA
Marika Groen	fermenter, Amsterdam	F	Japan, Netherlands
David Zilber	Noma, head of fermentation lab	M	Canada

APPENDIX E – NVIVO CODES LIST

Name	Files	References
! *(promising passages)*	39	105
actors	96	960
microbes	59	321
bacteria	2	3
enzymes	6	8
fungi	43	244
kōji	31	214
yeast	13	18
people	78	226
Andrew Lê	4	6
Anna Krzywoszynska	1	1
Anna Loraine Hartmann	2	2
Anna Tsing	1	1
Artur Gomes	1	1
Chris Stewart	4	6
Christoph Geyler	1	1
Daniel de Haas	1	1
David Zilber	5	19
Donna Haraway	1	16
Dylan Watson-Brawn	2	2
Ed Verner	1	1
Edith Salminen	4	4
Erika Szymanski	1	1
Heather Paxson	2	2
Henry Stevens	2	3
Hiro Takeda	4	5
Ian Moore	1	1
Jason White	7	18
Jia Hao Choo	3	3
Johannes Bay	1	1

Name	Files	References
Jonas Astrup Pedersen	1	1
Junichi Takahashi	1	1
Kamilla Seidler	2	2
Kaushik	2	2
Kim Wejendorp	3	8
Lars Williams	8	9
Lisa Abend	2	2
Louise Beck Brønnum	3	3
Luke Kolpin	2	3
Lynn Margulis	1	1
Marika Kawaguchi	1	1
Mark Emil Hermansen	1	5
Mathias Skovmand-Larsen	3	3
me	10	12
Myra Hird	1	1
Ni Lenette	2	2
Priyanca Patel	4	8
René Redzepi	15	31
Rob Dunn	3	9
Rodrigo Nincao	2	2
Rosio Sanchez	1	1
Réka Almási	2	2
Samantha Hunt	1	1
Sarah Kantrowitz	1	1
Sebastian	1	1
Spencer Christenson	1	1
Stefan Helmreich	1	6
Tamara Vega	2	2
Torsten Vilgaard	1	2
Troels Prahl	1	1
Vaughn Tan	1	1
Yu Ting Lin	4	5
Yuki Nielsen	1	1

Name	Files	References
products	50	413
beer	3	4
blackening	3	3
blending	3	7
bread	2	11
garum	6	30
kombucha	14	53
lacto	12	45
miso	33	186
shoyu	2	10
spirit	1	1
viili	2	8
vinegar	8	32
wash	1	1
wine	9	21
wort	1	1
concepts	110	3405
affect	36	106
agency	28	56
alive	5	9
Anthropocene	8	16
balance	5	14
construction	10	11
conviviality	18	41
cooking	20	46
discourse	20	48
diversity - difference - sameness	43	95
DNA	3	5
domestication	11	13
ecology	13	22
evolution	19	34
experiment - science - technology	35	76
Fermentation	43	252

Name	Files	References
history	37	221
interest	29	97
Japan	30	82
learning - training	21	48
magic - transformation	3	4
metaphor-rhetoric	7	32
multispecies	3	4
New Nordic	30	81
newness - innovation	39	156
politics	29	89
practices - work - labour - care - craft	58	306
scale	13	22
seasonality	9	17
sensing	28	66
social	55	312
space - place	29	76
style	32	175
Sustainability - waste	23	46
taste - smell - flavour - appetite	62	464
tradition	16	39
translation	17	45
umami	16	29
value	33	118
wildness	19	32
sites	97	1563
Amass	4	4
Empirical	34	1272
noma	53	267
SNM - sequencing	18	19
White Labs	1	1

APPENDIX F – EXPERIMENTAL KŌJI SENSORY ANALYSIS FORM

Experimental Koji Sensory Analysis

Age:

Gender:

Nationality:

	375	421	896
Please describe the smell of the koji. Use as many descriptors as you like. You may reuse descriptors.			
How much do you like the smell of the koji? On a scale from: 10 extremely like … 5 indifferent … 0 extremely dislike			
How likely would you use this koji for our brewing? On a scale from: 10 extremely likely … 5 maybe … 0 extremely unlikely			
Would you use this koji for other applications? If so, please list them. You may use them for more than one sample.			

APPENDIX G – COLLABORATIVE EXPERIMENTS METHODOLOGY

Here I describe the design and methods of sampling, sensory analysis, and DNA sequencing and analysis for the collaborative experiments with miso and kōji.

G.1 PRELIMINARY DATA

The design of the miso experiment was based in part on preliminary metagenomics data from six samples of existing Noma misos (Figures 57 & 58).[249] The misos were made based on Noma's standard miso recipe ratio (2 parts pearled barley kōji : 3 parts proteinous substrate + 4% of combined weight in salt). The proteinous substrates were yellow pea, nixtamalised yellow pea, lupin seed, Ureta pea, grey pea, and Gotland lentil.

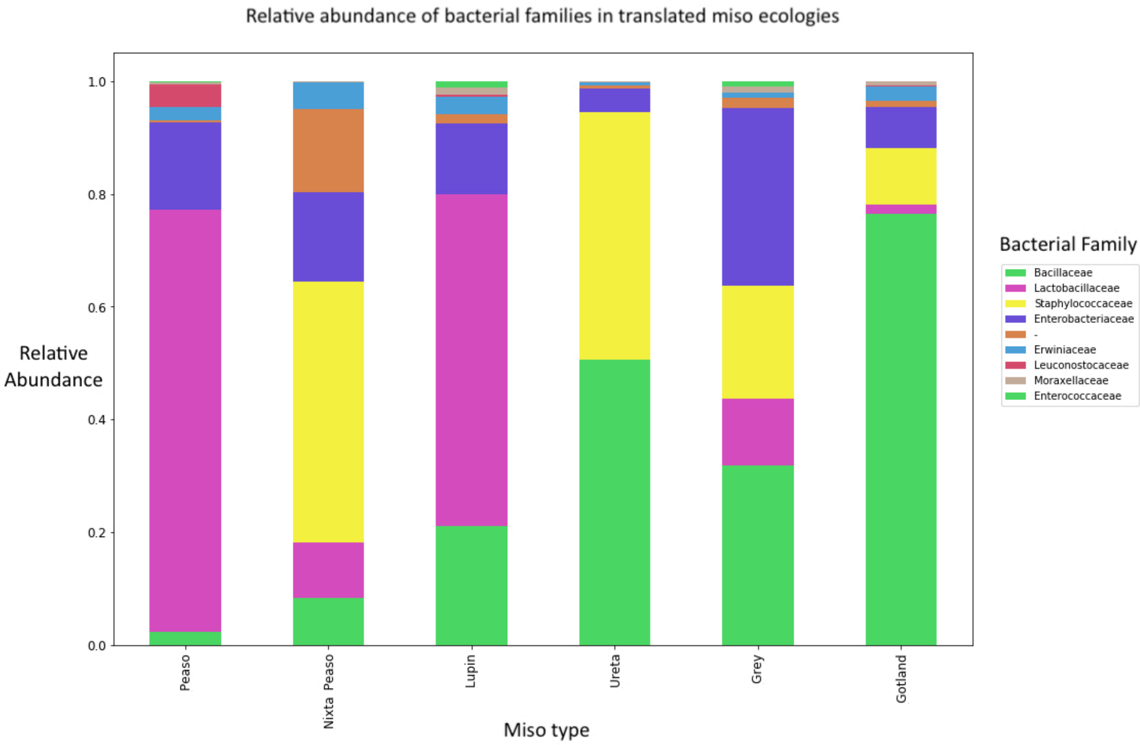

Figure 57—Relative abundance of bacterial families in translated miso ecologies (existing Noma samples). Figure by Jacob Agerbo Rasmussen.

All these misos appear to have some degree, if slight, of Staphylococcaceae and Enterobacteriaceae—families of bacteria typically associated with the gut microbiome. This is not necessarily to say that these bacteria originally 'came from' the maker's gut

[249] I thank Sarah Mak for receiving and preparing the samples, Jacob Agerbo Rasmussen for conducting the bioinformatic analysis and generating the graphs, and Tom Gilbert for funding the sequencing. These were carried out at the then Section for Evolutionary Genomics, Danish Natural History Museum, University of Copenhagen (now Center for Evolutionary Hologenomics, GLOBE Institute, University of Copenhagen).

microbiome, or that they are pathogenic. There is some precedent in the literature identifying other gut-microbiome-associated taxa in miso, eg. *Enterococcus faecium* in rice kōji and *E. faecalis* in bean kōji (H. Ito and Dou 1994) and other kōji-based Asian fermentations (Yan et al. 2013).[250] These findings link to broader current debates on moving beyond seeing specific taxa as inherently pathogenic. If specific taxa are present and are *not* pathogenic, that is what must be explained.

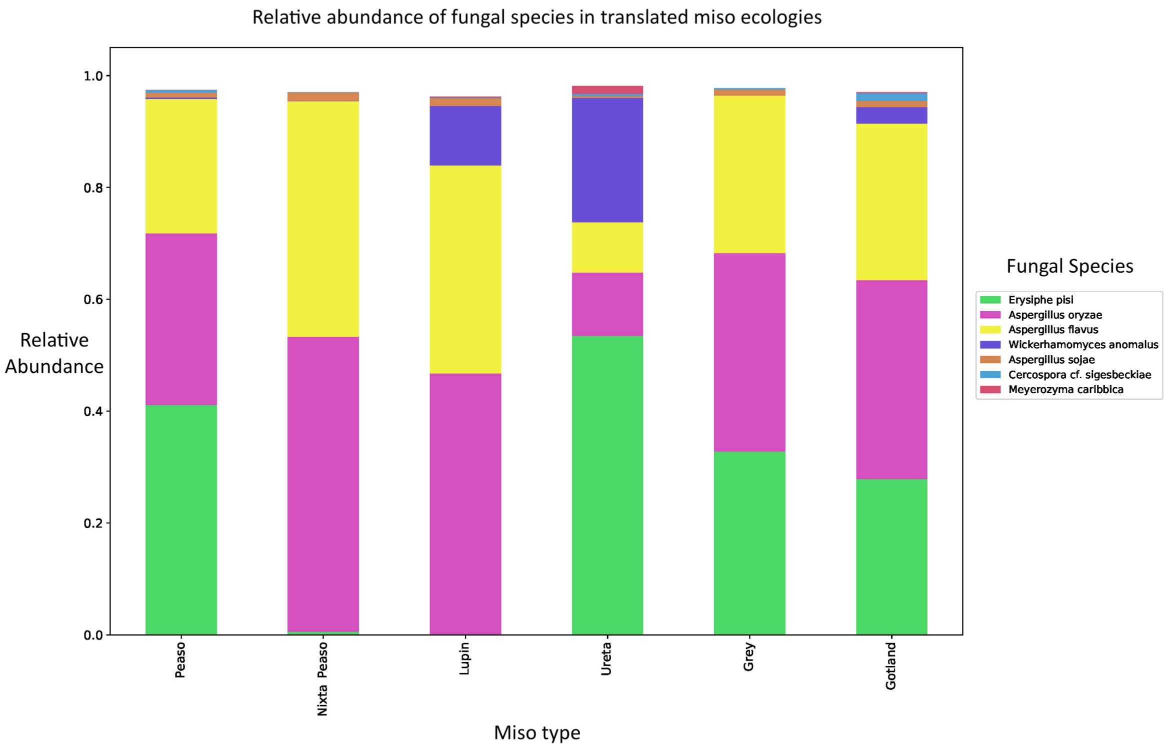

Figure 58—Relative abundance of fungal species in translated miso ecologies (existing Noma samples). Figure by Jacob Agerbo Rasmussen.

With the fungi, though *Aspergillus* spp. DNA dominates, as one might expect (the *A. flavus* reads likely belong to *A. oryzae*, as the species are so similar), there are also differences among the samples in their proportions of *Erysiphe pisi*—a common plant pathogen causing powdery mildew, which might suggest something about the agro-ecologies of some of the Nordic legumes used to produce the misos. One limitation of using DNA here is that it picks up signal from any DNA in the sample, whether or not it is from an organism currently living and metabolising there. This means that the signal of the main fungi actually transforming the miso—likely various salt-tolerant yeasts—are drowned out by the DNA from the kōji and the powdery mildew.

This problem of the 'signal' DNA being drowned out by 'noise' DNA was exacerbated by the sequencing method. For these preliminary samples, my colleagues at SNM used shotgun metagenomic sequencing to get a sense of how much DNA would be recovered from the microbes compared with from the plant substrates. As we had suspected, most of the DNA was plant, and therefore my colleagues and I decided to move forward with

[250] There also appear to be significant amounts of *Enterococcus* spp. in Inua's soy-yuzu miso; see Appendix H.

metabarcoding for the miso experiment, which would target only bacteria and fungi through the 16s and ITS genes respectively.

Together, these data suggest that varying misos by proteinous substrate does shape miso ecology. Yet these data alone were not sufficient for drawing conclusions, as the misos were not made all at the same time, by the same person, and in triplicate to control for batch variation. We proceeded by designing a controlled experiment to test the hypothesis.

G.2 EXPERIMENTAL DESIGN

Here I describe the design of the collaborative experiments with miso and with kōji.

G.2.1 MISO EXPERIMENTAL DESIGN

Goal:
To investigate diversity in microbial ecology of novel misos.

Site:
Restaurant Noma.

Design:
Based on Noma's existing practice of making experimental misos, we created 8 misos, 3 batches of each (2kg each batch), using their standard recipe. The misos were not inoculated with previously made misos (backslopping).[251] Ground pearled barley kōji and cooked ground proteinous substrates (detailed below) were combined in a 2:3 parts ratio (see kōji production method in Prologue). Salt equivalent to 4% salt of the combined weight was added and mixed thoroughly with gloved hands (fresh gloves for each substrate type), packed into large sterilised glass jars, covered on the surface with one layer of cling film, weighed down with ceramic weights, and fermented for 3 months in the miso room at a constant temperature set at 28˚C and ambient humidity.

Proteinous substrates included: 3 Nordic legumes (yellow peas, Gotland lentils, and fava beans); rye bread; and soybeans (made with rice kōji, as a more traditional control). The legumes were soaked in water overnight before cooking. Two treatments were used to prepare the 3 legume substrates: boiling and nixtamalisation, each cooked until al dente.[252] Nixtamalisation was conducted according to Noma's standard recipe. The soaked legumes were cooked in an aqueous solution of .1% calcium hydroxide (CaOH), brought to the boil, reduced to a simmer and cooked gently until al dente. The pots were removed from the heat, covered, and allowed to sit overnight. The following day, the legumes were

[251] Because Noma did not usually do so. However, investigating how much backslopping shapes the ecology compared with other variables could be a worthy direction for further study.

[252] Nixtamalisation is an ancient process developed in Central America to prepare corn. Cooking the corn in an alkaline solution (traditionally with *cal*, also known as slaked lime, or ash) helps break down the corn grains, making them more digestible, nutritious, and flavourful. David and Jason had experimented a bit with nixtamalised misos, a good example of translated fermentation—eg. one of the preliminary samples I took in December 2017 was a nixtamalised yellow pea miso—but had not explored it systematically across multiple substrates at once. This was one dimension of the collaborative experiment with miso that we designed hoping to yield not only DNA data useful for my PhD, but also sensory and culinary information useful for the Noma fermentation lab team.

drained from the solution, rinsed gently under cold water, and drained again before being ground (Redzepi and Zilber 2018).

Metadata on the date, temperature of the miso room, and final pH of the misos were recorded. Sensory analyses were subsequently conducted on the final misos.

Sampling:
Each miso was sampled 3 times over the 3-month fermentation period: at the start, after 1 month, and at the end (after 3 months). The 1-month and 3-month samples were taken by lifting away some of the top surface with sterile utensils and sampling the middle of the miso paste below. The miso pastes were put into 5ml Falcon tubes with sterile utensils, and placed into the freezer at -80˚C.

A total of 56 samples were collected:
(3 legumes x 2 treatments + 1 rye bread + 1 soybean/rice control) x 3 batches x 2 samplings + 8 start samplings = 56 samples.

Of these, 32 samples were sequenced:
(3 legumes x 2 treatments + 1 rye bread + 1 soybean/rice control) x 3 batches + 8 start samplings = 32 samples.

G.2.2 KŌJI EXPERIMENTAL DESIGN

Goal:
To investigate potential evolutionary divergence in populations of the kōji fungus *Aspergillus oyzae* across three sites.

Sites:
Restaurant Noma, Empirical Spirits, and the laboratory at the Danish Natural History Museum (SNM) / Center for Evolutionary Hologenomics.

Design:
A. oryzae from the same bag of pure commercial albino white rice kōji spores (from Bio'c, Japan, used by both Noma and Empirical) was grown in 3 parallel populations at each of 3 sites (Noma, Empirical, and SNM), for 25 generations, at 1 generation per site per week.[253] Spore from each generation was used to inoculate the next generation within the same population, keeping the populations at each site separate.

The inoculation and harvesting followed a standard schedule as far as possible. Spores were inoculated onto grains on Monday morning; the inoculated grains were spread out to sporulate on Tuesday morning; the sporulated grains were set to dry on Wednesday morning; and the dried sporulated kōji was harvested on Thursday morning.

At Noma and Empirical, the respective kōji populations were grown according to each site's standard production method.

---

[253] Similar laboratory experimental evolution studies with fungi have exhibited genetic change after 20 to 27 propagation cycles (de Crecy et al. 2009; Jeon et al. 2013; Schoustra et al. 2006, 2007). I originally aimed for 30, but significant change was observed after 25, so I could halt the experiment.

At Noma, the kōji was grown on pearled barley in stainless steel trays, wrapped and then covered with cloths, in one of the fermentation lab's three 'kōji rooms', small closets fitted with heaters, misters, and temperature and humidity sensors. The room was set to 32˚C and 70% relative humidity (RH) for the first 24h, 28˚C and 70%RH for the following 24h, and 28˚C with humidity off for the final 24h.

At Empirical, the kōji was grown on pearled barley in stainless steel trays, wrapped and then covered with cloths, in a repurposed chest freezer (their R&D department's standard method for small batches of experimental kōji and other fermentations requiring incubation) fitted with a small heating fan, an ultrasonic humidifier, and temperature and humidity controls. The chest was set to 30˚C and 70%RH for the first 48h, and 30˚C with humidity off for the final 24h with the top of the chest freezer opened slightly for humidity to escape.

In the laboratory at SNM the kōji was grown in the incubator, set to 30˚C, on plates of barley-agar medium I had prepared, wrapped around the edge with parafilm tape to keep the moisture in. Passaging from one generation to the next was conducted under flow hood.

Essentially this is a classic experimental evolution approach (for which there is demonstrable precedent and feasibility), though undertaken across both laboratory and field sites.[254]

For each population in each generation at each site metadata on date and time, temperature, humidity, and any changes in appearance were recorded. Sensory analyses were conducted of the final generation 25 kōjis (9 populations in total).

Sampling:
Once each population of sporulated kōji was dry, samples were collected in a plastic Ziploc bag. The bags of dry sporulated kōji were stored at ambient temperature for the next 3-4 days until the following Monday, when the spores were used to inoculate the next generation of each population at the respective sites. The bags with the remaining dry sporulated kōji were then placed into the freezer (-20˚C at Noma and Empirical; -80˚C at SNM). At the end of the experiment the samples for sequencing from Noma and Empirical were moved to the -80˚C freezer at SNM.

A total of 226 samples were collected:
3 sites x 3 populations x 25 generations + 1 original pure spore = 226 samples.

Of these, 18 samples were sequenced:
generation 1 (3 sites x 3 populations) + generation 25 (3 sites x 3 populations) = 18 samples.

The experimental setup for the kōji experiment, and the sampling method for both experiments, followed a factorial design (Parke 2012), to study multiple interacting

[254] This is another example of an experiment designed to be useful for both me and my collaborators—hopefully providing useful data for my theoretical interests, as well as information for Lars and David on what was going wrong when they tried passaging kōji, and how it might be averted.

factors—in this case, independent variables in the miso experiment included proteinous substrate and time, and in the kōji experiment included site and time.

G.3 SENSORY ANALYSIS

Here I describe the methods of sensory analysis for the collaborative experiments with miso and with kōji.

G.3.1 MISO SENSORY ANALYSIS

I conducted a sensory analysis using rapid sensory profiling methods (Frøst, Giacalone, and Rasmussen 2015) with Jason White, then deputy head of the Noma fermentation lab, on 26 November 2018. We smelled and tasted through the 8 experimental misos together; Jason offered his tasting notes first and I took notes and recorded. Based on his intimate knowledge of making Noma's misos and how they should taste, Jason was an ideal participant for tasting and offering notes on the misos from the collaborative experiment.

G.3.2 KŌJI SENSORY ANALYSIS

In addition to informally showing samples of the experimental kōji to participants at Noma and Empirical over the course of the experiment and asking for informal sensory feedback, I also conducted a formal sensory analysis with 20 members of the Empirical team on 11 June 2019, using the three generation 25 samples from Empirical. I administered the analysis with one participant at a time, in a separate room without distractions or other smells. The three kōji samples were grown the day before and offered for analysis after around 24h of growth—the peak of aromatic intensity. Each sample was placed in an identical 240ml round plastic container, with the lid on. Each container was assigned a random 3-digit number, by someone other than me who was also not participating in the experiment. They told me their assignment of numbers to populations afterwards. For each participant the three samples were arranged in a different order. The participant was invited to describe the smell of each sample (as many descriptors as they liked, reuse of descriptors for different samples allowed), as well as hedonic rating, and how likely they would use the sample for brewing and/or other applications. See Appendix F for the data collection form. The data were collated and quantified by descriptor. Top descriptors per sample were identified, and mean hedonic rating per sample was calculated.

G.4 LABWORK & SEQUENCING

Here I describe the methods of DNA labwork and sequencing for the collaborative experiments with miso and with kōji.

G.4.1 MISO LABWORK & SEQUENCING

The metabarcoding labwork for the miso samples was conducted under the guidance of Christian Carøe, a postdoc in the Gilbert Group at the Section for Evolutionary Genomics, University of Copenhagen.

32 samples from the miso experiment were prepared (8 starting samples + 24 final samples), along with 6 samples of misos from Inua, 6 samples of experimental kombucha (for another project), 4 extraction blanks and 2 PCR (Polymerase Chain Reaction) blanks.

Extraction

DNA from the samples was extracted using the Qiagen DNEasy PowerSoil Kit, with the following modifications:

1. Added 60 µl Solution C1 to PowerBead Tube.
2. Added 400 µl bead mixture to sample tube (to ensure all sample suspended).
3. Added sample + bead mixture to PowerBead Tube.
4. Proceeded from step 3 in protocol.
5. Skipped incubations in steps 7 and 10.

Combined qPCR and Barcoding PCR Amplification

All PCRs were set up in a dedicated pre-PCR laboratory with positive air pressure to minimize risk of contamination. PCR amplifications and post-PCR laboratory steps, including library preparations, were carried out in a dedicated post-PCR laboratory. In all laboratories, handling of reagents, samples, DNA extracts, PCR products and sequence libraries was performed in laminar flow hoods.

Combined qPCR (quantitative Polymerase Chain Reaction) and barcoding PCR amplifications were set up according to the Tagsteady protocol (Carøe and Bohmann 2020), with the following modifications:

1. 10 µl (not 25 µl) reactions (8 µl mastermix, 1 µl combined primer mix, 1 µl template DNA).
2. 0.8 mg/ml (not 0.5 mg/ml) BSA.
3. 2 µM (not 0.6 µM) of each forward and reverse tagged-primer mix.

16s primers were 515F (Parada, Needham, and Fuhrman 2016) and 806R (Apprill et al. 2015); ITS primers were ITS3_KYO2 (Toju et al. 2012) and ITS4 (White et al. 1990).

PCRs were run in triplicate for each primer set on an Agilent mx3005p instrument, with the following setup (annealing temps: 48˚C for ITS, 52˚C for 16s):

5 minutes 95°C

40 cycles of:
20 seconds 95°C (denaturing)
30 seconds 48/52°C (annealing)
45 seconds 72°C (extension)

1 minute 95˚C, 30 seconds 48/52˚C, 30 seconds 95˚C (final dissociation).

Pooling

The concentration of the samples with the highest and lowest Fluorescence Unit (FU) values from the final qPCR cycles was measured on a Qubit Fluorometer (Invitrogen) with High-Sensitivity (HS) reagents. Concentrations spanned from 3.08 ng/ml to 7.95 ng/ml, so all samples were pooled with same volume, 5 µl per sample, yielding six pools (16s*3 + ITS*3) of 250 µl each.

Purification

Pools were purified using Solid Phase Reversible Immobilization (SPRI) beads, following the Tagsteady protocol, with the following modifications:

1. Bead solution was mixed into pools by pipetting (not vortexing).
2. DNA was eluted in 20 µl Tris-EDTA-Tween (TET) buffer (not EB buffer), then incubated at 37˚C for 5 minutes; returned to magnet for 2 minutes, or until supernatant had cleared; then DNA collected and transferred to a 0.5 Eppendorf LoBind tube.

Library Preparation

Purified amplicon pools were quantified using a Qubit Fluorometer (Invitrogen) and HS reagents. The number of DNA templates in each amplicon library was calculated in molar units based on Qubit measurements and amplicon length (including primers and nucleotide tags). 2 pmol of each amplicon pool was taken and adjusted with water to a volume of 30 µl.

End-repair was conducted for each pool according to the Tagsteady protocol, with the following modifications:

1. The end-repair mastermix contained 1.5 µl Klenow Fragment (3'->5' exo-) (New England Biolabs, cat#M0212S, 5 U/µl), and no T4 DNA Polymerase or Taq DNA Polymerase.
2. 10 µl (not 10.1 µl) of this mastermix was added to each 30 µl amplicon pool, and mixed well by pipetting 10 times.
3. The pools were incubated for 30 minutes at 37°C (not 20˚C) followed by 30 minutes at 65°C and finally cooled to 4°C.

Adapter ligation was conducted according to the Tagsteady protocol.

qPCR and Final Pooling

Purified libraries were quantified according to the Tagsteady protocol. Libraries were pooled in equimolar ratio to a final concentration of 100 fmol, or 5 nM in 20 µl. The final sequencing pool was spiked with PhiX to increase complexity on the flow-cell.

Sequencing

The final library was sequenced on an Illumina MiSeq instrument on a Version 2 flow cell in paired-end mode running 250 cycles, at the Danish National High-Throughput Sequencing Center, University of Copenhagen, Denmark.

G.4.2 KŌJI LABWORK & SEQUENCING

The shotgun sequencing labwork for the kōji samples was conducted by Max Emil Ermter Ramsøe, a research assistant in the Gilbert Group at the Section for Evolutionary Genomics, under Christian Carøe's guidance (the same postdoc who guided me through the labwork for the miso samples).

18 samples from the kōji experiment were prepared (all populations of generations 1 and 25 from each site), along with 4 samples of wild kōji from Japan (for another project) and 1 extraction blank.

Extraction

Samples were extracted using Zymo Quick DNA/RNA MAGBEAD kit (R2130) following manufacturer's instructions for DNA and eluted in 50 µl elution buffer. Extracts were quantified using Qubit HS reagents on a Qubit 2.0 fluorometer. Extracted DNA was normalised with TE buffer to reach similar concentrations and fragmented to ~500 bp using New England Biolabs Nebnext fragmentase kit (M0348). Fragmented DNA was purified with SPRI beads (see library protocol) using 1.6x bead solution to fragment DNA. DNA was eluted in 40 µl EBT buffer.

Shotgun libraries

See BEST 2.0 protocol (Carøe 2019). Instead of Illumina adapters, BGI adapters and primers were used:

> All oligos are in 5'-3' direction.
>
> AD2_Long_2.0: GAACGACATGGCTACGATCCGACTT
> AD2_Short_2.0: AAGTCGGATCGT-[C3spacer]
>
> AD1_Long_2.0: TTGTCTTCCTAAGACCGCTTGGCCTCCGACTT
> AD1_Short_2.0: AAGTCGGAGGCC-[C3spacer]
>
> AD1 oligos are hybridised together and AD2 oligos are hybridised together, before mixing the two adapters (see BEST 2.0 protocol or Meyer and Kircher 2010).
>
> CommonprimerBGI: GAACGACATGGCTACGA
>
> Index primer: TGTGAGCCAAGGAGTTG NNNNNNNNNN TTGTCTTCCTAAGACCGC

Finished libraries were purified according to the BEST 2.0 protocol and amplified using Taq Gold 2x 360 mastermix and 5 µl sample in 25 µl reactions with the following conditions:

> Initial denaturation: 5 minutes at 95˚C

15 cycles of:
30 seconds 95˚C
30 seconds 61˚C
45 seconds 72˚C

Final extension: 5 minutes 72˚C

Amplified libraries were purified with SPRI beads according to the BEST 2.0 protocol. Products were quantified on Qubit fluorometer and molarity calculated using insert lengths. Samples were pooled equimolarly into one pool and sent for BGISeq500 platform PE150 chemistry sequencing at BGI Europe.

G.5 BIOINFORMATICS

Here I describe the methods of bioinformatic analysis of the DNA sequencing data for the collaborative experiments with miso and with kōji.

G.5.1 MISO BIOINFORMATICS

The analyses were conducted by Florent Mazel, then a postdoc at the University of British Columbia, now at L'Université de Lausanne.

Blanks

Most of the blanks had some degree of contamination (Figure 59). These could be due to either 'external' contaminations (from reagents, mixes, etc.) or cross contamination between wells while pipetting.

Two techniques were used to test the robustness of the results with respect to the contaminations:

(1) Removing external contaminants (using the R package decontam) by comparing the prevalence of Amplicon Sequence Variants (ASVs) in blanks vs samples. This technique removes the ASVs that are everywhere but particularly prevalent in blanks. However, this technique won't get rid of cross contaminations. For example, the most abundant bacterial ASV was found in 12 blanks, but also in 120 samples (the total sequence count is nearly 500,000 reads), and so won't be removed by decontamination. This ASV probably represents some cross-contaminations between wells.

(2) A more extreme technique that consist of removing all the ASVs found in the blanks. This approach has the advantage of being (overly) conservative, but comes with a huge loss of power—almost no pattern will be detectable afterwards because even with a small amount of cross-contamination all of the biological signal is removed.

Figures 60 and 61 show the results from technique (1); Figures 62 and 63 show the results from technique (2).

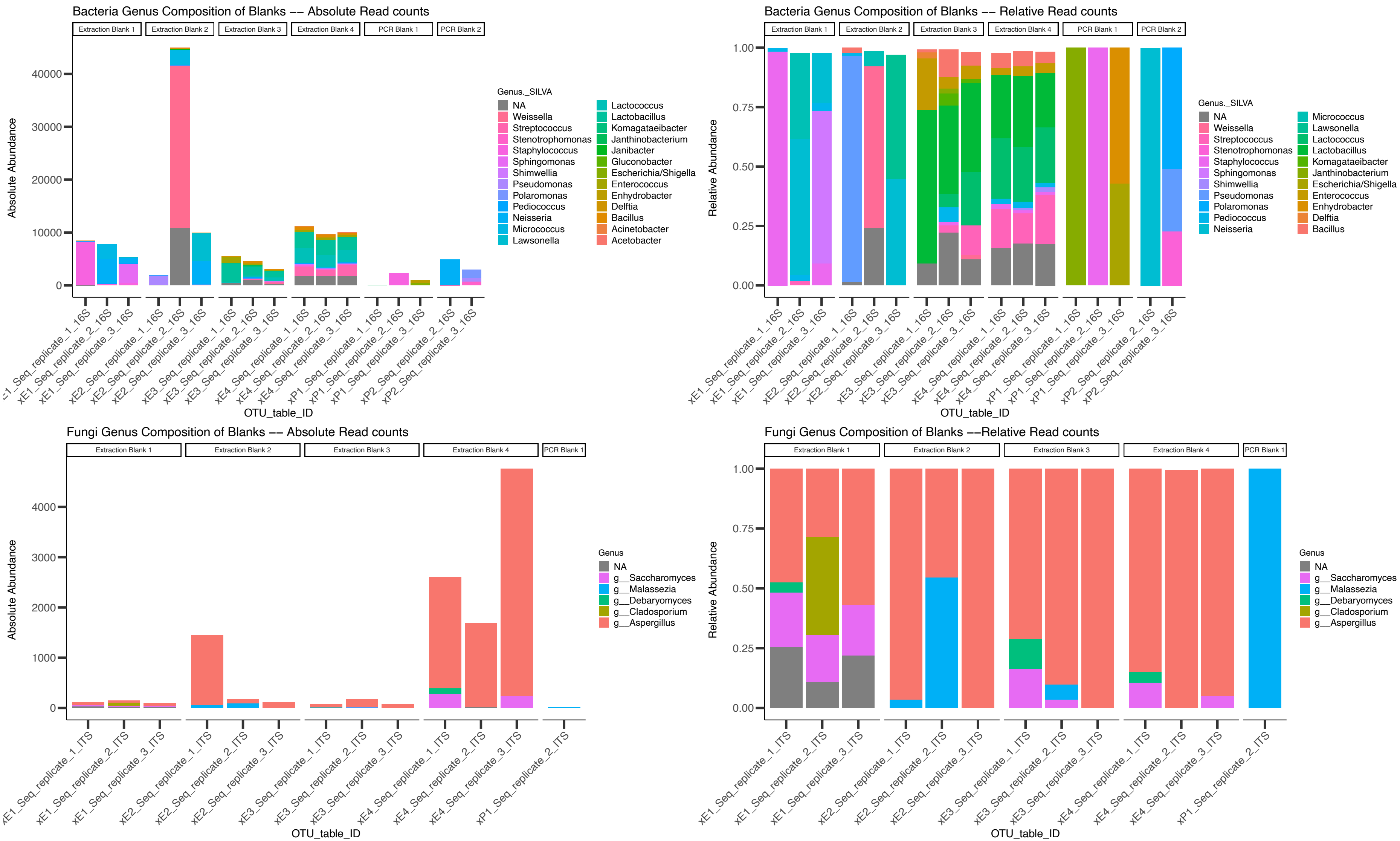

Figure 59—Composition of blanks. Figure by Florent Mazel.

Figure 60—Absolute reads for miso samples after decontam. Figure by Florent Mazel.

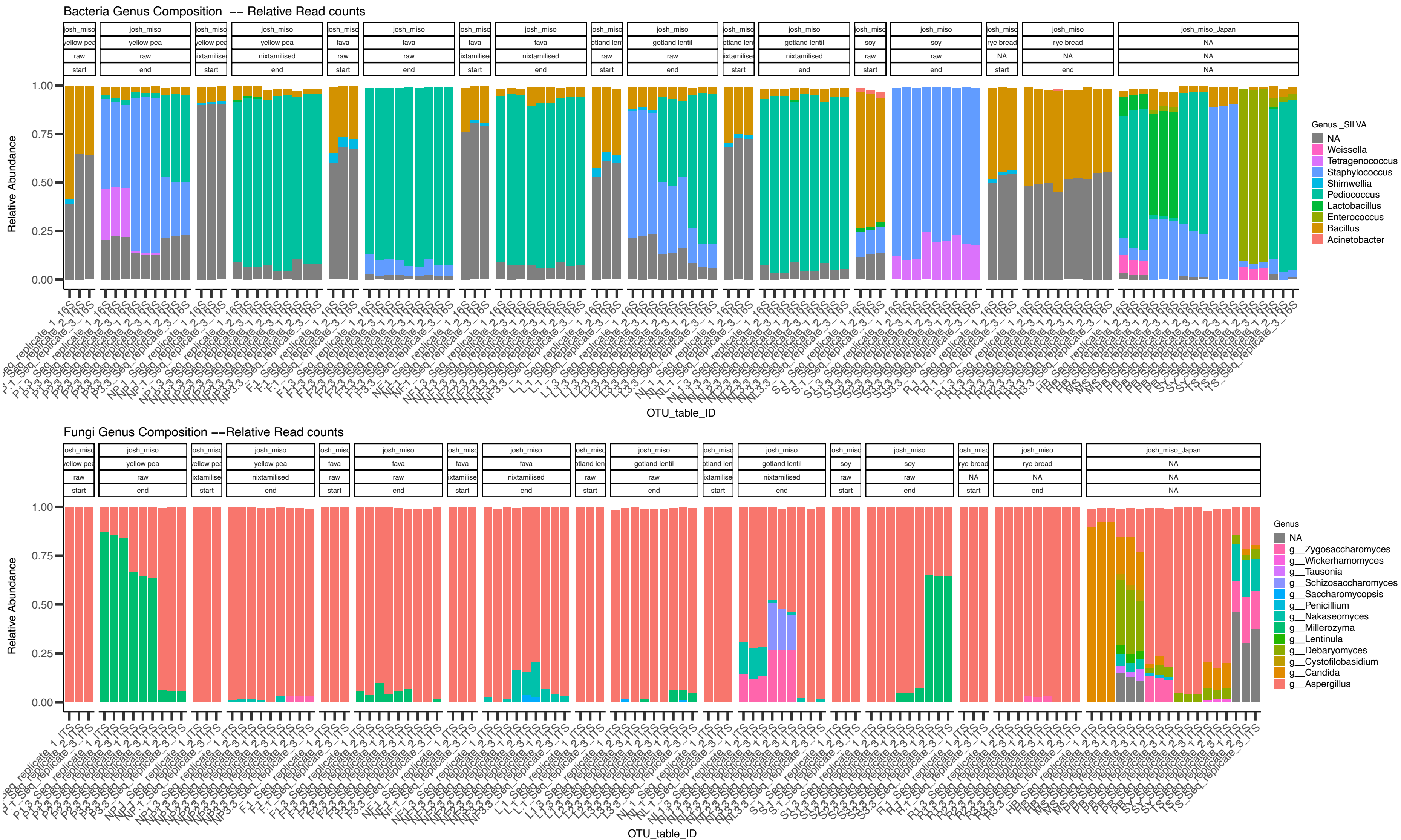

Figure 61—Relative reads for miso samples after decontam. Figure by Florent Mazel.

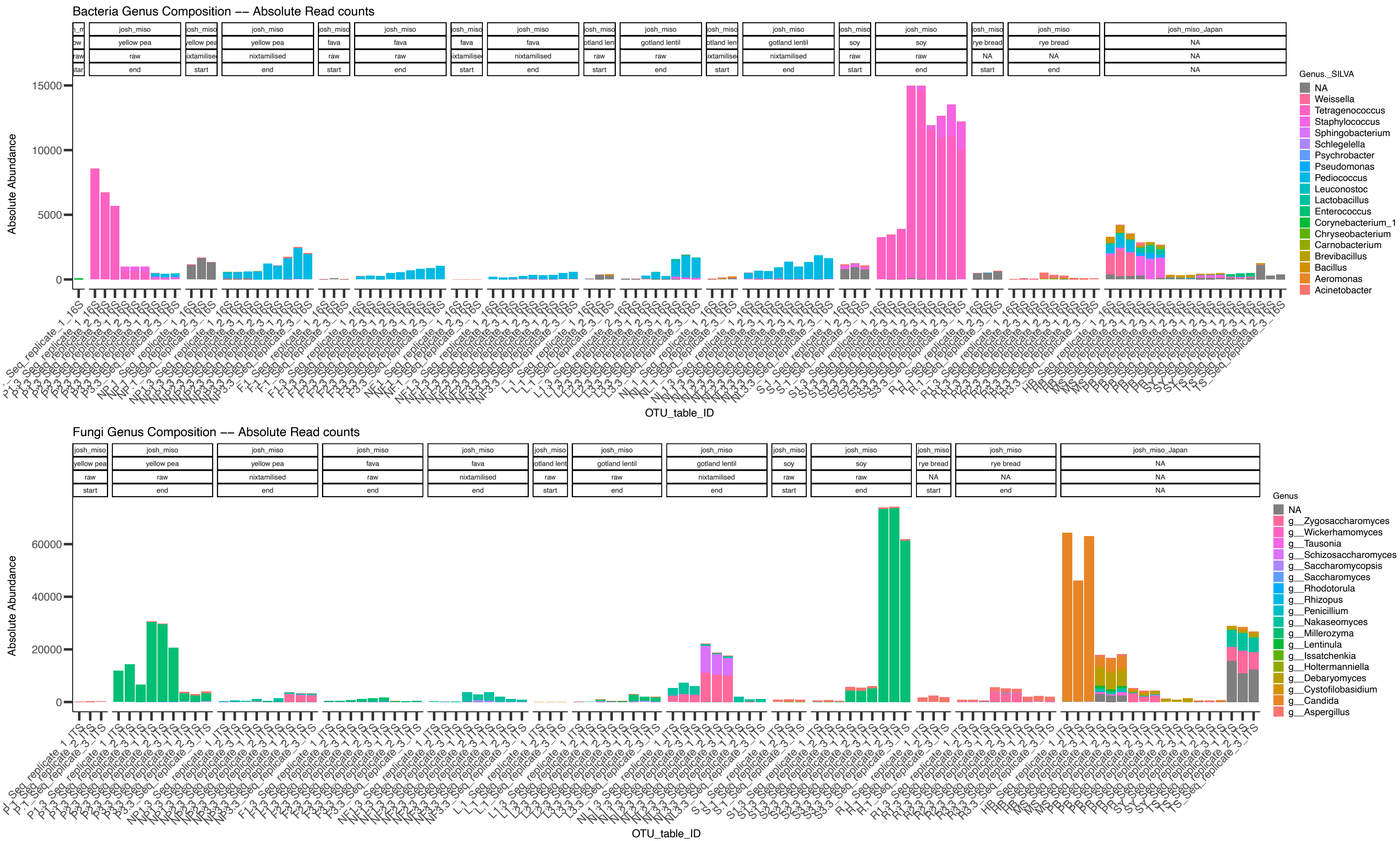

Figure 62—Absolute reads for miso samples after removing all ASVs in blanks. Figure by Florent Mazel.

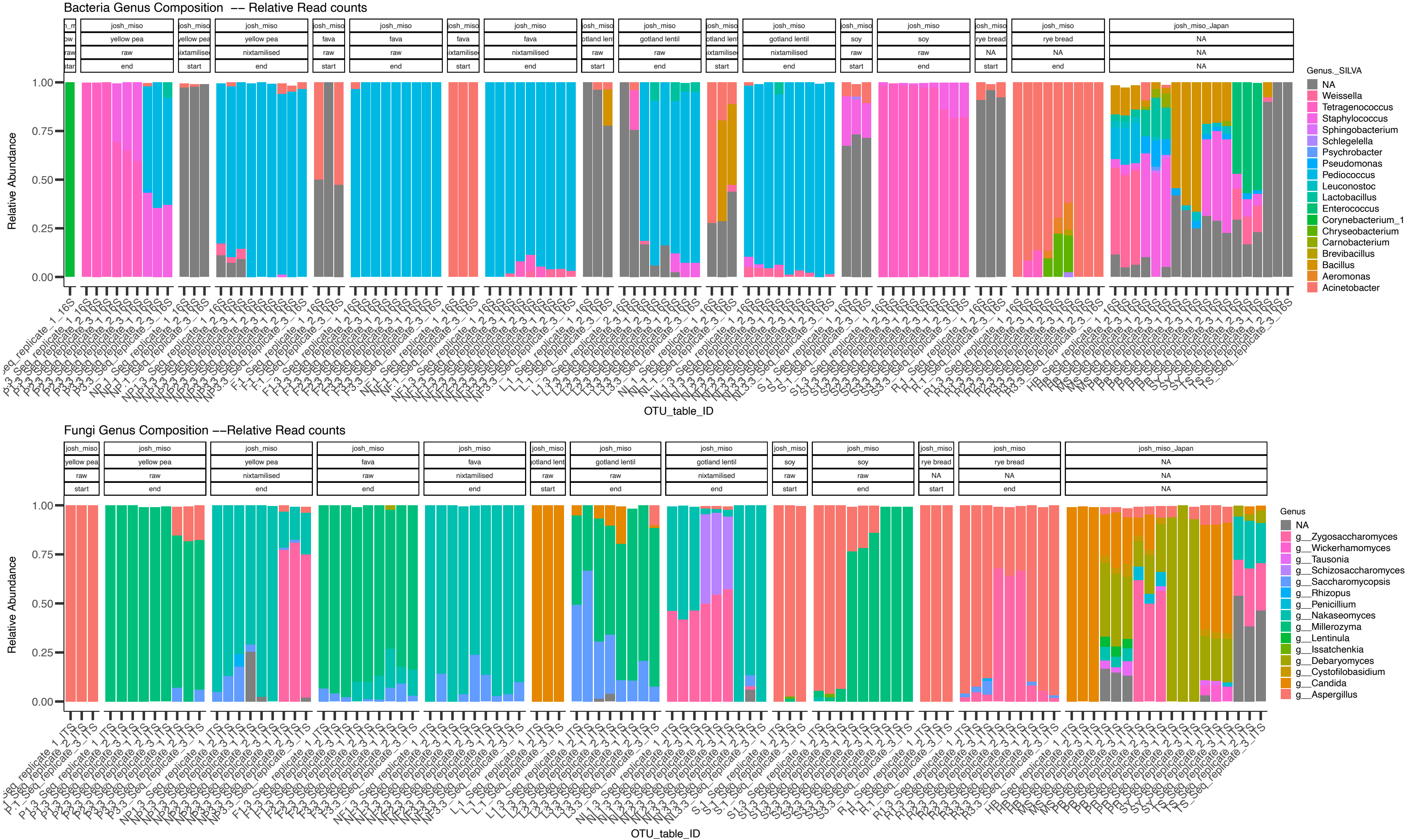

Figure 63—Relative reads for miso samples after removing all ASVs in blanks. Figure by Florent Mazel.

Technique (1) presents few changes; technique (2) presents many changes, removing too many of the reads from the samples. For example, the most abundant bacteria in the dataset (*Pediococcus* ASV #1, 1.5 million reads), present in 96 samples, is also present in 7 blanks, and is thus removed by this technique. Removing it makes nixtamalised samples not so convergent anymore (as *Pediococcus* appears to be a signature of the nixtamalised samples).

This result indicates that most contaminations are likely to be cross contaminations between samples and blanks. This conclusion is also supported by the non-metric multidimensional scaling (NMDS) ordination plot of the samples and blanks: the blanks are scattered around, meaning that they got contaminated differently by different samples (Figure 64).

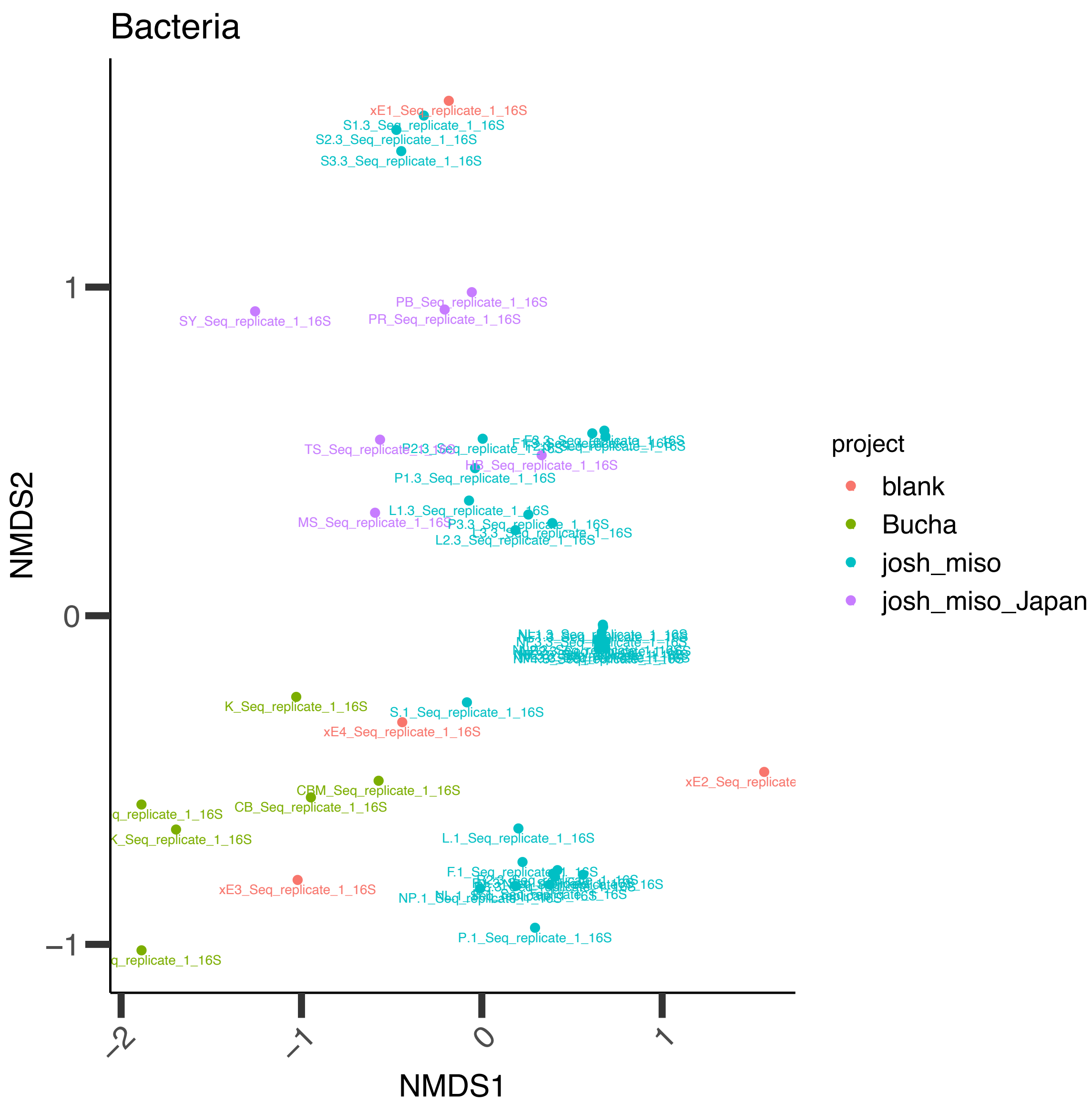

Figure 64—NMDS ordination plot of miso samples and blanks. 'josh_miso' refers to the Noma miso samples, and 'josh_miso_Japan' to the Inua miso samples ('Bucha' is from another project). Figure by Florent Mazel.

While the dataset does exhibit cross-contaminations, strong effects of substrate and time on sample composition are still recoverable, meaning that the cross contaminations did not completely blur the original biological pattern. The main problem with cross contamination is that the biological signal can get blurred (a loss of power), rather than increasing type 1 errors/false positives (i.e. detecting something one believes to be a biological signal while in fact it is an artefact). Yet this tendency only holds when the plate map (the arrangement of the samples in the wells during the labwork) does not correlate with the pattern of the biological samples. It is therefore important to randomise the position of the samples on the plate, to minimise the possibility of cross contaminations between nearby wells producing a signal that looks like a biological signal.

The plate setup in the experiments described above was not randomised. Samples were arranged according to sample type, with similar samples closer together on the plate (Table 6). In theory this can increase type 1 errors/false positives and make nearby wells looks similar. Because some adjacent samples were similar (the first four rows were arranged with the substrates in the same order, resulting in samples of the same substrate arranged in columns; the nixtamalised samples were also grouped adjacently), this could have made the substrate and nixtamalisation effects falsely strong. On the other hand, cross-contaminations between substrate columns would have weakened the signal.

	A	B	C	D	E	F	G	H
1	P.1	F.1	L.1	S.1	NP.1	NF.1	NL.1	R.1
2	P1.3	F1.3	L1.3	S1.3	NP1.3	NF1.3	NL1.3	R1.3
3	P2.3	F2.3	L2.3	S2.3	NP2.3	NF2.3	NL2.3	R2.3
4	P3.3	F3.3	L3.3	S3.3	NP3.3	NF3.3	NL3.3	R3.3
5	PB	PR	HB	TS	MS	SY	xE1	xE2
6	K	BK	BKM	BKF	CB	CBM	xE3	xE4
7							xP1	xP2
8								
9								
10								
11								
12								

Table 6—Plate setup for miso samples: row 1 are the misos before fermentation, rows 2–4 are the misos after fermentation; row 5 are the Inua misos; row 6 are kombucha samples; xE are extraction blanks; xP are PCR blanks.

However, strong signals were still observed for time (start and end of miso fermentation), substrate (of misos) and type of fermented food (miso or kombucha), which are unlikely to have come from cross contaminations (eg. the first row of samples looks very similar because they are all misos before fermentation). While we cannot correct fully in silico for cross-contaminations, we decided to proceed with technique (1).[255] The cross-contaminations led us to qualify our conclusions, but they do not refute the larger patterns.

[255] A further approach to try to correct for cross-contaminations would involve making systematic subgroups of wells that were adjacent on the plate and ones that were distant, then comparing them in eg. an NMDS plot.

Because potential cross-contamination should make samples appear more similar to each other, the differences according to substrate should then, if anything, be even greater than suggested by the current results.

Sequencing data processing and taxonomic annotation

Each PCR replicate was treated independently and then merged to produce the final ASV table. Raw reads were demultiplexed and barcodes and primers were trimmed using cutadapt version 2.9 (with parameters e=0, no-indels, m=100). Reads were then quality filtered using the *filterAndTrim* dada2 R function (with parameters maxEE =6, truncQ=2). 16S reads were trimmed to 200 base pairs (both forward and reverse reads, truncLen=0 in *filterAndTrim function*). The ITS region has variable length so we adapted the default procedure: ITS reads were not trimmed, and we checked that short ITS regions did not mistakenly contain primer reads. Amplicon sequence variants (ASVs) were inferred using the *dada* function and reads were merged using the *mergePairs* function (with parameter minOverlap=12). Chimeras were removed using the *removeBimeraDenovo* dada2 R function. ASVs were chosen instead of cluster of sequences based on an arbitrary threshold (e.g. 97%) because (1) they represent finer taxonomic units, (2) allow comparison between studies and (3) have become the unit of choice in environmental DNA analysis. We assigned taxonomy for each ASV using the naïve Bayesian RDP classifier, as implemented in dada2 (function *assignTaxonomy*, parameter minBoot set to 50) with the SILVA database for 16S reads and the UNITE database for the ITS reads.

ASV filtering

For 16S reads, ASVs assigned to chloroplasts, mitochondria or without phylum assignation were removed. For ITS reads, ASVs assigned to plants were removed. ASVs present in only one sample or with fewer than 10 reads were also removed. Finally, we used the decontam R package (function isContaminant with default parameters) to remove potential external contaminants.

Statistical analysis

Compositional dissimilarities between samples (beta-diversity) were measured using the Bray Curtis metric using a normalised ASV table (observed read count divided by total counts for each sample). The effects of time and substrate were assessed using PERMANOVA tests using all samples (M. Anderson and Walsh 2013) with marginal sums of squares (option 'by' set to margin in adonis2 function in the R package vegan). Some substrates (pea, lentil, fava) received a nixtamalisation treatment, so we only used these substrates to test the effect of nixtamalisation on community composition. Each test was run for each PCR replicate independently and the mean statistic (pseudo-F value, R2, pvalue) was reported.

G.5.2 KŌJI BIOINFORMATICS

The kōji shotgun metagenomics data were assigned to taxa with Kaiju, and analysed phylogenetically using Krona. The top results were summarised in Excel. These analyses were performed by John Gibbons, University of Massachusetts Amherst.

Further analyses to compare populations within and across generations (based on SNPs per gene, SNPs per chromosome, phylogeny, and pairwise Jaccard indices) were performed with MEGAHIT, Bowtie, SAMtools, Prodigal, Kaiju and Anvi'o. Subsequent parsing and figure generation was done via Python, Jupyter, Matplotlib and Pandas. These analyses were performed by Kimmo Sirén, University of Copenhagen.

APPENDIX H – COLLABORATIVE EXPERIMENTS DISCUSSION

To generate potentially new knowledge of taste shaping natures in translated fermentation, I designed and conducted two experiments with key participants at Noma and Empirical (see Appendix G for design and methodology). Here I discuss my observations during the experiments, sensory analysis data of the finished products, and DNA sequencing data analysis of samples taken at the start and end of the experiments. This discussion provides evidence to support arguments particularly in Chapter 7.

COLLABORATIVE EXPERIMENT 1: ECOLOGICAL CHANGE IN TRANSLATED MISOS

After allowing the 24 misos (3 replicates each of 8 substrate types) to ferment for 3 months (Figures 65 & 66), I held a tasting with Jason White, then deputy head of the Noma fermentation lab.

Figure 65—The finished Noma misos in glass crocks, before sampling and packing.

Figure 66—The finished Noma misos once sampled, packed and vacuum-sealed.

Jason had years of fermentation experience and oversaw many of the day-to-day operations at the fermentation lab, including the production of existing misos for the menu and trials of new misos for the R&D and the test kitchen. So he was an ideal and consipiently-representative palate for tasting the misos and providing sensory data. His tasting notes are in Table 7.

miso	notes
pea (P)	Good moisture level, slightly drier than regular (likely due to smaller volume, dried out more), tiny bit more acidic than regular noma peaso. Little essence of yeast and fruitiness spot on. Peas might be slightly undercooked, slightly crunchy.
lentil (L)	Perfect, spicy, tastes like the starting ingredient—nice lentil flavour, gotland lentil has unique peppery note that comes through a lot. Right amount of acid, right moisture.
fava (F)	Very neutral flavour. Tastes like it could be peaso. Moisture level and degree of fermentedness is fine. Only way to get fresh fava taste is with fresh favas, and the miso ferments very fast, like in one month, 1.5 months.
nixta pea (NP)	More caramelised than the other peaso. Consistency is softer, more moisture than the others. Noticed it with nixtamalised misos before. Little musty flavour, dust, dusty. Not better than a peaso. Coffee-ish flavour, roasty almost. Not bad, but I wouldn't reach for it.
nixta lentil (NL)	Never done this before. More sour than the non-nixtamalised. Not uncomfortable amount of sourness, good, bright sourness. More pineapple flavour than the non-nixtamalised. Delicious. Maybe more yeast, more esters.
nixta fava (NF)	Don't think I've done this either. Unbalanced, strange, confusing flavour profiles. Not the worst thing, not terrible, just not stable.
soy (S)	Don't think I've ever had a 4% salt soy miso ever, either. Very nutty, creamy. But also a strange flavour to it.. Not cheesy.. Yeasty maybe? But it fermented well, the acidity is almost not present at all. Brightness, amazing texture. Looks like a really good miso, nice and caramelised.
ryebread (R)	Very sweet, creamy, chocolatey almost. Don't know if it's the bread or not, but I've had better ryeso, with more seed, more characters from the ingredients. So it must be the quality of the bread.
	None were completely off.

Table 7—Jason White's miso tasting notes (2018.11.26).

The flavour of the misos certainly varied according to substrate. The nixtamalised misos, meanwhile, were closer to each other in flavour than their non-nixtamalised counterparts were. This makes sense, both because the nixtamalisation process produces similar, masa-like flavours,[256] and because the nixtamalisation would function as an ecological selection pressure, shaping the composition of the microbial ecology.

The nixtamalisation produced similar physical effects as well: these misos were softer, moister, and more caramelised than the others. The initial increased pH of the nixtamalised legumes would explain the darker colour and more caramelised flavours, as higher pH (i.e. more alkaline conditions) facilitates Maillard reactions.[257] Nixtamalisation also breaks down the proteinous legumes more than boiling at more neutral pH, freeing up more moisture and thus facilitating greater microbial growth. This increased growth helps explain the greater sourness in the finished misos.

Some of these sensory observations are borne out in the 16s/ITS sequencing data.[258] In addition to the 24 miso replicates created in the Noma fermentation lab, I procured samples of 6 experimental misos created at a restaurant in Tokyo, founded by and affiliated with Noma, called Inua, run by one of Noma's former R&D chefs.[259] These misos were made with the same recipe as the Noma misos (3 parts legume : 2 parts kōji + 4% salt, fermented for 3 months), and though there was only one sample of each type rather than the triplicates that would enable robust conclusions, they nonetheless provide an interesting comparison, especially the yellow-pea miso with barley kōji (made with the same recipe as the Noma peaso).

Means and standard deviations of alpha diversity of the Noma and Inua misos can be found in Figures 67–69; statistical analyses of their alpha diversity in Tables 8 and 9; ordination plots in Figures 70 and 71; relative bacterial and fungal read counts in Figure 72; and statistical analyses of variance in Tables 10 and 11.[260]

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256 'Masa' is a dough made from nixtamalised maize/corn, used to make tortillas, tamales, and other Mexican and Central American dishes.
257 A set of chemical reactions between amino acids and sugars, catalysed by heat, that give browned foods their distinctive flavours; described by French chemist Louis Camille Maillard in 1912.
258 My labwork guide Christian Carøe and I decided to proceed with metabarcoded sequencing, because we were concerned that all the plant DNA from the substrates might drown out the microbial DNA signal we were interested in, as suggested by the shotgun sequencing results from the preliminary samples (Appendix G). Targeting the 16s and ITS genes (for bacteria and fungi respectively) would be one way to avoid this. Metabarcoding is also cheaper (in money and analysis time) than metagenomics. As it targets only a single gene in bacteria and fungi, it does not allow for study of genomes. But my research question with this experiment—do the ecologies change according to substrate—did not require this level of resolution.
259 The chef was Thomas Frebel, who kindly had some of his misos sent to me. Inua opened in May 2018, and closed with the spread of Covid-19 in March 2020. At the time of writing it has not reopened.
260 Alpha diversity is a measure of the diversity of taxa within a sample; ordination plots show graphically how similar different samples are to each other. Within alpha diversity, Chao1 estimates total richness (the number of different taxa), while the Shannon index integrates richness and evenness (the distribution of these differences). All alpha-diversity analyses were conducted using replicate 1 samples, as using all three replicates for the stats would result in a loss of power. The Kruskal-Walllis chi-squared test measures the degree of deviation from the null hypothesis—in this case, that all the samples have the same alpha diversity. Permutational Multivariate Analysis of Variance (PERMANOVA) allows measurement of variance between samples for a given factor (in this case, substrate, time, and nixtamalisation): 'degrees of freedom' (dF) is the

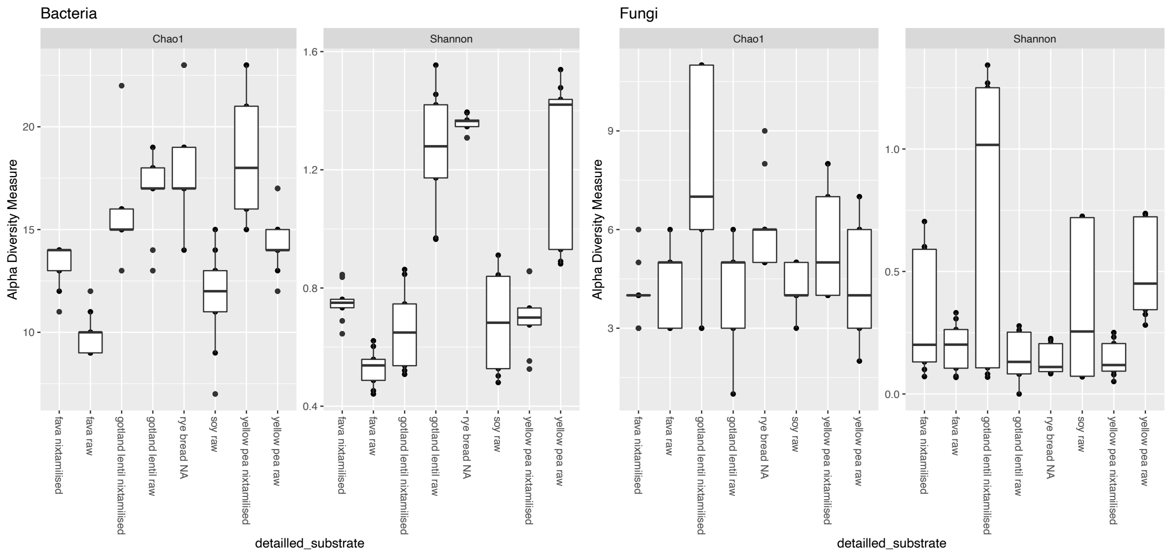

Figure 67—Alpha-diversity (Chao1 richness and Shannon index), with mean and standard deviation, of finished experimental Noma misos. Figure by Florent Mazel.

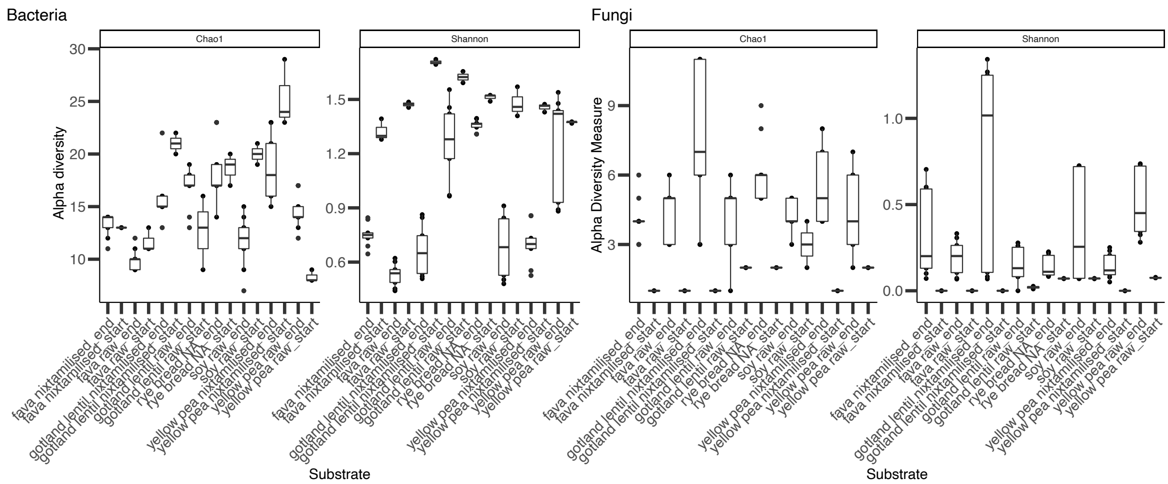

Figure 68—Alpha-diversity (Chao1 richness and Shannon index), with mean and standard deviation, of experimental Noma misos at start and end of fermentation. Figure by Florent Mazel.

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number of parameters that can vary for a given factor; 'Sum of Squares' (SumOfSqs) measures the amount of variance linked to a given factor; 'R-squared' (R2) measures the percentage of total variance explained by the factor; 'Pseudo F' (F) measures the ratio of the variance between sample means and the variance within sample means, which indicates whether the factor has an effect and its magnitude; and 'p-value' (p_val) is the estimation of the probability of the observed variance being due to chance.

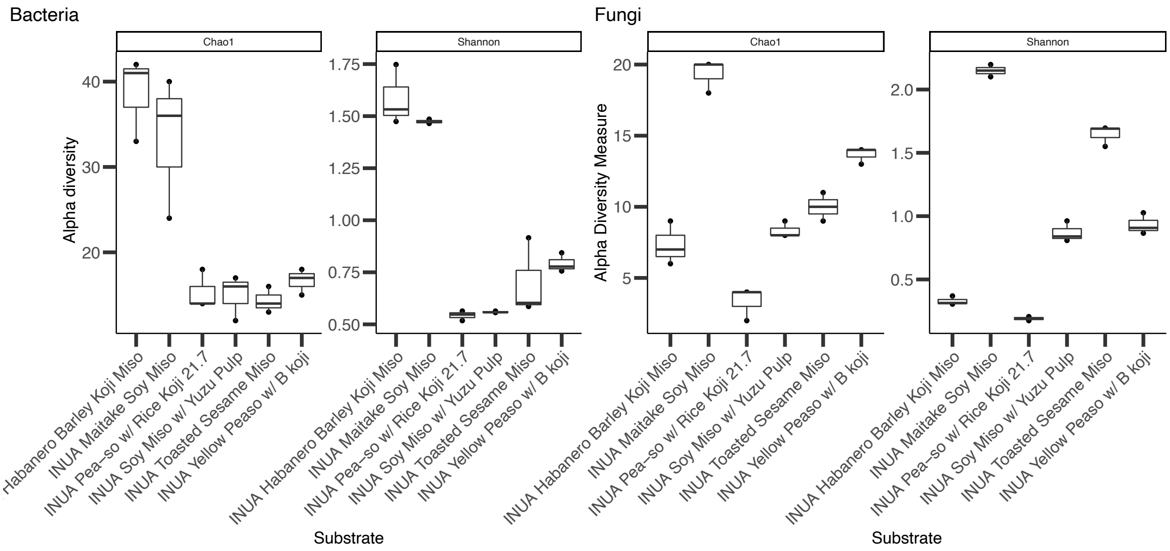


Figure 69—Alpha-diversity (Chao1 richness and Shannon index), with mean and standard deviation, of Inua misos at end of fermentation. Figure by Florent Mazel.

Taxa	Test	Kruskal-Wallis chi-squared value	Df	p-value
Bacteria	Shannon	17.229	9	0.04525
Bacteria	Chao1	16.815	9	0.05169
Fungi	Shannon	13.127	9	0.1569
Fungi	Chao1	12.34	9	0.1948

Table 8—Ranked comparison of Noma misos' alpha-diversity using the Kruskal-Wallis chi-squared test. Analysis by Florent Mazel.

Taxa	Test	Kruskal-Wallis chi-squared value	Df	p-value
Bacteria	Shannon	15.55	5	0.008254
Bacteria	Chao1	12.712	5	0.2624
Fungi	Shannon	16.251	5	0.006162
Fungi	Chao1	16.033	5	0.006751

Table 9—Ranked comparison of Inua misos' alpha-diversity using the Kruskal-Wallis chi-squared test. Analysis by Florent Mazel.

In all cases, Wilcoxon pairwise comparison did not lead to significant comparisons using Benjamini-Hochberg correction of p-values (likely due to too low power).[261]

[261] Wilcoxon pairwise comparison is used to determine if two or more sets of pairs differ from one another in a statistically significant way. The Benjamini-Hochberg correction is used to help avoid false positives when p-values are low but the null hypothesis is correct.

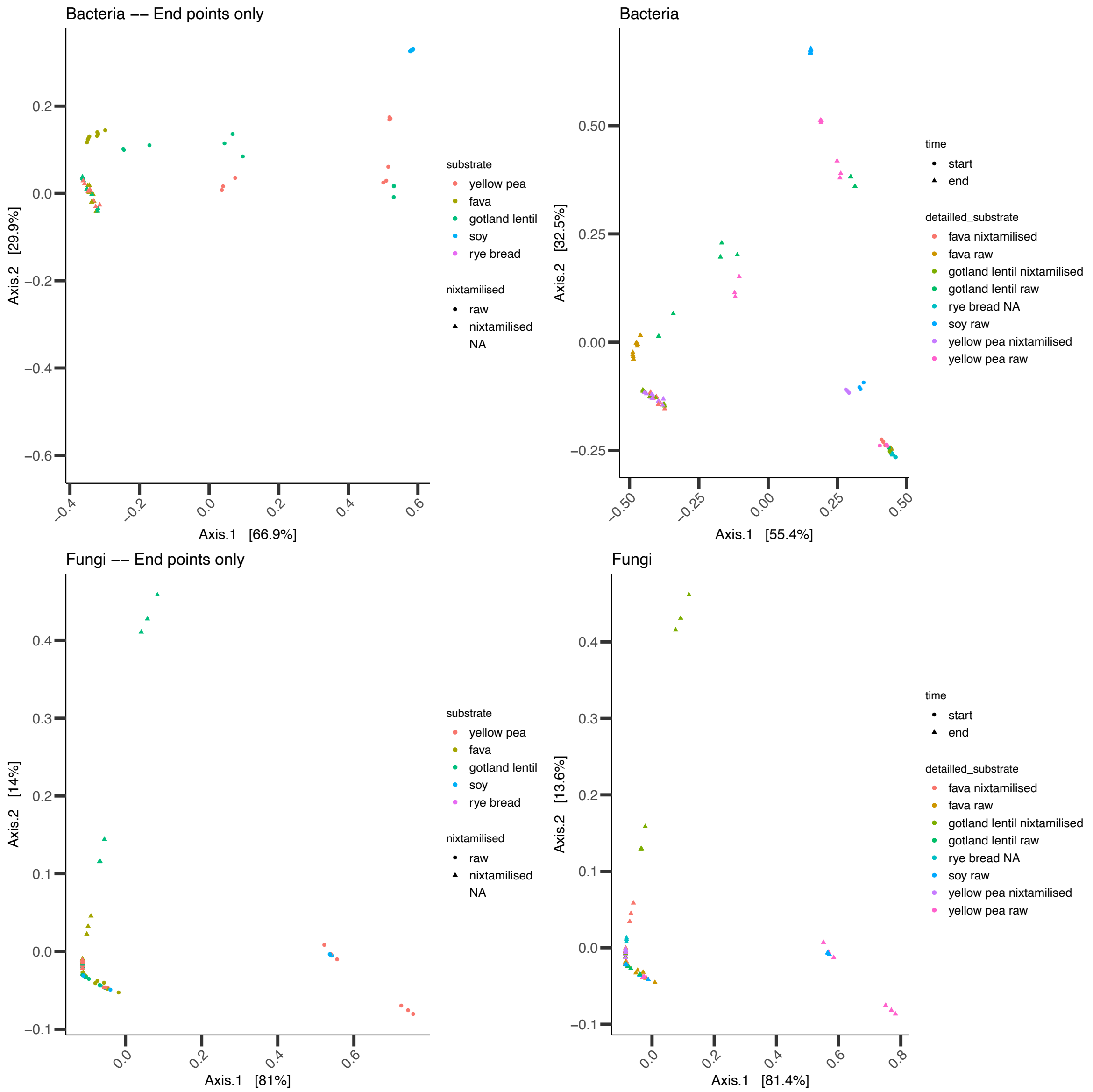


Figure 70—Bacterial and fungal ordination plots for Noma misos at start and end of fermentation. Figure by Florent Mazel.

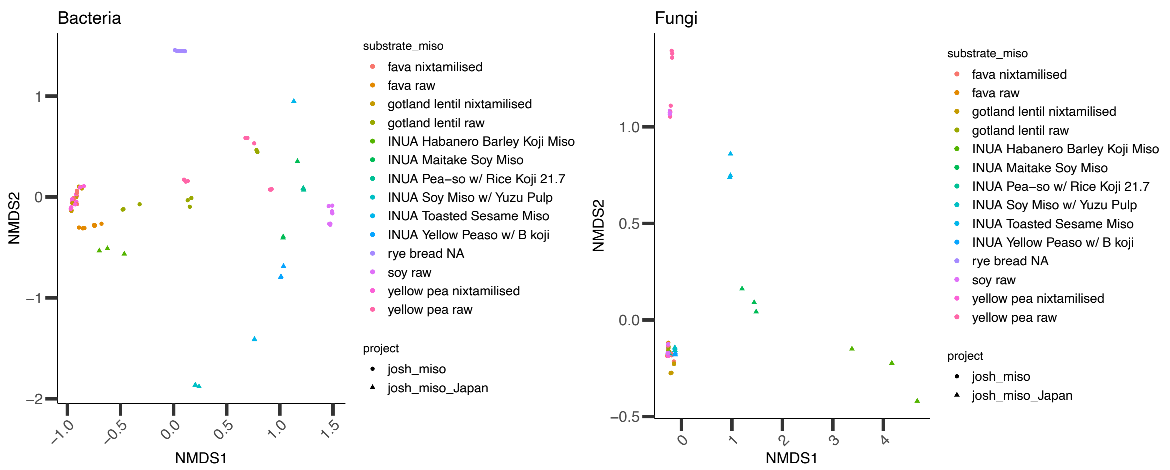
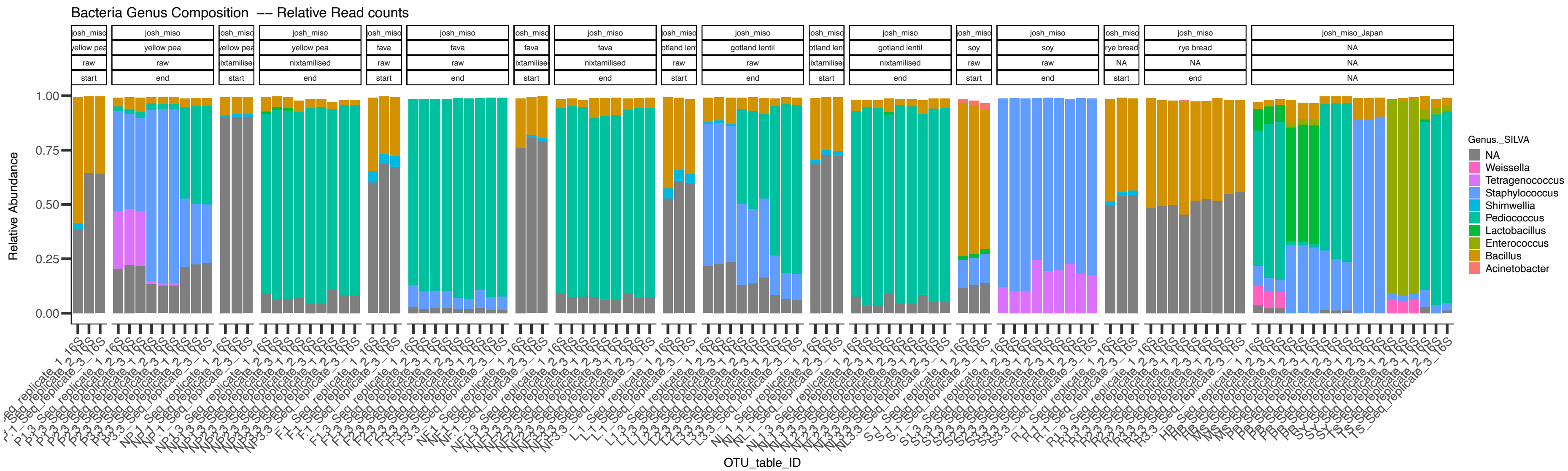


Figure 71—Bacterial and fungal ordination plots for finished Noma and Inua misos. Figure by Florent Mazel.



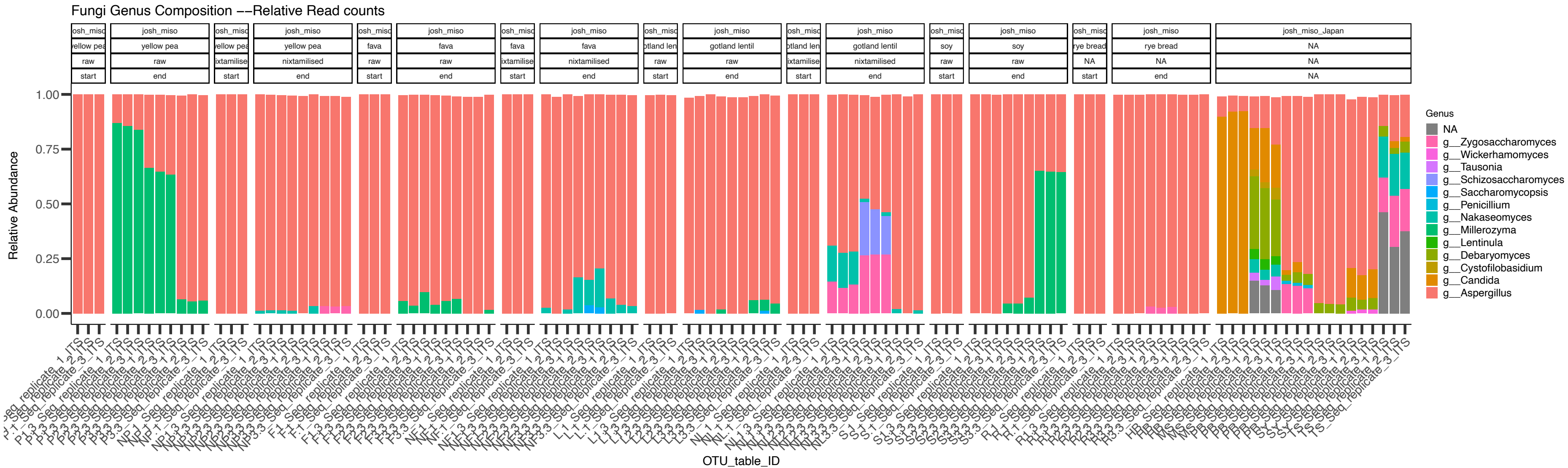


Figure 72—Relative read counts for bacterial and fungal genus composition of Noma and Inua misos. Figure by Florent Mazel.

	data	factors	Df	SumOfSqs	R2	F	p_val
1	Bacteria	Residual	26	3.07666666666667	0.37		
2	Bacteria	substrate	4	2.98666666666667	0.36	6.31666666666667	0.001
3	Bacteria	time	1	2.28	0.27	19.2466666666667	0.001
4	Bacteria	Total	31	8.34333333333333	1		
5	Fungi	Residual	26	1.38	0.8		
6	Fungi	substrate	4	0.256666666666667	0.15	1.20333333333333	0.233666666666667
7	Fungi	time	1	0.0866666666666667	0.05	1.62333333333333	0.136333333333333
8	Fungi	Total	31	1.71666666666667	1		

Table 10—Permutational Multivariate Analysis of Variance (PERMANOVA) of Noma misos for effects of substrate and time. Analysis by Florent Mazel.

	data	factors	Df	SumOfSqs	R2	F	p_val
1	Bacteria	nixtamilised	1	0.736666666666667	0.356666666666667	11.25	0.00266666666666667
2	Bacteria	Residual	14	0.92	0.446666666666667		
3	Bacteria	substrate	2	0.403333333333333	0.196666666666667	3.1	0.0556666666666667
4	Bacteria	Total	17	2.06333333333333	1		
5	Fungi	nixtamilised	1	0.17	0.133333333333333	2.78	0.0293333333333333
6	Fungi	Residual	14	0.866666666666667	0.676666666666667		
7	Fungi	substrate	2	0.246666666666667	0.193333333333333	1.98	0.143
8	Fungi	Total	17	1.28333333333333	1		

Table 11—Permutational Multivariate Analysis of Variance (PERMANOVA) of Noma misos for effects of nixtamalisation. Analysis by Florent Mazel.

As one might expect, the microbiomes of the misos after fermentation are distinct from those of the misos at the start.[262] There is a strong effect of nixtamalisation,[263] and a moderate but significant effect of substrate,[264] on the final microbiomes. These effects are most prominent with bacterial composition, as the fungal compositions of most samples are, unsurprisingly, dominated by *A. oryzae* (Figure 72). There is nonetheless a small but significant effect of nixtamalisation on fungal composition.[265] On bacterial composition, meanwhile, nixtamalisation lead *Pediococcus* spp. to dominate, with a bit of *Bacillus* spp. and not much else (Figure 72).

At the level of genus, the finished nixtamalised misos appear less diverse than the finished non-nixtamalised ones (Figure 72). Non-nixtamalised lentil, yellow pea, and rye bread misos in particular are more bacterially diverse at the end of the fermentation than the

[262] PERMANOVA test, pseudo F = 19.247, p = .001, Table 10.
[263] PERMANOVA test, pseudo F = 11.25, p = .0027, Table 11.
[264] PERMANOVA test, pseudo F = 6.317, p = .001, Table 10.
[265] PERMANOVA test, pseudo F = 2.78, p = .0293, Table 11.
For all these statistical tests, I use the standard threshold of significance of $p<0.05$, though I recognise that statisticians have recently been debating to move beyond this somewhat arbitrary truth-fetish (Amrhein, Greenland, and McShane 2019; Wasserstein, Schirm, and Lazar 2019).

others (Figure 67). The alpha diversity graphs also show clear patterns in how the miso ecologies change over time: between the start and end miso samples, bacteria become less diverse while fungi become more diverse (Figure 68). This pattern makes sense given how the misos were made. The misos were not inoculated or backslopped, so they received a random input of microbes from the environment. Over time this diversity decreased for bacteria, as those bacteria not adapted to the miso niche disappeared and others favoured by the miso environment proliferated. With fungi, a similar process happened—except that the number of reads from this random input of fungi at the start was overwhelmed by the number of *A. oryzae* reads from the kōji. By the end of the fermentation, the miso environment having disfavoured the kōji and favoured other salt-tolerant yeasts, the fungal diversity increased.

At the level of genus, the fava and soy show consistency across experimental replicates, while the yellow pea and lentil show some variation between experimental replicates (Figure 72). One explanation for this variation within substrate is simple batch variation, which I don't think would be so unlikely; another explanation is that the samples I took from each batch happened to capture a different part of the total community in that tiny amount (0.15-0.2g was sampled for DNA extraction), even if the total community across the batches might be similar. When I took these final samples, I removed part of the surface of the fermented miso, filled a 5ml Falcon tube with paste from the middle of the miso, and then transferred the rest of the miso to a plastic vacuum bag. In retrospect, it would have been better to first harvest the miso, mix it in a stomacher until homogenous, and then sample, according to standard practice—this might have helped reduce random sampling variation that could be the case for the pea and lentil samples. Further experimental samples for pea and lentil might shed more light on whether the ecologies associated with these substrates tend toward a similar bacterial composition across replicates.

It is also notable that for both bacterial and fungal composition the soy and yellow pea misos are more similar to each other than to any others, suggesting that the yellow pea was a good choice for a substrate to replace soy not only in terms of protein content and flavour (6.2.2), but also in terms of the microbial ecology it facilitates.

To investigate the relative abundance of bacteria and fungi in relation to each other could be done with qPCR, which would enable better analysis of the total ecology eg. how certain taxa increase/decrease in total proportion of the composition. Shotgun metagenomics to a depth that allowed full-genome assembly could also enable finer-grained analysis, such as resolving taxa to species and strain level. This further approach would give a more detailed and possibly different picture of the diversity within and between misos.

I had hoped to compare these DNA sequencing data of novel misos to more traditional misos. But thorough searches in Scopus, Web of Science, and Oxford SOLO search engines revealed that there do not yet seem to be any papers (in English) using DNA sequencing techniques to study miso ecology, which I found strange. A few older papers exist that use only culture-dependent methods (Hesseltine 1983; H. Ito and Dou 1994), but the few taxa identified 'do not exclude certain other halophilic yeasts and bacteria from growing in or on the fermenting paste' (Hesseltine 1983: 589), because culturing techniques, as discussed, can miss microbes involved in the fermentation but unculturable in the lab (1.2.3). Onda et al. published a handful of studies on miso bacteria using 16s rRNA sequence analysis for identification (Onda et al. 2002; Onda, Yanagida, Tsuji, et al. 2003; Onda, Yanagida, Uchimura, et al. 2003), but these only study bacteria, not fungi, and use rRNA, not DNA. Kim et al. studied bacterial and fungal communities in miso and Chinese analogues, but used PCR-DGGE (Kim et al. 2010; Tanaka, Watanabe, and Mogi 2012 used the same method to study microbial communities in soy sauce). Nam et al. used NGS methods to analyse the microbial communities in *doenjang*, Korean soybean pastes, but these products are made differently from miso (Nam, Lee, and Lim 2012). Allwood et al. provide a useful recent review of studies on the fermentation and microbial communities of Japanese kōji and miso (Allwood, Wakeling, and Bean 2021). After reviewing the scant literature (in English) on miso ecology, they conclude that 'due to the limitations of these studies, lack of details available regarding the ingredients and fermentation conditions of the purchased miso samples, along with the different methodologies used, it is difficult to draw any conclusions from these studies to identify a typical microbial profile for miso.' (ibid.: 2200)

It is therefore difficult to compare these novel misos to more traditional ones, as even the traditional ones have yet to be sufficiently characterised. But based on a partial list compiled by Allwood et al. (2021: 2199), the experimental misos feature many genera already identified in misos, as well as some additional ones: *Staphylococcus* spp. among the bacteria, and *Millerozyma* spp., *Saccharomyces* spp., and *Debaryomyces* spp. among the yeasts.

Overall, the miso experiment sequencing data suggest a few key findings:

(1) The misos vary in microbial composition according to substrate—some substrates more clearly than others, and (in the Noma misos) in bacterial composition more than fungal.

(2) There is notable variation in bacteria and fungi composition of the Inua misos according to substrate, though of course it is difficult to say if this variation is related to substrate or just batch variation, as there are no batch replicates within a substrate type. There are comparable compositions for the same substrates (especially yellow pea and barley kōji) between Inua and Noma, but not in identical proportions.

(3) At the genus level, treatment (substrate, process eg. nixtamalisation) seems to have more influence on composition than geography.[266]

(4) Generally, the Noma and Inua misos contain many of the common miso microbes from the literature, as well as others—the specificity lies in the total composition, and may extend to species and strain differences.

(5) The results from these novel misos suggest that they might be positioned to contribute to the field in miso ecology (in English).

[266] This finding supports recent work on the concept of 'microbial terroir' that reaches similar conclusions for the microbial ecology of cheese rinds. See Wolfe et al. (2014). This conclusion is also based on 16s/ITS data that resolves to genus; Wolfe et al. also acknowledge that much of the diversity is probably at the strain level.

COLLABORATIVE EXPERIMENT 2: EVOLUTIONARY CHANGE IN TRANSLATED KŌJI

The parallel triplicate populations at Noma and Empirical underwent notable morphological changes (Table 12, further down). To order the experimental kōjis across populations, generations, and sites, I use the following naming convention: letter refers to site (N=Noma, E=Empirical, L=laboratory), first number is generation, second number is population. Thus eg. N25.1 is Noma kōji, generation 25, population 1.

At Noma, the white-sporulating kōji (Figure 73) began to exhibit small spots of green sporulation in one of the populations of generation 6 (Figure 74); at this point I mixed all the grains together.

Figure 73—N1.1 at 24h.

Figure 74—N6.1 at 72h.

In generation 7, larger areas in two populations were sporulating green (Figures 75 & 76). At this point I decided to try to select only areas of white spores, to mimic past practices of keeping the line distinct.

Figure 75—N7.1 at 72h.

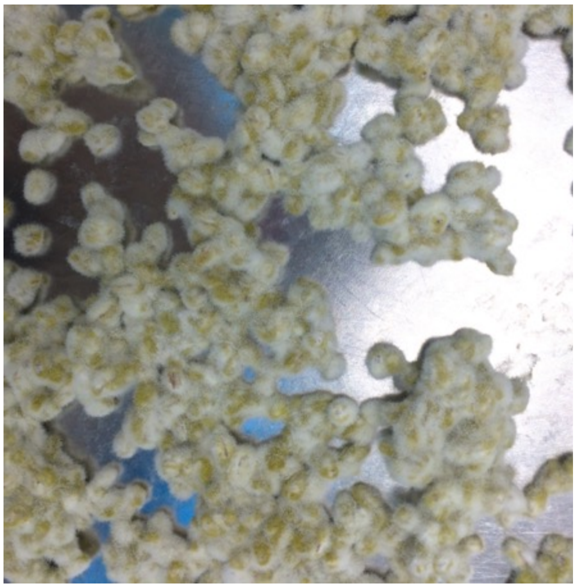


Figure 76—N7.2 at 72h.

Regardless, by generation 8 all three populations were sporulating mostly or partly green (Figures 77–79).

Figure 77—N8.1 at 72h.

Figure 78—N8.2 at 72h.

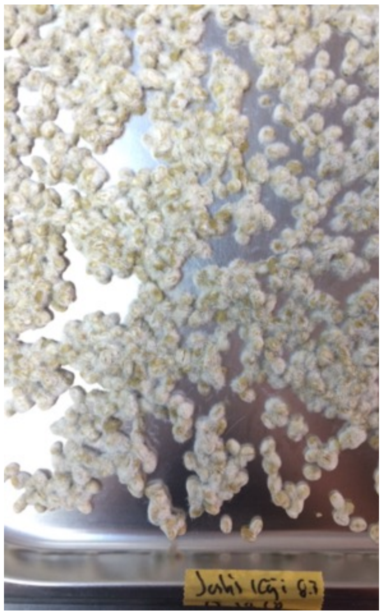


Figure 79—N8.3 at 72h.

Mixed green and white sporulation persisted for the next few generations, sometimes again becoming more white (as N8.3 above). Around generation 10, the aromas of the sporulated kōji began to change: population 1 became more pungent, like cannabis or hops, while population 3 developed smells common to yellow/green-sporulated kōji once sporulated, like a sausage cellar. The aroma in the middle of the fermentation, around hour 24, was still strongly of tropical fruit and citrus. By generation 12, Jason also noticed the different smell once sporulated, which he described as 'like tempe on a different substrate' from the usual soybeans. From generation 13, the smells of all populations during fermentation began to shift toward aromas of peach and melon.

By generation 14, one of the populations (N14.2) began to exhibit black sporulation mixed in with white and green (Figure 80). By the next generation, this black sporulation came to dominate the population (15.2), while another population of the same generation (15.3) suddenly exhibited very furry, grey conidiophores with small black spores at the end (Figures 81 & 82).

Figure 80—N14.2 at 72h.

Figure 81—N15.2 at 72h.

Figure 82—N15.3 at 72h.

At this point I was unsure whether this population was still *Aspergillus oryzae*, as I had never seen this type of growth before in kōji. I considered adding wood ash to the grains, a traditional practice in Japanese kōji spore production to raise the pH (inhibiting certain bacteria) and provide minerals that aid spore formation. Ultimately I decided to continue the experiment as planned, because its purpose was to see what would happen by extending production of spore based on the practices the teams at Noma and Empirical already themselves used.

N16.2 sporulated entirely black, and smelled yeasty and melony (Figure 83); N16.3 sporulated a mix of black and furry grey (Figure 84). N17.1 sporulated furry grey; N17.2 and N17.3 sporulated a mix of black and furry grey (Figures 85 & 86). Each population exhibited varying mixes of black and furry grey sporulation for the next few generations.

Figure 83—N16.2 at 72h.

Figure 84—N16.3 at 72h.

Figure 85—N17.1 at 72h.

Figure 86—N17.2 at 72h.

Around generation 19, the fermentation lab team had to dispose of 50kg of their own kōji because it looked and smelled like mine and was therefore unusable for production and service. We continued the experiment, but from generation 20 restricted it to the same kōji chamber each time, with separate equipment, and I inoculated, fermented, turned, and dried the kōji all in the same chamber rather than in the main fermentation lab space as I had up to that point. By this point all three populations had this fresh yeast, fresh dough smell during growth.

gen.	N1	N2	N3	E1	E2	E3	L1	L2	L3
1	commercial white-sporulating pure culture	commercial white-sporulating pure culture	commercial white-sporulating pure culture	commercial white-sporulating pure culture	commercial white-sporulating pure culture	commercial white-sporulating pure culture	commercial white-sporulating pure culture	commercial white-sporulating pure culture	commercial white-sporulating pure culture
2									
3									
4									
5									
6	spots of green sporulation								
7	more green spots	more green spots							
8	mostly green	mostly green	mostly green						
9									
10	new spore aromas: cannabis, hops		new spore aromas: musty						
11									
12				spots of black sporulation					
13	new fermentation aromas: stone fruit, melon	new fermentation aromas: stone fruit, melon	new fermentation aromas: stone fruit, melon	all black sporulation	white/black sporulation	mostly black sporulation			
14		spots of black sporulation		new fermentation aromas: stone fruit / almond	all black sporulation; new fermentation aromas: stone fruit / almond	all black sporulation; new fermentation aromas: stone fruit / almond	new aromas: lychee, underripe banana	new aromas: lychee, underripe banana	new aromas: lychee, underripe banana
15		mostly black sporulation	furry, grey conidiophores						
16		all black sporulation; aromas of yeast and melon	mix of black and furry grey sporulation	new fermentation aromas: fresh dough, yeast	new fermentation aromas: fresh dough, yeast	new fermentation aromas: fresh dough, yeast		slightly longer conidiophores ?	
17	furry grey sporulation	mix of black and furry grey sporulation	mix of black and furry grey sporulation						
18									
19	mix of black and furry grey sporulation								
20	new fermentation aromas: fresh dough	new fermentation aromas: fresh dough	new fermentation aromas: fresh dough	furry grey and black sporulation	furry grey and black sporulation	furry grey and black sporulation			
21							slightly beige sporulation	slightly beige sporulation	slightly beige sporulation
22									
23									
24									
25									

Table 12—Kōji experiment observations overview.

At Empirical, a similar overall pattern emerged, but with different stages and timing. All three populations remained white-sporulating (like Figure 87) until generation 12, at which point the first population exhibited some small patches of dark blue/black spores (Figure 88).

Figure 87—E1.1 at 48h.

Figure 88—E12.1 at 72h.

I separated these from the white patches for storage, but nonetheless, by the next generation, population 1 was all black, population 2 was half white half black, and population 3 mostly black (Figures 89–91).

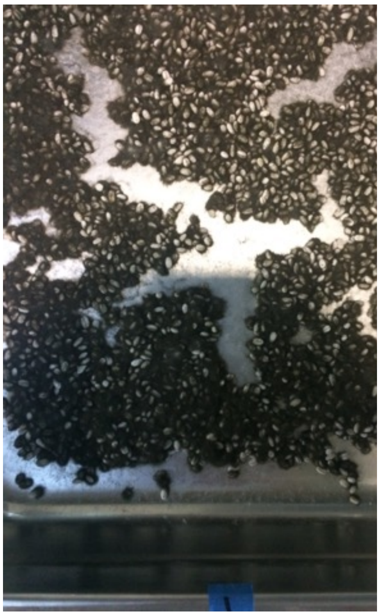


Figure 89—E13.1 at 72h.

Figure 90—E13.2 at 72h.

Figure 91—E13.3 at 72h.

By generation 14, the smell of all three populations after 24h had changed, to amaretto/plum pit/maraschino cherry. Hiro Takeda, then head of R&D at Empirical, concurred that they smelled ‘different’ from the standard kōji, ‘like plum kernel with some flesh still on.'

At generation 16, all three populations were still exhibiting the same smells and sporulating black. I showed them to Lars, who was not surprised by the result but was reminded of his own earlier experiments in propagating kōji. He commented that the populations smelled to him like fresh yeast; three members of the brewing team concurred that they smelled like rising white bread dough. I tasted them for the first time; they were lightly sour.

From generation 13 until generation 19, the populations had white mycelia and only became black once sporulated. From generation 20, all three populations began exhibiting spots of extra furriness, as at Noma (Figures 92–94).

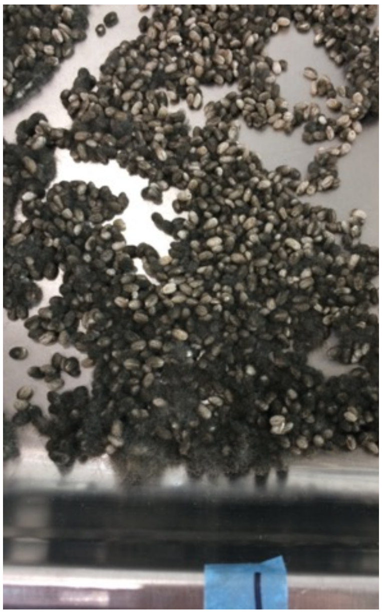


Figure 92—E20.1 at 72h.

Figure 93—E20.2 at 72h.

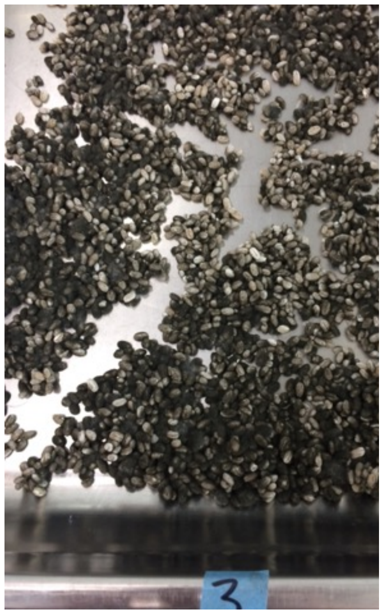


Figure 94—E20.3 at 72h.

This grey furriness increased over generations 21–22 and decreased but did not disappear over generations 23–25.

By generation 25, the populations at Noma and Empirical were consistently sporulating black, with similar smells and degrees of grey furriness (Figures 95–100). They had clearly undergone some kind of change, whatever the source, and the experiment could be stopped.



Figure 95—N25.1 at 72h. *Figure 96—N25.2 at 72h.* *Figure 97—N25.3 at 72h.*



Figure 98—E25.1 at 72h. *Figure 99—E25.2 at 72h.* *Figure 100—E25.3 at 72h.*

The populations in the laboratory at the University of Copenhagen, meanwhile, remained white-sporulating as they began (Figures 101–103).

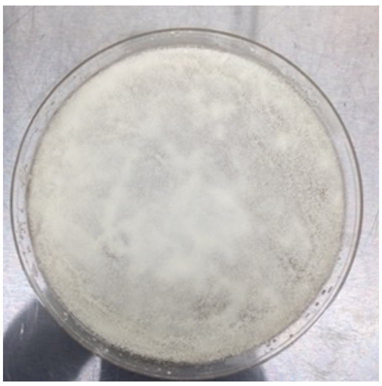
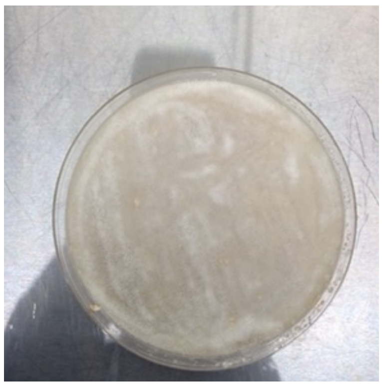




Figure 101—L3.1 at 96h. *Figure 102—L3.2 at 96h.* *Figure 103—L3.3 at 96h.*

Around generation 14 I noticed they began to smell distinctly of lychee and underripe bananas, which persisted to the end of the experiment. From generation 16, population 2 seemed to develop longer conidiophores than the other two populations (Figure 105, compared with Figure 104), which persisted until the end of the experiment, though I did not measure this observation quantitatively.

Figure 104—L16.1 at 7 days.

Figure 105—L16.2 at 7 days.

Around generation 21, the spores began to develop a slightly off-white colour, but this change seemed likely from the prolonged exposure to heat during the extended time I held the last few batches in the incubator to really dry the spore for storage, rather than from actual change in sporulation colour as observed at Noma and Empirical (Figures 106–108).

Figure 106—L21.1 at 27 days.

Figure 107—L21.2 at 27 days.

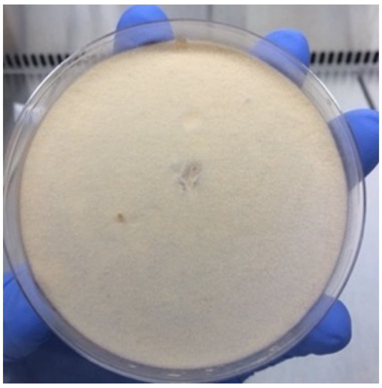


Figure 108—L21.3 at 27 days.

I stopped the experiment at generation 25 in the lab as well (Figures 109–111).

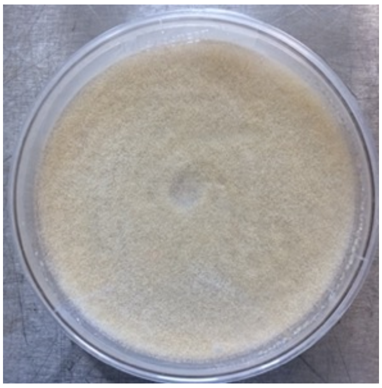


Figure 109—L25.1 at 14 days.

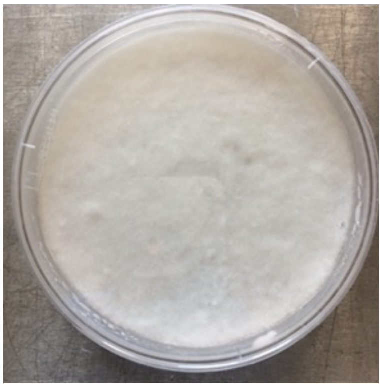


Figure 110—L25.2 at 14 days.

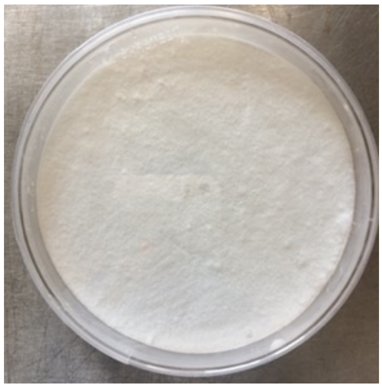


Figure 111—L25.3 at 14 days.

I then conducted a sensory analysis of the Empirical populations with 20 members of the Empirical team (Appendix G; methods outlined in Frøst, Giacalone, and Rasmussen 2015).

descriptor	E25.1	E25.2	E25.3	TOTAL
yeast	9	8	9	26
grain / wheat / starchy / barley	7	9	9	25
fruity	9	9	7	25
baked / bread / cake / pastry	7	8	7	22
sweet	5	6	3	14
green / fresh / clean	8	5	0	13
alcoholic / boozy / CO2 / fermented	3	3	5	11
almond	5	3	2	10
mushroom / fungal / mould	2	1	7	10
sour	4	2	4	10
floral	5	2	3	10
fresh dough	3	3	4	10
lactic	3	3	3	9
apple	2	3	4	9
citrus / orange / lemon	4	3	1	8
sourdough	3	3	2	8

Table 13—Top aggregated descriptors per population from experimental kōji sensory analysis at Empirical (n=20).

Of the top sensory descriptors (Table 13), the most notable for being not associated with typical kōji (of *A. oryzae*) were 'yeast', 'green', 'almond', 'sour', 'fresh dough', and 'sourdough'. What is also not apparent in the aggregated category of 'fruity' is how the quality of the fruit is quite different to regular kōji—while kōji typically has more tropical fruit aromas (guava, pineapple, etc.), this experimental kōji was more stone fruit (peach, plum, etc.) and, as specified, 'apple' and 'citrus'.

Mean hedonic ratings of the three kōjis (on a scale of 10 'extremely like', 5 'indifferent', and 0 'extremely dislike') were 7.35, 7.15, and 5.95, respectively, with a mean hedonic rating across populations of 6.82 (Table 14).[267]

	E25.1	E25.2	E25.3	ALL
Mean hedonic rating (n=20)	7.35	7.15	5.95	6.82
Hedonic rating standard deviation	1.27	1.14	1.54	0.76

Table 14—Mean hedonic rating for each generation 25 kōji population at Empirical.

I also conducted a sensory analysis of the Noma populations with Jason. He thought the Noma populations smelled like 'cherry blossom and almond', and liked them, commenting that he had 'never smelled kōji like this before.'[268] In my estimation, the populations at Noma and Empirical not only looked but also smelled highly similar.[269]

This was the question, though—was this still kōji? The shotgun sequencing data[270] suggests that all populations of generation 25 at Noma and Empirical were predominated by *Rhizopus delemar* (top-ranked taxon in all samples; Table 15).[271] This result corresponds with the observed morphology: long furry grey-black hyphae and conidiophores. So, the main species had changed. The observational data suggest that this shift happened gradually, likely as the *A. oryzae* weakened, as a result of deliberately following standard growth protocols for production instead of those for favouring sporulation (light pearling, eg. only 97%, to include nutrients from husk; adding ash of oak or camellia for nutrients, to raise pH, and to facilitate airflow between grains).[272] To figure out when and how exactly *R. delemar* came to predominate would require sequencing and analysing the intermediate generations.

[267] If I were to do this analysis again, I would include a standard kōji sample in the sensory analysis for comparison.
[268] It was not practical to assemble a sensory panel of a similar size at Noma at the time. If I were to do this analysis again I would attempt to do so.
[269] Of course, the ideal method would have been to gather equally sized sensory panels of relevant individuals from both Noma and Empirical, and have both panels smell all samples from both sites together. This would have been a significantly more complex logistical task to organise and execute, and as the quantitative sensory analysis data is a mere supplement here, it was not a priority. However it would be fascinating and worthwhile to do such a study in the future, with sufficient time and resources. A Master's project in itself, or as part of some other PhD.
[270] For the kōji experiment, my labwork guide Christian Carøe and I decided to use shotgun metagenomics, because I was interested in potential changes within the whole *A. oryzae* genome as well as potential ecological changes among the other taxa growing alongside (Appendix G). These questions wouldn't be possible to address with metabarcoding, which, because it only targets the single well-conserved 16s and ITS genes, allows for identification of taxa but not of other changes in the genome.
[271] *Rhizopus delemar* is considered closely related to *R. oryzae* (the main difference being which organic acids they primarily produce; Abe et al. 2007). *R. oryzae* is a GRAS organism ('Generally Recognised as Safe' by the US Food and Drug Administration), frequently used to make the Indonesian fermented soybean product tempe. At least some strains of *R. delemar* are also GRAS (Marhendraswari et al. 2020); full safety information for the whole species appears at the time of writing unavailable.
[272] Marika Groen, pers.comm., email 17.1.19.

sample	# reads	% total reads	% reads w/o taxa	% assigned reads	rank
N1.1	1555	0.072179	86.511987	0.5351%	9/6125
N1.2	4203	0.042988	86.176413	0.3110%	11/10017
N1.3	7166	0.036727	85.861087	0.2598%	14/11844
N25.1	4483100	37.149784	54.976733	82.5124%	1/11864
N25.2	1532818	37.933014	54.087934	82.6210%	1/7882
N25.3	6710246	37.738533	54.341003	82.6530%	1/12979
E1.1	1189	0.023109	86.688521	0.1736%	22/8488
E1.2	2056	0.02771	86.569086	0.2063%	16/9551
E1.3	7917	0.044861	86.115167	0.3231%	12/11765
E25.1	7494	12.608944	82.587408	72.4128%	1/1111
E25.2	218804	32.26836	60.086331	80.8454%	1/4427
E25.3	3839107	36.32571	54.798583	80.3641%	1/11591
L1.1	10676	0.070156	85.71412	0.4911%	10/11980
L1.2	2057	0.049477	85.34969	0.3377%	14/7490
L1.3	4522	0.04882	85.660054	0.3404%	10/9404
L25.1	7303	0.058769	86.138899	0.4240%	9/10526
L25.2	8105	0.055861	87.311368	0.4402%	11/10751
L25.3	4571	0.043479	85.978343	0.3101%	12/10215

Table 15—Percentage of reads assigned to R. delemar *in each kōji population, and rank among assigned taxa. Analysis by John Gibbons. Green values indicate generation 1 populations where* R. delemar *was present in small amounts; blue values indicate generation 25 populations where* R. delemar *became predominant.*

Notable here is that there are small numbers of reads (1189–10676 reads; 0.0231%-0.0721% of total reads; 0.1736%-0.5351% of assigned reads; Table 15) of *R. delemar* in all first-generation replicates at all sites. These figures are small compared with the predominant taxa but are not so low that they suggest sequencing artefacts.[273] This means that there were in fact trace amounts of *R. delemar* in the commercial 'pure' spore, which gradually increased over the generations, in response to some assemblage of favourable conditions. It is common that 'pure' kōji is actually an ecology, with small amounts of bacteria and other fungi playing important roles in regulating kōji's growth. It is possible that the producer of these spores, Bio'c, made not just a pure culture of one strain of *A. oryzae* but assembled a 'cocktail' of *A. oryzae* and small amounts of pure cultures of other bacterial and fungal symbionts. Because such an assemblage would not be an established ecology, it would easily change once allowed to grow together. Another possibility is that the ecology was designed to be unstable, to prevent indefinite passaging and ensure ongoing business.[274] The passaging of kōji beyond a few generations is not a new difficulty but existed long before the emergence of pure culturing of kōji in Meiji Japan. Producers of kōji spore have correspondingly long kept their exact methods secret (Lee 2015: 241; Lee 2018).

What is particularly significant is that a comparable process occurred in all populations and at both sites. It was not random, nor mere 'contamination'. Keeping the kōji open to potential change from environmental effects also kept open the possibility of the entire ecology changing, which it did in an apparently predictable way. Further research could

[273] PCR with *R. delemar*-specific primers and validating with Sanger sequencing could be done to confirm that *R. delemar* was in the original spore.
[274] I thank Aviaja Lyberth Hauptmann for these two speculations.

investigate what factors led to the rise of *R. delemar* specifically, given it did not come to predominate in the laboratory populations even though it was also present at similar levels at the start (even greater than in some populations of N1 and E1) and remained at these levels at the end (Table 15). One likely reason could be the substrate effect—the commercial spore was bred for growth on white rice (with eg. higher proportions of starch) so repeated growth on pearled barley (with more lignocellulose) could gradually have made it easier for other species more suited to the substrate, like *R. delemar*, to predominate.[275] Another could be related to drying the spore, which was necessary to shake it off the grain and inoculate the next generation. Drying would have killed most bacteria (aside from spore-forming ones), altering the community when it is passaged, reducing the stabilising function of community diversity and making it easier for another taxa like *R. delemar* to take over.[276] More broadly, this experiment shows how, in most circumstances, kōji now requires human involvement to reproduce. When practices of care, such as growing a strain on its preferred substrate, are relaxed, it does not go feral, but is eventually taken over. Interest is now crucial to its life and livelihood (Ch7).

Deeper analysis of the shotgun data to reveal whether the populations of *R. delemar* that came to dominate the populations exhibit any variation within and between sites is complicated by some of the samples having rather low read counts (only 1.6M for E25.2, and only .6M for E25.1; the remaining generation 25 populations had between 5.5M and 28M reads; Table 16). However, a comparison of E25.3 and N25.3 (the only generation 25 samples with deep enough coverage) reveals 49 genes absent in the former that are present in the latter (Table 17), which suggests that *R. delemar* not only came to dominate all populations at both sites, but also continued to evolve in the different environments.[277]

condition	sample name	raw read pairs
Noma	N1.1	2,621,152
Noma	N1.2	11,626,388
Noma	N1.3	22,900,634
Noma	N25.1	13,458,159
Noma	N25.2	5,474,398
Noma	N25.3	27,992,515
Empirical	E1.1	6,689,032
Empirical	E1.2	9,007,347
Empirical	E1.3	20,125,133
Empirical	E25.1	616,093
Empirical	E25.2	1,591,910
Empirical	E25.3	13,891,432
Laboratory	L1.1	18,572,371
Laboratory	L1.2	5,733,348
Laboratory	L1.3	10,875,379
Laboratory	L25.1	13,933,924
Laboratory	L25.2	17,439,986
Laboratory	L25.3	12,916,722

Table 16—Raw read pairs for each generation 25 kōji population. Analysis by John Gibbons. Green values indicate particularly low read counts.

[275] I thank Tiffany Mak for this suggestion.
[276] I thank Leonie Jahn for this suggestion.
[277] Absence of evidence is not evidence of absence, however, without full genome assembly.

	contig	start	stop	direction
1	CH476759.1	1685	1850	r
2	CH476758.1	26825	27005	f
3	CH476756.1	42543	42753	r
4	CH476750.1	511195	511423	f
5	CH476749.1	308849	308951	f
6	CH476748.1	381959	382106	r
7	CH476746.1	1207249	1207393	r
8	CH476745.1	1186725	1186920	f
9	CH476743.1	214769	214913	f
10	CH476743.1	404123	404237	f
11	CH476743.1	1053086	1053329	f
12	CH476743.1	1255711	1255843	r
13	CH476742.1	504053	504155	f
14	CH476741.1	521388	521487	f
15	CH476740.1	907769	907892	f
16	CH476740.1	1783729	1783822	r
17	CH476740.1	1902631	1902793	r
18	CH476740.1	2145597	2145762	r
19	CH476739.1	1176877	1176988	r
20	CH476739.1	1522869	1522974	r
21	CH476738.1	77267	77408	r
22	CH476738.1	1134640	1134796	f
23	CH476738.1	1574546	1574834	r
24	CH476738.1	1952351	1952519	f
25	CH476738.1	2517235	2517331	r
26	CH476738.1	2607836	2608022	f
27	CH476737.1	1999942	2000125	f
28	CH476737.1	2957621	2957720	r
29	CH476737.1	3095289	3095451	r
30	CH476736.1	645667	645835	r
31	CH476736.1	876691	877003	f
32	CH476736.1	1046062	1046170	f
33	CH476735.1	1300694	1300868	r
34	CH476735.1	1954330	1954438	f
35	CH476735.1	2940167	2940314	f
36	CH476734.1	110659	110770	r
37	CH476734.1	487271	487439	r
38	CH476734.1	1823118	1823247	f
39	CH476733.1	647332	647449	r
40	CH476733.1	1952818	1952917	r
41	CH476733.1	3302863	3303040	f
42	CH476733.1	3376230	3376368	r
43	CH476732.1	2044958	2045099	r
44	CH476732.1	2670581	2670926	f
45	CH476732.1	2907341	2907515	r
46	CH476732.1	3064998	3065169	f
47	CH476732.1	3560185	3560401	r
48	CH476732.1	5573733	5573883	f
49	CH476732.1	5680624	5680855	f

*Table 17—*R. delemar *genes absent in E25.3 and present in N25.3. Analysis by Kimmo Sirén.*

Meanwhile, in the laboratory populations *A. oryzae* remained dominant. This might have been because this strain of *A. oryzae* was used to growing in the highly controlled laboratory environment of prepared media, petri dishes, and incubators, as this is likely also how they would be propagated at Bio'c.[278] Another factor might have been that, unlike at Noma and Empirical, where I grew the kōji on whole grains of pearled barley, in the lab I grew them on media made from the same barley, but milled. Milling would make the nutrients of the barley more accessible to the kōji and might have helped it stay dominant. An additional factor is related to drying, as discussed above. Unlike the Noma and Empirical populations, the Laboratory populations on plates did not need to be fully dried out before passaging, as I could inoculate a fresh plate by rubbing it with a small patch of sporulated mycelium from the previous plate. This means that, in principle, more of the bacterial communities would survive across generations, maintaining more community stability in comparison with the populations at Noma and Empirical.

Such stability is also suggested by comparing populations to each other. Analysis of Jaccard indices[279] for all pairwise combinations among the 6 laboratory populations (n=15) indicate that the generation 25 populations were actually more similar to each other than the generation 1 populations were (L25 mean: 0.934088; L1 mean: 0.881548; Table 18). This would suggest that the three populations of kōji in the lab started off more metagenomically diverse, and gradually converged over 25 generations. This is not surprising, as the highly specific, stable, and enriched conditions of the laboratory would select for some taxa and against others, making the populations less diverse over time (as was the case for the misos between the start and end of the fermentation).

Within populations, the effect is less clear.[280] L25.1 is slightly more similar to L1.1 than to L25.2 and L25.3, while in populations 2 and 3 the reverse is true. The global effect described above seems to be largely due to L1.2's different community composition, in particular a greater presence of the bacterium *Massilia timonae* (3.9565% of assigned reads in L1.2, compared with 0.7237% in L1.1 and 0.2633% in L1.3). Analysis of change in the genomes of *A. oryzae* specifically within each population would involve assembling full genomes and comparing eg. SNPs, which would require more coverage.

Jaccard	L25.1	L25.2	L25.3	L1.1	L1.2	L1.3
L25.1	1					
L25.2	0.935872	1				
L25.3	0.9334	0.932992	1			
L1.1	0.940038	0.931167	0.928683	1		
L1.2	0.853812	0.86426	0.861977	0.847679	1	
L1.3	0.935898	0.934149	0.93269	0.931099	0.865865	1

Table 18—Jaccard indices for pairwise combinations of laboratory populations of kōji. Analysis by Kimmo Sirén. Green values indicate pairwise combinations for generation 1 (mean=0.881548); blue values indicate pairwise combinations for generation 25 (mean=0.934088); orange values indicate comparisons between generation 25 and generation 1 within each population.

Even here in the laboratory, ecological change emerged. In L25.2, the bacterium *Bacillus amyloliquefaciens* became co-dominant with *A. oryzae* (*B. amyloliquefaciens* had 28.73% of

[278] I thank Aviaja Lyberth Hauptmann for this thought.
[279] A measure of diversity used to compare datasets (the ratio of the intersection to the union).
[280] I thank Tiffany Mak for noting this.

assigned reads, Table 19; *A. oryzae* had 29.34% of assigned reads).[281] In L25.1 and L25.3, it did not become quite so prevalent, but it still became the main non-Aspergillus taxon (fourth and third most prevalent taxa, respectively; Table 19), increasing in prevalence by over two orders of magnitude compared with their respective first-generation populations (ibid.).

sample	# reads	% total reads	% reads w/o taxa	% assigned reads	rank
N1.1	213	0.009887	86.511987	0.0733%	44/6125
N1.2	841	0.008602	86.176413	0.0622%	47/10017
N1.3	721	0.003695	85.861087	0.0261%	83/11844
N25.1	427	0.003538	54.976733	0.0079%	87/11864
N25.2	55	0.001361	54.087934	0.0030%	259/7882
N25.3	419	0.002356	54.341003	0.0052%	127/12979
E1.1	1977	0.038425	86.688521	0.2887%	12/8488
E1.2	166	0.002237	86.569086	0.0167%	126/9551
E1.3	1424	0.008069	86.115167	0.0581%	53/11765
E25.1	6	0.010095	82.587408	0.0580%	28/1111
E25.2	9	0.001327	60.086331	0.0033%	264/4427
E25.3	635	0.006008	54.798583	0.0133%	71/11591
L1.1	236	0.001551	85.71412	0.0109%	187/11980
L1.2	67	0.001612	85.34969	0.0110%	174/7490
L1.3	158	0.001706	85.660054	0.0119%	145/9404
L25.1	34216	0.275344	86.138899	1.9865%	4/10526
L25.2	529007	3.646017	87.311368	28.7345%	2/10751
L25.3	54951	0.522694	85.978343	3.7278%	3/10215

Table 19—Percentage of reads assigned to B. amyloliquefaciens *in each kōji population, and rank among assigned taxa. Analysis by John Gibbons. Green values indicate the reads assigned to* B. amyloliquefaciens *in the first-generation populations at all sites; blue values indicate the higher percentage of reads assigned to* B. amyloliquefaciens *in L25 compared with L1.*

As with *R. delemar*, *B. amyloliquefaciens* appears in all first-generation populations at all sites, in trace amounts but still with read numbers higher than likely artefacts (67–1977 reads; 0.0016%–0.0384% of total reads; 0.0109%-0.2887% of assigned reads; Table 19). This initial presence would be enough for the bacterium to gradually multiply over the generations, as it did in the laboratory but not at Noma or Empirical. Indeed at the latter two sites its presence decreased in all populations between the first and last generations. In the laboratory, all populations were iteratively passaged into fresh petri dishes with sterile implements and under a flow hood, so it is exceedingly unlikely that this result would have come from contamination, especially as growth of *B. amyloliquefaciens* emerged within all three populations. As with *R. delemar* predominating at Noma and Empirical but not in the laboratory, further research could investigate what factors led to *B. amyloliquefaciens*

281 *B. amyloliquefaciens* is often used as a root-colonising biocontrol bacterium and was originally discovered in the soil. Similarly to kōji, it produces alpha amylase, so is also often used commercially to hydrolyse starch. Because of their similar metabolic functions and presumable substrate preferences, it is possible but not yet clear that *A. oryzae* and *B. amyloliquefaciens* were competitors in this ecological context.

becoming more prominent and even co-dominant in the laboratory populations and not at the other sites.

At the other sites, before the *R. delemar* took over around generations 16 (at Noma) and 20 (at Empirical), by its growth the kōji still appeared to be predominantly *A. oryzae*. The observed shift in spore colour from white to yellow-green to black seemed to mirror (in reverse) the evolutionary history of kōji, in which the albino mutation was selected for from populations of yellow-green-sporulating kōji, which in turn was previously selected for from the earliest forms of kōji, such as *A. awamori*, which are black and produce citric acid (5.2.1), comparable to the sour taste of the generation 16 black kōji at Empirical. The question of whether these shifts in spore colour corresponded to shifts in the genome or simply gene expression is a question that further sequencing and analysis might be able to answer. Either way, a key question remains: why would the kōji change in this way?

Pigment production is a documented stress response in many fungi, including *Aspergillus* spp. (Chang et al. 2020; see also Hagiwara et al. 2017; Ye et al. 2014). The observed change in sporulation colour from white to green to black might indicate the *A. oryzae* having come under increasing stress, until it became so weak that *R. delemar* took over. Such stress might have been due to multiple factors. One is the substrate effect, as discussed—this commercial kōji spore was bred for growth on white rice, not barley. Rice has higher proportions of starch, while barley has more lignocellulose. Over the generations, the rice kōji might have had a gradually harder time metabolising the barley, while other taxa like the *R. delemar* might have been favoured by it. Another is growth technique. As discussed, growing kōji for spore and breeding usually involves different practices than growing kōji for production, such as lighter pearling (only to 97%) to include more husk nutrients, and using ash (eg. oak or camellia) to raise pH and increase airflow between grains. More recently it also involves breeding pure cultures of *A. oryzae* in laboratory conditions rather than from commercial 'cocktails', which, as described, may be effective for production but tend not to remain stable when passaged.

In this light, the gradual predominance of *R. delemar* takes on new significance—rather than an ecological shift that interrupted the kōji's spore colour shifts, it could also be seen as an extension of this same retro-evolutionary trajectory. Before kōji was purified into single species of *Aspergillus* in Japan, its forebears, such as *qu* from mainland China and *nuruk* in Korea, were grown on mixed grain and/or legume substrates, and featured mixed ecologies of *Aspergillus*, *Rhizopus*, *Mucor*, and *Monascus* species, along with various yeasts and lactic acid bacteria (Chen et al. 2009).[282] Purifying *Aspergillus* species from these mixed cultures, and selecting mutations from these purified cultures, relied on progressively less ecological competition, through less stressful conditions maintained by humans. Once these conditions were relaxed, it makes sense that kōji would gradually 'revert' to earlier states, even to the point where *A. oryzae* becomes no longer predominant. Testing this explanation as a hypothesis is one direction for further research.

[282] *Qu* is pronounced 'chü'.

REFERENCES

@nomacph. 2021. “Opening Day for Game & Forest Season.” Instagram. 2021. https://www.instagram.com/p/CUKWNchMtLr/.

———. 2022. “A Cornucopia of Color.” Instagram. 2022. https://www.instagram.com/p/CYQ-uIpMAIC/.

@nomaferments. 2018. “Wild Japanese Knotweed.” Instagram. 2018. https://www.instagram.com/p/BiXX5PXBRqS/.

@reneredzepinoma. 2018a. “Baby Jellyfish Salad.” Instagram. 2018. https://www.instagram.com/p/BrVNgoqHRwW/.

———. 2018b. “Beetle.” Instagram. 2018. https://www.instagram.com/p/BqZrdM7HoZ5/.

———. 2018c. “Danish ‘Chiles.’” Instagram. 2018. https://www.instagram.com/p/Bn6dbyLCR5r/.

———. 2018d. “Duck Feet.” Instagram. 2018. https://www.instagram.com/p/BowctqpC9mX.

———. 2018e. “Sunflower.” Instagram. 2018. https://www.instagram.com/p/BnJZs5vAr2l/.

———. 2018f. “Tomatoes.” Instagram. 2018. https://www.instagram.com/p/BnwOdoKCqZo/.

———. 2019a. “Butterfly.” Instagram. 2019. https://www.instagram.com/p/B08R9SAlcn-.

———. 2019b. “Citrus.” Instagram. 2019. https://www.instagram.com/p/Bu6JUx3n4MP/.

———. 2019c. “Coriander.” Instagram. 2019. https://www.instagram.com/p/BxHwHA8HVq_/.

———. 2019d. “Crab Flatbread.” Instagram. 2019. https://www.instagram.com/p/Bsf38i5Hc9X.

———. 2019e. “Local ‘Chiles.’” Instagram. 2019. https://www.instagram.com/p/B06SmIYlofD/.

———. 2019f. “Shrimps.” Instagram. 2019. https://www.instagram.com/p/BtOWpICHdnh/.

———. 2019g. “Starfish.” Instagram. 2019. https://www.instagram.com/p/BvMgHQeHvDT.

Abe, Ayumi, Yuji Oda, Kozo Asano, and Teruo Sone. 2007. “Rhizopus Delemar Is the Proper Name for Rhizopus Oryzae Fumaric-Malic Acid Producers .” *Mycologia* 99 (5): 714–22. https://doi.org/10.1080/15572536.2007.11832535.

Abrahamsson, Sebastian, and Filippo Bertoni. 2014. “Compost Politics: Experimenting with Togetherness in Vermicomposting.” *Environmental Humanities* 4: 125–48.

Alcock, Joe, Carlo C. Maley, and C. Athena Aktipis. 2014. “Is Eating Behavior Manipulated by the Gastrointestinal Microbiota? Evolutionary Pressures and Potential Mechanisms.” *BioEssays* 36 (10): 940–49. https://doi.org/10.1002/bies.201400071.

Allaby, Robin G, Chris Stevens, Leilani Lucas, Osamu Maeda, Dorian Q Fuller, and Dorian Q Fuller. 2017. “Geographic Mosaics and Changing Rates of Cereal Domestication.” *Philosophical Transactions of the Royal Society B: Biological Sciences* 372: 1–10.

Allwood, Joanne G., Lara T. Wakeling, and David C. Bean. 2021. “Fermentation and the Microbial Community of Japanese Koji and Miso: A Review.” *Journal of Food Science* 86 (6): 2194–2207. https://doi.org/10.1111/1750-3841.15773.

Almeida, Pedro, Raquel Barbosa, Polona Zalar, Yumi Imanishi, Kiminori Shimizu, Benedetta Turchetti, Jean Luc Legras, et al. 2015. “A Population Genomics Insight into the Mediterranean Origins of Wine Yeast Domestication.” *Molecular Ecology* 24 (21): 5412–27. https://doi.org/10.1111/mec.13341.

Amato, Katherine R., Óscar M. Chaves, Elizabeth K. Mallott, Timothy M. Eppley, Filipa Abreu, Andrea L. Baden, Adrian A. Barnett, et al. 2021. “Fermented Food Consumption in Wild Non-Human Primates and Its Ecological Drivers.” *American Journal of Physical Anthropology* 175 (3): 513–530. https://doi.org/10.1002/ajpa.24257.

Amato, Katherine R., Thiviya Jeyakumar, Hendrik Poinar, and Philippe Gros. 2019. “Shifting Climates, Foods, and Diseases: The Human Microbiome through Evolution.” *BioEssays* 41 (10): 1–9. https://doi.org/10.1002/bies.201900034.

Amato, Katherine R., Elizabeth K. Mallott, Paula D’Almeida Maia, and Maria Luisa Savo Sardaro. 2021. “Pre-Digestion as an Evolutionary Impetus for Human Fermented Food Use.” *Current Anthropology* 62 (S24): S207–219.

Amrhein, Valentin, Sander Greenland, and Blake McShane. 2019. “Retire Statistical Significance.” *Nature* 567: 305–7.
Anderson, B. 1991. *Imagined Communities: Reflections on the Origin and Spread of Nationalism*. London and New York: Verso.
Anderson, Kay. 1995. “Culture and Nature at the Adelaide Zoo: At the Frontiers of ‘Human’ Geography.” *Transactions of the Institute of British Geographers* 20 (3): 275. https://doi.org/10.2307/622652.
———. 1997. “A Walk on the Wild Side: A Critical Geography of Domestication.” *Progress in Human Geography* 21 (4): 463–85. https://doi.org/10.1191/030913297673999021.
Anderson, Kirk E, Mark J Carroll, T I M Sheehan, and Brendon M Mott. 2014. “Hive-Stored Pollen of Honey Bees: Many Lines of Evidence Are Consistent with Pollen Preservation, Not Nutrient Conversion.” *Molecular Ecology* 23: 5904–17. https://doi.org/10.1111/mec.12966.
Anderson, Marti J., and Daniel C.I. Walsh. 2013. “PERMANOVA, ANOSIM, and the Mantel Test in the Face of Heterogeneous Dispersions: What Null Hypothesis Are You Testing?” *Ecological Monographs* 83 (4): 557–74. https://doi.org/10.1890/12-2010.1.
Andreassen, Rikke. 2014. “The Search for the White Nordic: Analysis of the Contemporary New Nordic Kitchen and Former Race Science.” *Social Identities* 20 (6): 438–51. https://doi.org/10.1080/13504630.2014.1002599.
Antonsen, Dea, and Ida Bencke. n.d. “Laboratory for Aesthetics and Ecology.” http://www.labae.org/.
Appadurai, Arjun. 1988. “How to Make a National Cuisine: Cookbooks in Contemporary India.” *Comparative Studies in Society and History* 30 (1): 3–24.
———. 1996. *Modernity at Large: Cultural Dimensions of Globalization*. Public Worlds. Minneapolis, MN: University of Minnesota Press.
Apprill, Amy, Sean Mcnally, Rachel Parsons, and Laura Weber. 2015. “Minor Revision to V4 Region SSU RRNA 806R Gene Primer Greatly Increases Detection of SAR11 Bacterioplankton.” *Aquatic Microbial Ecology* 75 (2): 129–37. https://doi.org/10.3354/ame01753.
Arendt, Hannah. 1958. *The Human Condition*. Charles R. Walgreen Foundation Lectures. Chicago: University of Chicago Press.
Aristotle. 2000. *Nicomachean Ethics*. Edited and translated by Roger Crisp. Cambridge Texts in the History of Philosophy. Cambridge: Cambridge University Press.
Armitage, P. L. 1986. “Domestication of Animals.” In *Bioindustrial Ecosystems*, edited by D. J. A. Cole and G. C. Brander, 5–30. Amsterdam: Elsevier.
Arvela, Paula, Adam Balic, Anthony F Buccini, Jan Davison, Alexandra Grigorieva, Sharon Hudgins, Jin Kyung Kim, and Zachary Nowak. 2012. “Wrapped & Stuffed.” In *Oxford Symposium on Food and Cookery*. Oxford: OSFC.
Asafu-Adjaye, John, Linus Blomqvist, Stewart Brand, Barry Brook, Ruth Defries, Erle Ellis, David Keith, et al. 2015. *An Ecomodernist Manifesto*.
Ashmore, M. 2015. “Reflexivity in Science and Technology Studies.” *International Encyclopedia of the Social & Behavioral Sciences*. Elsevier. https://doi.org/10.1016/b0-08-043076-7/03157-0.
ATCC. 2017. “Six Factors Affecting Reproducibility in Life Science Research and How to Handle Them.” *Nature Portfolio*.
Auerbach, Erich. 2013. *Mimesis: The Representation of Reality in Western Literature - New and Expanded Edition*. Translated by W R Trask. Princeton Classics. Princeton, NJ: Princeton University Press.
Bachmann, Herwig, Marjo J C Starrenburg, Douwe Molenaar, Michiel Kleerebezem, and Johan E T Van Hylckama Vlieg. 2012. “Microbial Domestication Signatures of Lactococcus Lactis Can Be Reproduced by Experimental Evolution.” *Genome Research* 22: 115–24. https://doi.org/10.1101/gr.121285.111.
Bapteste, Eric, and John Dupré. 2013. “Towards a Processual Microbial Ontology.” *Biology and Philosophy* 28 (2): 379–404. https://doi.org/10.1007/s10539-012-9350-2.

Barad, K. 2007. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Duke University Press. Durham: Duke University Press.
Barnes, Barry. 1981. "On the 'Hows' and 'Whys' of Cultural Change (Response to Woolgar)." *Social Studies of Science* 11: 481–98.
Barnes, Barry, and John Dupré. 2013. *Genomes and What to Make of Them*. Chicago: University of Chicago Press.
Barthes, R. 1972. *Mythologies*. New York: Hill and Wang.
Bartoshuk, L. M. 2000. "Comparing Sensory Experiences across Individuals: Recent Psychophysical Advances Illuminate Genetic Variation in Taste Perception." *Chemical Senses* 25 (4): 447–60. https://doi.org/10.1093/chemse/25.4.447.
BBC. 2020. "How Kimchi Rekindled a Decades-Long Feud," December 18, 2020. http://www.bbc.com/travel/story/20201217-how-kimchi-rekindled-a-decades-long-feud.
Beckwith, Brenda R. 2004. "'The Queen Root of This Clime': Ethnoecological Investigations of Blue Camas and Its Landscapes on Southern Vancover Island, British Columbia." Victoria, BC: University of Victoria.
Benezra, Amber. 2016. "Datafying Microbes: Malnutrition at the Intersection of Genomics and Global Health." *BioSocieties* 11: 334–351. https://doi.org/10.1057/biosoc.2016.16.
———. 2020. "Race in the Microbiome." *Science Technology and Human Values* 45 (5): 877–902. https://doi.org/10.1177/0162243920911998.
Benezra, Amber, Joseph DeStefano, and Jeffrey I. Gordon. 2012. "Anthropology of Microbes." *Proceedings of the National Academy of Sciences of the United States of America* 109 (17): 6378–81. https://doi.org/10.1073/pnas.1200515109.
Benjamin, Walter. (1923) 1996. "The Task of the Translator." In *Walter Benjamin, Selected Writings, Volume 1, 1913-1926*, edited by Marcus Bullock and Michael W. Jennings. Cambridge, Mass,; London: The Belknap Press of Harvard University Press.
———. (1968) 2007. "The Work of Art in the Age of Mechanial Reproduction." In *Illuminations: Essays and Reflections*, edited by H Arendt and H Zohn, 288. Boston: Houghton Mifflin Harcourt.
Bennett, Jane. 2001. "The Enchantment of Modern Life. Attachments, Crossings, and Ethics." *Crossings, and Ethics (Princeton University Press, …*, no. May 2020: 224.
———. 2010. *Vibrant Matter: A Political Ecology of Things*. Durham, N.C.: Duke University Press.
Bentham, Jeremy. 1879. *An Introduction to the Principles of Morals and Legislation*. Oxford: Clarendon Press.
Bergflødt, Sigurd, Virginie Amilien, and Silje Elisabeth Skuland. 2012. "Nordic Food Culture(s) – Thoughts and Perspectives by Way of Introduction." *Anthropology of Food*, no. S7. https://doi.org/10.4000/aof.7296.
Bergold, Jarg, and Stefan Thomas. 2012. "Participatory Research Methods: A Methodological Approach in Motion." *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research* 13 (1): 1–23.
Bergson, Henri. (1907) 1911. *Creative Evolution*. Translated by Arthur Mitchell. New York: Henry Holt and Company.
Bertoni, Filippo. 2013. "Soil and Worm: On Eating as Relating." *Science as Culture* 22 (1): 61–85. https://doi.org/10.1080/09505431.2013.776365.
Besky, Sarah. 2020. *Tasting Qualities: The Past and Future of Tea*. Atelier: Ethnographic Inquiry in the Twenty-First Century. Oakland: University of California Press.
Besky, Sarah, and A Blanchette. 2019. *How Nature Works: Rethinking Labor on a Troubled Planet*. School for Advanced Research Advanced Seminar Series. Albuquerque: University of New Mexico Press.
Bettinger, Robert L., Loukas Barton, and Christopher Morgan. 2010. "The Origins of Food Production in North China: A Different Kind of Agricultural Revolution." *Evolutionary Anthropology* 19 (1): 9–21. https://doi.org/10.1002/evan.20236.
Bharucha, Zareen, and Jules Pretty. 2010. "The Roles and Values of Wild Foods in Agricultural

Systems." *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 365 (1554): 2913–26. https://doi.org/10.1098/rstb.2010.0123.

Biehl, Janet, and Peter Staudenmaier. 1996. *Ecofascism: Lessons from the German Experience*. Edinburgh: AK Press.

Bigey, Frédéric, Diego Segond, Anne Friedrich, Stephane Guezenec, Aurélie Bourgais, Lucie Huyghe, Nicolas Agier, Thibault Nidelet, and Delphine Sicard. 2020. "Evidence for Two Main Domestication Trajectories in Saccharomyces Cerevisiae Linked to Distinct Bread-Making Processes," 1–11. https://doi.org/10.1101/2020.05.28.120584.

Blaser, M. 2014. *Missing Microbes: How Killing Bacteria Creates Modern Plagues*. London: Oneworld Publications.

Bloomfield, Paul. 2007. *Morality and Self-Interest*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195305845.001.0001.

Boas, Franz. 1921. *Ethnology of the Kwakiutl. 35th Annual Report of the Bureau of American Ethnology*. Washington, DC: Government Printing Office.

Bobrow-Strain, Aaron. 2008. "White Bread Bio-Politics: Purity, Health, and the Triumph of Industrial Baking." *Cultural Geographies* 15 (1): 19–40. https://doi.org/10.1177/1474474007085783.

Bodinaku, Ina, Jason Shaffer, Allison B. Connors, Jacob L. Steenwyk, Erik Kastman, Antonis Rokas, Albert Robbat, and Benjamin Wolfe. 2019. "Rapid Phenotypic and Metabolomic Domestication of Wild Penicillium Molds on Cheese." *MBio* 10 (5): 1–16. https://doi.org/10.1101/647172.

Bokulich, Nicholas A., Thomas Collins, Chad Masarweh, Greg Allen, Hildegarde Heymann, Susan Ebeler, and David Mills. 2016. "Associations among Wine Grape Microbiome, Metabolome, and Fermentation Behavior Suggest Microbial Contribution to Regional Wine Characteristics." *MBio* 7 (3): 1–12. https://doi.org/10.1128/mBio.00631-16.Editor.

Bokulich, Nicholas A., Zachery T Lewis, Kyria Boundy-Mills, and David A Mills. 2016. "A New Perspective on Microbial Landscapes within Food Production." *Current Opinion in Biotechnology* 37: 182–89. https://doi.org/10.1016/j.copbio.2015.12.008.

Bokulich, Nicholas A., and David A. Mills. 2012. "Next-Generation Approaches to the Microbial Ecology of Food Fermentations." *BMB Reports* 45 (7): 377–89. https://doi.org/10.5483/BMBRep.2012.45.7.148.

Bokulich, Nicholas A., John H. Thorngate, Paul M. Richardson, and David A. Mills. 2014. "Microbial Biogeography of Wine Grapes Is Conditioned by Cultivar, Vintage, and Climate." *Proceedings of the National Academy of Sciences of the United States of America* 111 (1): 139–48. https://doi.org/10.1073/pnas.1317377110.

Bonneuil, Christophe, and Jean-Baptiste Fressoz. 2016. *Shock of the Anthropocene: The Earth, History, and Us*. London: Verso Books.

Bordenstein, Seth R., and Kevin R. Theis. 2015. "Host Biology in Light of the Microbiome: Ten Principles of Holobionts and Hologenomes." *PLoS Biology* 13 (8): 1–23. https://doi.org/10.1371/journal.pbio.1002226.

Borkenhagen, Chad. 2017. "Evidence-Based Creativity: Working between Art and Science in the Field of Fine Dining." *Social Studies of Science* 47 (5): 630–54. https://doi.org/10.1177/0306312717725204.

Born, Georgina, and Andrew Barry. 2010. "Art-Science: From Public Understanding to Public Experiment." *Journal of Cultural Economy* 3 (1): 103–19. https://doi.org/10.1080/17530351003617610.

Bourdieu, Pierre. (1979) 1984. *Distinction: A Social Critique of the Judgement of Taste*. Translated by Richard Nice. Cambridge MA: Harvard University Press.

Bourriaud, Nicolas. (1998) 2002. *Relational Aesthetics*. Translated by Simon Pleasance, Fronza Woods, and Mathieu Copeland. Collection Documents Sur l'art. Dijon: Les Presses du réel.

Boy, John D., and Justus Uitermark. 2017. "Reassembling the City through Instagram." *Transactions of the Institute of British Geographers* 42 (4): 612–24.

https://doi.org/10.1111/tran.12185.
Boyhus, Else-Marie. 1996. *Grønsager - En Køkkenhistorie*. København: Gyldendal.
———. 1998. *Grisen - En Køkkenhistorie*. København: Gyldendal.
———. 2000. *I Lære Som Kokkepige: Det Danske Borgerlige Køkken 1880-1910*. København: Dafolo.
Bozzi, Nicola. 2020. "#digitalnomads, #solotravellers, #remoteworkers: A Cultural Critique of the Traveling Entrepreneur on Instagram." *Social Media and Society* 6 (2). https://doi.org/10.1177/2056305120926644.
Bras, Michel. 2002. *Essential Cuisine*. Woodbury, CT: Ici La Press.
Braun, Bruce. 2002. *The Intemperate Rainforest: Nature, Culture, and Power on Canada's West Coast*. Minneapolis; London: University of Minnesota Press.
———. 2004. "Nature and Culture: On the Career of a False Problem." *A Companion to Cultural Geography*, 151–79. https://doi.org/10.1002/9780470996515.ch11.
Breckenridge, Carol A., and Conduce Vogler. 2001. "The Critical Limits of Embodiment: Disability's Criticism." *Public Culture* 13 (3): 349–57. https://doi.org/10.1215/08992363-13-3-349.
Bren, Anat, and Michael Eisenbach. 2000. "How Signals Are Heard during Bacterial Chemotaxis : Protein-Protein Interactions in Sensory Signal Propagation." *Journal of Bacteriology* 182 (24): 6865–73. https://doi.org/10.1128/JB.182.24.6865-6873.2000.Updated.
Brenner, M, P Sörensen, and D Weitz. 2020. *Science and Cooking: Physics Meets Food, From Homemade to Haute Cuisine*. New York: W. W. Norton.
Brice, Jeremy. 2014. "Killing in More-than-Human Spaces: Pasteurisation, Fungi, and the Metabolic Lives of Wine." *Environmental Humanities* 4: 171–94.
Brives, Charlotte, Matthäus Rest, and Salla Sariola, eds. 2021. *With Microbes*. Manchester: Mattering Press.
Brumberg-Kraus, Jonathan, and Betsey Dexter Dyer. 2011. "Cultures and Cultures: Fermented Foods as Culinary 'Shibboleths.'" In *Cured, Fermented, and Smoked Foods: Proceedings of the Oxford Symposium on Food and Cookery 2010*, edited by Helen Saberi. Devon, UK: Prospect.
Bubandt, Nils, and Anna L. Tsing. 2018a. "Feral Dynamics of Post-Industrial Ruin: An Introduction." *Journal of Ethnobiology* 38 (1): 1. https://doi.org/10.2993/0278-0771-38.1.001.
———. 2018b. "Supplement An Ethnoecology for the Anthropocene: How A Former Brown-Coal Mine in Denmark Shows Us the Feral Dynamics of Post-Industrial Ruin." *Journal of Ethnobiology* 38 (1): 1–13.
Buchanan, Brett. 2009. *Onto-Ethologies: The Animal Environments of Uexkull, Heidegger, Merleau-Ponty, and Deleuze*. Albany, NY: SUNY Press.
Bud, R. 1994. *The Uses of Life: A History of Biotechnology*. Cambridge: Cambridge University Press.
Bull, Jacob. 2014. "Between Ticks and People: Responding to Nearbys and Contentments." *Emotion, Space and Society* 12 (1): 73–84. https://doi.org/10.1016/j.emospa.2014.03.002.
Burke, Molly K., Gianni Liti, and Anthony D. Long. 2014. "Standing Genetic Variation Drives Repeatable Experimental Evolution in Outcrossing Populations of Saccharomyces Cerevisiae." *Molecular Biology and Evolution* 31 (12): 3228–39. https://doi.org/10.1093/molbev/msu256.
Burrow, Colin. 2019. *Imitating Authors: Plato to Futurity*. Oxford: Oxford University Press.
Cairns, Timothy C., Corrado Nai, and Vera Meyer. 2018. "How a Fungus Shapes Biotechnology: 100 Years of Aspergillus Niger Research." *Fungal Biology and Biotechnology* 5 (1): 1–14. https://doi.org/10.1186/s40694-018-0054-5.
Callon, Michel. 1984. "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of Saint-Brieuc Bay." *The Sociological Review* 32 (1): 196–233. https://doi.org/10.22394/0869-5377-2017-2-49-90.
———. 1999. "The Role of Lay People in the Production and Dissemination of Scientific Knowledge." *Science, Technology and Society* 4 (1): 81–94. https://doi.org/10.1177/097172189900400106.
Callon, Michel, Pierre Lascoumes, and Yannick Barthe. 2009. *Acting in an Uncertain World: An*

Essay on Technical Democracy. Cambridge MA: MIT Press. https://doi.org/10.1353/tech.2012.0016.
Callon, Michel, and John Law. 1982. "On Interests and Their Transformation: Enrolment and Counter-Enrolment." *Social Studies of Science* 12 (4): 615–25.
Calvert, Jane, and Erika Szymanski. 2020. "A Feeling for the (Micro)Organism? Yeastiness, Organism Agnosticism and Whole Genome Synthesis." *New Genetics and Society* 39 (4): 385–403. https://doi.org/10.1080/14636778.2020.1736537.
Campion, Kristy. 2021. "Defining Ecofascism: Historical Foundations and Contemporary Interpretations in the Extreme Right." *Terrorism and Political Violence* 00 (00): 1–19. https://doi.org/10.1080/09546553.2021.1987895.
Canavan, Hillary Dixler. 2019. "Noma's Trompe l'Oeil Dishes Are the Dad Jokes of the Fine Dining World." Eater. 2019.
Candea, Matei. 2010. "I Fell in Love with Carlos the Meerkat: Engagement and Detachment in Human-Animal Relations." *American Ethnologist* 37 (2): 241–58. https://doi.org/10.1111/j.1548-1425.2010.01253.x.
Capozzi, Vittorio, and Giuseppe Spano. 2011. "Food Microbial Biodiversity and 'Microbes of Protected Origin.'" *Frontiers in Microbiology* 2: 1–3. https://doi.org/10.3389/fmicb.2011.00237.
Carbonetto, Belén, Johan Ramsayer, Thibault Nidelet, Judith Legrand, and Delphine Sicard. 2018. "Bakery Yeasts, a New Model for Studies in Ecology and Evolution." *Yeast* 35 (11): 591–603. https://doi.org/10.1002/yea.3350.
Carøe, Christian. 2019. "BEST Protocol 2.0: Blunt-End Single-Tube Illumina Library Building for Modern and Ancient DNA." Copenhagen, Denmark.
Carøe, Christian, and Kristine Bohmann. 2020. "Tagsteady: A Metabarcoding Library Preparation Protocol to Avoid False Assignment of Sequences to Samples." *Molecular Ecology Resources*, 1–12. https://doi.org/10.1111/1755-0998.13227.
Carolan, Michael. 2015. "Affective Sustainable Landscapes and Care Ecologies: Getting a Real Feel for Alternative Food Communities." *Sustainability Science* 10 (2): 317–29. https://doi.org/10.1007/s11625-014-0280-6.
Carrigan, Matthew A., Oleg Uryasev, Carole B. Frye, Blair L. Eckman, Candace R. Myers, Thomas D. Hurley, and Steven A. Benner. 2015. "Hominids Adapted to Metabolize Ethanol Long before Human-Directed Fermentation." *Proceedings of the National Academy of Sciences* 112 (2): 458–63. https://doi.org/10.1073/pnas.1404167111.
Cassidy, Rebecca, and Molly Mullin, eds. 2007. *Where the Wild Things Are Now: Domestication Reconsidered*. Oxford: Berg.
Castree, Noel. 2003. "Environmental Issues: Relational Ontologies and Hybrid Politics." *Progress in Human Geography* 27 (2): 203–11. https://doi.org/10.1191/0309132503ph422pr.
———. 2005. *Nature*. Key Ideas in Geography. Abingdon: Routledge.
———. 2014a. "Geography and the Anthropocene II: Current Contributions." *Geography Compass* 8 (7): 450–63. https://doi.org/10.1111/gec3.12140.
———. 2014b. *Making Sense of Nature: Representation, Politics and Democracy*. Abingdon: Routledge.
———. 2014c. "The Anthropocene and Geography I: The Back Story." *Geography Compass* 8 (7): 436–49. https://doi.org/10.1111/gec3.12141.
———. 2014d. "The Anthropocene and Geography III: Future Directions." *Geography Compass* 8 (7): 464–76. https://doi.org/10.1111/gec3.12139.
———. 2017. "Nature." *The International Encyclopedia of Geography*. John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118786352.wbieg0522.
Castree, Noel, and Bruce Braun. 2001. *Social Nature: Theory, Practice and Politics*. Hoboken: Wiley.
———. 2006. "Constructing Rural Natures." In *Handbook of Rural Studies*, 161–70. London: Sage Publications Ltd. https://doi.org/10.4135/9781848608016.n11.
Castree, Noel, and Catherine Nash. 2006. "Posthuman Geographies." *Social and Cultural*

Geography 7 (4): 501–4. https://doi.org/10.1080/14649360600825620.
Cattaneo, Camilla, Giorgio Gargari, Ranjan Koirala, Monica Laureati, Patrizia Riso, Simone Guglielmetti, and Ella Pagliarini. 2019. “New Insights into the Relationship between Taste Perception and Oral Microbiota Composition.” *Scientific Reports* 9 (1): 1–8. https://doi.org/10.1038/s41598-019-40374-3.
Cattaneo, Camilla, Patrizia Riso, Monica Laureati, Giorgio Gargari, and Ella Pagliarini. 2019. “Exploring Associations between Interindividual Differences in Taste Perception, Oral Microbiota Composition, and Reported Food Intake.” *Nutrients* 11 (1167): 1–17.
Chan, Miin. 2021. “Lost in the Brine.” Eater. March 2021. https://www.eater.com/2021/3/1/22214044/fermented-foods-industry-whiteness-kimchi-miso-kombucha.
Chang, Perng Kuang, Jeffrey W. Cary, and Matthew D. Lebar. 2020. “Biosynthesis of Conidial and Sclerotial Pigments in Aspergillus Species.” *Applied Microbiology and Biotechnology* 104 (6): 2277–86. https://doi.org/10.1007/s00253-020-10347-y.
Chapman, Robert L. 2006. “Ecological Restoration Restored.” *Environmental Values* 15 (4): 463–78. https://doi.org/10.5849/jof.15-800.
Chen, Fusheng, Li Li, Jiong Qu, and Chunxu Chen. 2009. “Cereal Vinegars Made by Solid-State Fermentation in China.” In *Vinegars of the World*, 243–59. https://doi.org/10.1007/978-88-470-0866-3_15.
Chera, Madeline. 2012. “Ideologies of Fermented Foods.” *Indiana Food Review*, no. 2: 1–8. https://www.academia.edu/1438584/Ideologies_of_Fermented_Foods.
Chiaro, Delia, and Linda Rossato. 2015. “Introduction: Food and Translation, Translation and Food.” *Translator* 21 (3): 237–43. https://doi.org/10.1080/13556509.2015.1110934.
Chilvers, Jason, and Matthew Kearnes. 2020. *Remaking Participation in Science and Democracy*. *Science Technology and Human Values*. Vol. 45. https://doi.org/10.1177/0162243919850885.
Chisholm, Dianne. 2010. “Biophilia, Creatve Involuton, and the Ecological Future of Queer Desire.” In *Queer Ecologies: Sex, Nature, Politics, Desire*, edited by Catriona Mortimer-Sandilands and Bruce Erickson, 359–82. Bloomington, IN: Indiana University Press.
Choy, Timothy. 2011. *Ecologies of Comparison: An Ethnography of Endangerment in Hong Kong*. Experimental Futures : Technological Lives, Scientific Arts, Anthropological Voices. Durham and London: Duke University Press.
Choy, Timothy, and Jerry Zee. 2015. “Condition—Suspension.” *Cultural Anthropology* 30 (2): 210–23. https://doi.org/10.14506/ca30.2.04.
Clark, Nigel, and Myra J Hird. 2014. “‘Deep Shit.’” *O-Zone: A Journal of Object-Oriented Studies*, no. 1: 44–52.
Clark, Nigel, and Bronislaw Szerszynski. 2020. *Planetary Social Thought: The Anthropocene Challenge to the Social Sciences*. Hoboken, NJ: Wiley.
Clutton-Brock, Juliet, ed. 1989. *The Walking Larder: Patterns of Domestication, Pastoralism and Predation*. London: Unwin Hyman.
———. 1992. “The Process of Domestication.” *Mammal Review* 22 (2): 79–85. https://doi.org/10.1111/j.1365-2907.1992.tb00122.x.
———. 1994. “The Unnatural World: Behavioural Aspects of Humans and Animals in the Process of Domestication.” In *Animals and Human Society: Changing Perspectives*, edited by A. Manning and J. A. Serpell, 23–35. London: Routledge.
———. 1999. *A Natural History of Domesticated Mammals*. Cambridge: Cambridge University Press.
———. 2012. *Animals as Domesticates: A World View Through History*. The Animal Turn. East Lansing, MI: Michigan State University Press.
Cockell, Charles S. 2004. “The Rights of Microbes.” *Interdisciplinary Science Reviews* 29 (2): 141–50. https://doi.org/10.1179/030801804225012635.
———. 2005. “The Value of Microorganisms.” *Environmental Ethics* 27 (4): 375–90. https://doi.org/10.5840/enviroethics20052744.

Codere, Helen. 1957. "Kwakiutl Society: Rank without Class." *American Anthropologist* 59 (3): 473–86.
Colehour, Alese M., James F. Meadow, Melissa A. Liebert, Tara J. Cepon-Robins, Theresa E. Gildner, Samuel S. Urlacher, Brendan J.M. Bohannan, J. Josh Snodgrass, and Lawrence S. Sugiyama. 2014. "Local Domestication of Lactic Acid Bacteria via Cassava Beer Fermentation." *PeerJ* 2: e479. https://doi.org/10.7717/peerj.479.
Collard, Rosemary-claire, Jessica Dempsey, and Juanita Sundberg. 2014. "A Manifesto for Abundant Futures." *Annals of the Association of American Geographers* 105 (2): 322–330. https://doi.org/10.1080/00045608.2014.973007.
Collins, H M, and Robert Evans. 2002. "The Third Wave of Science Studies: Studies of Expertise and Experience." *Social Studies of Science* 32 (2): 235–96.
Collinson, Diané. 1985. "Ethics and Aesthetics Are One." *British Journal of Aesthetics* 25 (3): 266–272. https://doi.org/10.4324/9781315233925-10.
Conklin, Harold C. 1961. "The Study of Shifting Cultivation." *Current Anthropology* 2 (1): 27–61. https://doi.org/10.2307/480485.
Conklin, Harold C. 1959. "Shifting Cultivation and Succession to Grassland Climax." In *Proceedings of the Ninth Pacific Science Congress*, 7:60–62.
Conrad, T. M., N. E. Lewis, and B. O. Palsson. 2014. "Microbial Laboratory Evolution in the Era of Genome-Scale Science." *Molecular Systems Biology* 7 (1): 509–509. https://doi.org/10.1038/msb.2011.42.
Coton, Monika, Audrey Pawtowski, Bernard Taminiau, Gaëtan Burgaud, Franck Deniel, Laurent Coulloumme-Labarthe, Abdoulaye Fall, Georges Daube, and Emmanuel Coton. 2017. "Unraveling Microbial Ecology of Industrial-Scale Kombucha Fermentations by Metabarcoding and Culture-Based Methods." *FEMS Microbiology Ecology* 93 (5): 1–16. https://doi.org/10.1093/femsec/fix048.
Counihan, Carole, and Susanne Højlund. 2018. *Making Taste Public: Ethnographies of Food and the Senses*. London: Bloomsbury Academic.
Courtwright, David T. 2019. *The Age of Addiction: How Bad Habits Became Big Business*. Cambridge MA: Harvard University Press.
Crecy, Eudes de, Stefan Jaronski, Benjamin Lyons, Thomas J. Lyons, and Nemat O. Keyhani. 2009. "Directed Evolution of a Filamentous Fungus for Thermotolerance." *BMC Biotechnology* 9 (74): 1–11. https://doi.org/10.1186/1472-6750-9-74.
Crist, Eileen. 2013. "On the Poverty of Our Nomenclature." *Environmental Humanities* 3: 129–147. https://doi.org/10.1057/palgrave.pcs.2100097.
Cronon, William. 1983. *Changes in the Land: Indians, Colonists, and the Ecology of New England*. American Century Series. New York: Hill and Wang.
———. 1996. "The Trouble with Wilderness: Or, Getting Back to the Wrong Nature." *Environmental History* 1 (1): 7–28.
Crutzen, Paul J, and Eugene F Stoermer. 2000. "The Anthropocene." *Global Change Newsletter*, no. 41: 17–18. http://www.igbp.net/publications/globalchangemagazine/globalchangemagazine/globalchangenewslettersno4159.5.5831d9ad13275d51c098000309.html.
Cuomo, Chris. 1998. *Feminism and Ecological Communities: An Ethic of Flourishing*. London and New York: Routledge. https://doi.org/10.5840/wpr19992111.
Curry, Janel M. 2002. "Care Theory and 'Caring' Systems of Agriculture." *Agriculture and Human Values* 19 (2): 119–31. https://doi.org/10.1023/A:1016074832696.
Dansk-Folkeparti. 2021. "Forsvar Dansk Kultur – et Modsvar Til Identitspolitikken [Defend Danish Culture – a Response to Identity Politics]." Copenhagen, Denmark: Dansk Folkeparti [the Danish People's Party].
Darwin, Charles. (1883) 1896. *The Variation of Animals and Plants under Domestication*. 2nd ed. New York: D. Appleton and Company.
———. (1859) 1982. *On the Origin of Species by Means of Natural Selection; or The Preservation of*

Favoured Races in the Struggle for Life. London: Penguin.
Davies, Gail. 2010. “Where Do Experiments End?” *Geoforum* 41 (5): 667–70. https://doi.org/10.1016/j.geoforum.2010.05.003.
Davis, Bernard D. 1987. “Bacterial Domestication: Underlying Assumptions.” *Science* 235 (4794): 1329–35.
Davis, Simon J M. 2005. “Why Domesticate Food Animals? Some Zoo-Archaeological Evidence from the Levant.” *Journal of Archaeological Science* 32 (9): 1408–16. https://doi.org/10.1016/j.jas.2005.03.018.
Deleuze, Gilles. (1988) 1992. *The Fold*. Translated by Tom Conley. Minneapolis: University of Minnesota Press.
Deleuze, Gilles, and Felix Guattari. (1980) 1987. *A Thousand Plateaus: Capitalism and Schizophrenia*. Minneapolis; London: University of Minnesota Press. https://doi.org/10.1017/CCO9780511753657.008.
Derrida, Jacques. 2008. *The Animal That Therefore I Am*. Edited by Marie-Louise Mallet. Translated by David Wills. New York: Fordham University Press.
Descola, Philippe. 2013. *Beyond Nature and Culture*. Chicago: University of Chicago Press.
Desjardins, Renée. 2018a. “Food, Feminism, and Fermentation: Editor’s Introduction (1).” *CuiZine: Journal of Canadian Food Cultures* 9 (1).
———. 2018b. “Food, Feminism, and Fermentation: Editor’s Introduction (2).” *CuiZine: Journal of Canadian Food Cultures* 9 (2).
DeSoucey, Michaela. 2010. “Gastronationalism: Food Traditions and Authenticity Politics in the European Union.” *American Sociological Review* 75 (3): 432–55. https://doi.org/10.1177/0003122410372226.
Despret, Vinciane. 2004. “The Body We Care for: Figures of Anthropo-Zoo-Genesis.” *Body & Society* 10 (2–3): 111–34. https://doi.org/10.1177/1357034X04042938.
———. 2013. “Responding Bodies and Partial Affinities in Human-Animal Worlds.” *Theory, Culture & Society* 30 (7–8): 51–76. https://doi.org/10.1177/0263276413496852.
———. 2014. “Domesticating Practices.” *Routledge Handbook of Human-Animal Studies*, no. 10511: 23. https://doi.org/10.4324/9780203101995.ch2.
Deur, D, and N J Turner. 2005. *Keeping It Living: Traditions of Plant Use and Cultivation on the Northwest Coast of North America*. Seattle: University of Washington Press.
Deutsch, Tracey. 2019. “Home, Cooking: Why Gender Matters to Food Politics.” In *Food Fights: How History Matters to Contemporary Food Debates*, 208–227. Durham: University of North Carolina Press.
Diamond, Jared M. 1997. *Guns, Germs, and Steel: The Fates of Human Societies*. New York: W.W. Norton.
———. 2002. “Evolution, Consequences and Future of Plant and Animal Domestication.” *Nature* 418 (August): 700–707.
Dias, Brian G., and Kerry J. Ressler. 2014. “Parental Olfactory Experience Influences Behavior and Neural Structure in Subsequent Generations.” *Nature Neuroscience* 17 (1): 89–96. https://doi.org/10.1038/nn.3594.
Dicks, Bella, Bambo Soyinka, and Amanda Coffey. 2006. “Multimodal Ethnography.” *Qualitative Research* 6 (1): 77–96. https://doi.org/10.1177/1468794106058876.
Digard, J.-P. 1990. *L’homme et Les Animaux Domestiques: Anthropologie d’une Passion*. Collection Le Temps Des Sciences. Paris: Fayard.
———. 1992. “A Little Known Aspect of the History of the Americas: The Domestication of Animals.” *Homme* 32 (122–24): 253–70.
Dobney, K., and G. Larson. 2006. “Genetics and Animal Domestication: New Windows on an Elusive Process.” *Journal of Zoology* 269: 261–271. https://doi.org/10.1111/j.1469-7998.2006.00042.x.
Donati, Kelly. 2014. “The Convivial Table: Imaginging Ethical Relations through Multispecies Gastronomy.” *The Aristologist* 4: 127–43.

———. 2016. “Towards a Multispecies Gastronomy: Stories of More-than-Human Entanglements on Small Farms in Victoria, Australia.” University of Melbourne.
———. 2019. “‘Herding Is His Favourite Thing in the World’: Convivial World-Making on a Multispecies Farm.” *Journal of Rural Studies* 66 (April 2018): 119–29. https://doi.org/10.1016/j.jrurstud.2018.12.008.
Dončev, Stefan I., and Petar N. Iankov. 1989. “State and Tendencies of Synanthropization and Synurbanization of Birds in Bulgaria.” *Bulgarian Academy of Sciences - Ecology* 22.
Doolittle, W Ford. 1999. “Phylogenetic Classification and the Universal Tree.” *Science (New York, N.Y.)* 284 (5423): 2124–29. https://doi.org/10.1126/science.284.5423.2124.
Dooren, Thom van. n.d. “Military Snails: Multispecies Solidarities in Hawai‘I.”
———. 2014. “Flight Ways: Life and Loss at the Edge of Extinction,” 224.
Dooren, Thom van, Eben Kirksey, and Ursula Münster. 2016. “Multispecies Studies: Cultivating Arts of Attentiveness.” *Environmental Humanities* 8 (1): 1–23. https://doi.org/10.1215/22011919-3527695.
Doyle, Richard M. 2011. *Darwin’s Pharmacy: Sex, Plants, and the Evolution of the Noosphere*. In Vivo: The Cultural Mediations of Biomedical Science. Seattle: University of Washington Press.
Drewnowski, Adam, Susan Ahlstrom Henderson, Alisa Levine, and Clayton Hann. 1999. “Taste and Food Preferences as Predictors of Dietary Practices in Young Women.” *Public Health Nutrition* 2 (4): 513–19. https://doi.org/10.1017/s1368980099000695.
Drumonde-Neves, João, Ricardo Franco-Duarte, Eugénia Vieira, Inês Mendes, Teresa Lima, Dorit Schuller, and Célia Pais. 2018. “Differentiation of Saccharomyces Cerevisiae Populations from Vineyards of the Azores Archipelago: Geography vs Ecology.” *Food Microbiology* 74: 151–62. https://doi.org/10.1016/j.fm.2018.03.017.
Ducos, Pierre. 1978. “Domestication Defined and Methodological Approaches to Its Recognition in Faunal Assemblages.” In *Approaches to Faunal Analysis in the Middle East*, edited by R. H. Meadow and M. A. Zeder, 53–56. Cambridge: Peabody Museum.
———. (1989) 2016. “Defining Domestication: A Clarification.” In *The Walking Larder: Patterns of Domestication, Pastoralism, and Predation*, edited by Juliet Clutton-Brock, 28–30. Routledge Library Editions: Archaeology. London and New York: Routledge.
Dumas, Emilie, Alice Feurtey, Ricardo C. Rodríguez de la Vega, Stéphanie Le Prieur, Alodie Snirc, Monika Coton, Anne Thierry, et al. 2020. “Independent Domestication Events in the Blue-Cheese Fungus Penicillium Roqueforti.” *Molecular Ecology* 29 (14): 2639–60. https://doi.org/10.1111/mec.15359.
Dunn, Elizabeth Cullen. 2008. “Postsocialist Spores: Disease, Bodies, and the State in the Republic of Georgia.” *American Ethnologist* 35 (2): 243–58. https://doi.org/10.1111/j.1548-1425.2008.00032.x.
Dunn, Rob, and Monica Sanchez. 2021. *Delicious: The Evolution of Flavor and How It Made Us Human*. Princeton, NJ: Princeton University Press.
Dunn, Robert R. 2018. *Never Home Alone: From Microbes to Millipedes, Camel Crickets, and Honeybees, the Natural History of Where We Live*. New York: Basic Books.
Dunn, Robert R., Katherine R. Amato, Elizabeth A. Archie, Mimi Arandjelovic, Alyssa N. Crittenden, and Lauren M. Nichols. 2020. “The Internal, External and Extended Microbiomes of Hominins.” *Frontiers in Ecology and Evolution* 8 (February): 1–12. https://doi.org/10.3389/fevo.2020.00025.
Dupré, John. 1992. “Species: Theoretical Contexts.” In *Keywords in Evolutionary Biology*, edited by E F Keller and E A Lloyd, 312–17. Cambridge MA: Harvard University Press.
———. 1995. *The Disorder of Things: Metaphysical Foundations of the Disunity of Science*. Cambridge MA: Harvard University Press.
———. 2001. “In Defence of Classification.” *Studies in History and Philosophy of Science Part C :Studies in History and Philosophy of Biological and Biomedical Sciences* 32 (2): 203–19. https://doi.org/10.1016/S1369-8486(01)00003-6.

———. 2016. “The Disunity of Science.” *Mind* 92 (367): 321–46.
Dupré, John, and Stephan Guttinger. 2016. “Viruses as Living Processes.” *Studies in History and Philosophy of Science Part C :Studies in History and Philosophy of Biological and Biomedical Sciences* 59: 109–16. https://doi.org/10.1016/j.shpsc.2016.02.010.
Dupré, John, and Maureen A. O’Malley. 2007. “Metagenomics and Biological Ontology.” *Studies in History and Philosophy of Science Part C :Studies in History and Philosophy of Biological and Biomedical Sciences* 38 (4): 834–46. https://doi.org/10.1016/j.shpsc.2007.09.001.
———. 2009. “Varieties of Living Things: Life at the Intersection of Lineage and Metabolism.” *Philosophy and Theory in Biology* 1: e003.
DuPuis, E. Melanie. 2015. *Dangerous Digestion: The Politics of American Dietary Advice*. Berkeley: University of California Press. https://doi.org/10.1111/j.1835-9310.1982.tb01239.x.
Dyck, Isabel, and Parin Dossa. 2007. “Place, Health and Home: Gender and Migration in the Constitution of Healthy Space.” *Health and Place* 13 (3): 691–701. https://doi.org/10.1016/j.healthplace.2006.10.004.
Eberlein, Chris, Jean Baptiste Leducq, and Christian R. Landry. 2015. “The Genomics of Wild Yeast Populations Sheds Light on the Domestication of Man’s Best (Micro) Friend.” *Molecular Ecology* 24 (21): 5309–11. https://doi.org/10.1111/mec.13380.
Edwards, C. J, R. Bollongino, A. Scheu, A. Chamberlain, A. Tresset, J.-D. Vigne, J. F Baird, et al. 2007. “Mitochondrial DNA Analysis Shows a Near Eastern Neolithic Origin for Domestic Cattle and No Indication of Domestication of European Aurochs.” *Proceedings of the Royal Society B: Biological Sciences* 274 (1616): 1377–85. https://doi.org/10.1098/rspb.2007.0020.
Eitzel, M V, Jessica L Cappadonna, Chris Santos-Lang, Ruth Ellen Duerr, Arika Virapongse, Sarah Elizabeth West, Christopher Conrad Maximillian Kyba, et al. 2017. “Citizen Science Terminology Matters: Exploring Key Terms.” *Citizen Science: Theory and Practice* 2 (1): 1. https://doi.org/10.5334/cstp.96.
Elena, Santiago F, and Richard E Lenski. 2003. “Evolution Experiments with Microorganisms: The Dynamics and Genetic Bases of Adaptation.” *Nature Reviews. Genetics* 4 (6): 457–69. https://doi.org/10.1038/nrg1088.
Ereshefsky, Marc, and Makmiller Pedroso. 2013. “Biological Individuality: The Case of Biofilms.” *Biology and Philosophy* 28 (2): 331–49. https://doi.org/10.1007/s10539-012-9340-4.
———. 2015. “Rethinking Evolutionary Individuality.” *Proceedings of the National Academy of Sciences of the United States of America* 112 (33): 10126–32. https://doi.org/10.1073/pnas.1421377112.
Eriksson, Camilla, and Jacob Bull. 2017. “Place-Making with Goats and Microbes: The More-than-Human Geographies of Local Cheese in Jämtland, Sweden.” *Journal of Rural Studies* 50: 209–17. https://doi.org/10.1016/j.jrurstud.2017.01.010.
Evans, Adrian B., and Mara Miele. 2012. “Between Food and Flesh: How Animals Are Made to Matter (and Not Matter) within Food Consumption Practices.” *Environment and Planning D: Society and Space* 30 (2): 298–314. https://doi.org/10.1068/d12810.
Evans, Josh. 2015. “Beyond New Nordic.” Nordic Food Lab. 2015. https://nordicfoodlab.wordpress.com/2015/05/18/2015-5-18-beyond-new-nordic.
Evans, Josh, and Jamie Lorimer. 2019. “Noma 2.0’s First Peaso.” Wenner-Gren Foundation. 2019. http://www.wennergren.org/events/cultures-fermentation/topics/noma-20s-first-peaso.
Evans, Joshua. 2017. “Found Land or Made Land? Indigenous Cultivation and the Politics of Conservation in the Pacific Northwest of North America, 1778–2017.” University of Cambridge.
———. 2021. “What Is Fermentation?” 2021. https://doi.org/https://doi.org/10.52750/79573.
Evans, Joshua D. 2021. “Frontiers of Fermentation: Three Proposals for a Multispecies Ethics.” Tavros. 2021. https://www.hypercomf.com/biosentinel.
Evans, Joshua, and Jamie Lorimer. 2021. “Taste-Shaping-Natures: Making Novel Misos with Charismatic Microbes and New Nordic Fermenters in Copenhagen.” *Current Anthropology* 62 (S24): S361–375. https://doi.org/https//doi.org//10.1086/714851.

Fay, Justin, Ping Liu, Giang Ong, Maitreya Dunham, Gareth Cromie, Eric Jeffery, Catherine Ludlow, and Aimée Dudley. 2018. "A Polyploid Admixed Origin of Beer Yeasts Derived from European and Asian Wine Populations." *A Polyploid Admixed Origin of Beer Yeasts Derived from European and Asian Wine Populations*, 466276. https://doi.org/10.1101/466276.

Feeney, E., S. O'Brien, A. Scannell, A. Markey, and E. R. Gibney. 2011. "Genetic Variation in Taste Perception: Does It Have a Role in Healthy Eating?" *Proceedings of the Nutrition Society* 70 (1): 135–43. https://doi.org/10.1017/S0029665110003976.

Felder, Daniel, Daniel Burns, and David Chang. 2012. "Defining Microbial Terroir: The Use of Native Fungi for the Study of Traditional Fermentative Processes." *International Journal of Gastronomy and Food Science* 1 (1): 64–69. https://doi.org/10.1016/j.ijgfs.2011.11.003.

Figley, Charles R. 1995. "Compassion Fatigue: Toward a New Understanding of the Costs of Caring." In *Secondary Traumatic Stress: Self-Care Issues for Clinicians, Researchers, and Educators*, 3–28. Baltimore, MD, US: The Sidran Press.

———. 2002. *Treating Compassion Fatigue*. Routledge Psychosocial Stress Series. New York: Taylor & Francis.

Fine, Gary Alan. 1996. *Kitchens: The Culture of Restaurant Work*. Updated. Ebook Central. Berkeley, CA: University of CA Press.

Fishel, Stefanie R. 2017. *The Microbial State: Global Thriving and the Body Politic*. Minneapolis, MN: University of Minnesota Press.

Fitzharris, Lindsey. 2017. *The Butchering Art: Joseph Lister's Quest to Transform the Grisly World of Victorian Medicine*. London: Penguin Books Limited.

Flachs, Andrew, and Joseph D. Orkin. 2019. "Fermentation and the Ethnobiology of Microbial Entanglement." *Ethnobiology Letters* 10 (1): 35–9. https://doi.org/10.14237/ebl.10.1.2019.1481.

———. 2021. "On Pickles: Biological and Sociocultural Links between Fermented Foods and the Human Gut Microbiome." *Journal of Ethnobiology and Ethnomedicine* 17 (1): 1–18. https://doi.org/10.1186/s13002-021-00458-9.

Flandroy, Lucette, Theofilos Poutahidis, Gabriele Berg, Gerard Clarke, Maria Carlota Dao, Ellen Decaestecker, Eeva Furman, et al. 2018. "The Impact of Human Activities and Lifestyles on the Interlinked Microbiota and Health of Humans and of Ecosystems." *Science of the Total Environment* 627: 1018–38. https://doi.org/10.1016/j.scitotenv.2018.01.288.

Flink, Linus Girdland, Richard Allen, Ross Barnett, Helena Malmström, Joris Peters, Jonas Eriksson, Leif Andersson, Keith Dobney, and Greger Larson. 2014. "Establishing the Validity of Domestication Genes Using DNA from Ancient Chickens." *Proceedings of the National Academy of Sciences of the United States of America* 111 (17): 6184–89. https://doi.org/10.1073/pnas.1308939110.

Foster, Kevin R., Jonas Schluter, Katharine Z. Coyte, and Seth Rakoff-Nahoum. 2017. "The Evolution of the Host Microbiome as an Ecosystem on a Leash." *Nature* 548 (7665): 43–51. https://doi.org/10.1038/nature23292.

Foucault, Michel. 1980. *Power/Knowledge: Selected Interviews and Other Writings, 1972-1977*. Edited by Colin Gordon. New York: Pantheon Books.

———. (1976) 1990. *The History of Sexuality, Vol. 1*. New York: Vintage Books.

———. (1966) 2005. *The Order of Things*. Routledge Classics. Abingdon: Routledge.

———. (2004) 2008. *The Birth of Biopolitics: Lectures at the Collège de France, 1978-1979*. Translated by Graham Burchell. Michel Foucault, Lectures at the Collège de France. Basingstoke: Palgrave Macmillan UK.

———. 2009. *Security, Territory, Population: Lectures at the College De France, 1977 - 78*. Edited by Arnold I. Davidson. Translated by Graham Burchell. London: Palgrave Macmillan UK.

Fournier, Lauren. 2020. "Fermenting Feminism as Methodology and Metaphor." *Environmental Humanities* 12 (1): 88–112. https://doi.org/10.1215/22011919-8142220.

Fowler, P. W., and S. D. Guest. 2005. "A Symmetry Analysis of Mechanisms in Rotating Rings of Tetrahedra." *Proceedings of the Royal Society A: Mathematical, Physical and Engineering*

Sciences 461 (2058): 1829–46. https://doi.org/10.1098/rspa.2004.1439.
Freedman, Paul. 2007. *Food: The History of Taste*. California Studies in Food and Culture. Berkeley, CA: University of California Press.
———. 2012. "The Medieval Spice Trade." In *The Oxford Handbook of Food History*, 324–340. Oxford Handbooks in History. New York: OUP USA.
Frøst, M.B., Davide Giacalone, and K.K. Rasmussen. 2015. "Alternative Methods of Sensory Testing: Working with Chefs, Culinary Professionals and Brew Masters." In *Rapid Sensory Profiling Techniques*, edited by Julien Delarue, J Ben Lawlor, and Michel Rogeaux, 1st ed., 363–82. Cambridge: Woodhead Publishing. https://doi.org/10.1533/9781782422587.3.363.
Frye, J, and M Bruner, eds. 2012. *The Rhetoric of Food: Discourse, Materiality, and Power*. Routledge Studies in Rhetoric and Communication. Abingdon: Taylor & Francis.
Fuller, Dorian Q., Robin G. Allaby, and Chris Stevens. 2010. "Domestication as Innovation: The Entanglement of Techniques, Technology and Chance in the Domestication of Cereal Crops." *World Archaeology* 42 (1): 13–38. https://doi.org/10.1080/00438240903429680.
Gabrys, Jennifer, and Kathryn Yusoff. 2012. "Arts, Sciences and Climate Change: Practices and Politics at the Threshold." *Science as Culture* 21 (1): 1–24. https://doi.org/10.1080/09505431.2010.550139.
Galagan, James E., Sarah E. Calvo, Christina Cuomo, Li-jun Ma, Jennifer R. Wortman, Serafim Batzoglou, Christina C. Spevak, et al. 2005. "Sequencing of Aspergillus Nidulans and Comparative Analysis with A. Fumigatus and A. Oryzae." *Nature* 438: 1105–15. https://doi.org/10.1038/nature04341.
Gallone, Brigida, Jan Steensels, Guy Baele, Steven Maere, Kevin J Verstrepen, Troels Prahl, Leah Soriaga, et al. 2016. "Domestication and Divergence of Saccharomyces Cerevisiae Beer Yeasts." *Cell* 166 (6): 1397-1410.e16. https://doi.org/10.1016/j.cell.2016.08.020.
Gammage, Bill. 2011. *The Biggest Estate on Earth: How Aborigines Made Australia*. Crows Nest, NSW: Allen and Unwin.
Gammon, Andrea R. 2018. "The Many Meanings of Rewilding: An Introduction and the Case for a Broad Conceptualisation." *Environmental Values* 27 (4): 331–50. https://doi.org/10.3197/096327118X15251686827705.
Gan, Elaine, Anna L. Tsing, and Daniel Sullivan. 2018. "Using Natural History in the Study of Industrial Ruins." *Journal of Ethnobiology* 38 (1): 39–54. https://doi.org/10.2993/0278-0771-38.1.039.
Gao, Jihai. 2013. "Deleuze's Conception of Desire." *Deleuze Studies* 7 (3): 406–20. https://doi.org/10.3366/dls.2013.0120.
Garland-Thomson, Rosemarie. 2011. "Misfits: A Feminist Materialist Disability Concept." *Hypatia* 26 (3): 591–609. https://doi.org/10.1111/j.1527-2001.2011.01206.x.
Gatys, Leon, Alexander Ecker, and Matthias Bethge. 2016. "A Neural Algorithm of Artistic Style." *Journal of Vision* 16 (12): 326. https://doi.org/10.1167/16.12.326.
Gibbons, John G., and David C. Rinker. 2015. "The Genomics of Microbial Domestication in the Fermented Food Environment." *Current Opinion in Genetics and Development* 35: 1–8. https://doi.org/10.1016/j.gde.2015.07.003.
Gibbons, John G., and Antonis Rokas. 2013. "The Function and Evolution of the Aspergillus Genome." *Trends in Microbiology* 21 (1): 14–22. https://doi.org/10.1016/j.tim.2012.09.005.
Gibbons, John G., Leonidas Salichos, Jason C. Slot, David C. Rinker, Kriston L. McGary, Jonas G. King, Maren A. Klich, David L. Tabb, W. Hayes McDonald, and Antonis Rokas. 2012. "The Evolutionary Imprint of Domestication on Genome Variation and Function of the Filamentous Fungus Aspergillus Oryzae." *Current Biology* 22 (15): 1403–9. https://doi.org/10.1016/j.cub.2012.05.033.
Gibbons, Michael, Camille Limoges, Helga Nowotny, and Simon Schwartzman. 2010. "The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies." London: Sage Publications Ltd. https://doi.org/10.4135/9781446221853.
Gieryn, Thomas F. 1983. "Boundary-Work and the Demarcation of Science from Non-Science:

Strains and Interests in Professional Ideologies of Scientists." *American Sociological Review* 48 (6): 781–95.
———. 1999. *Cultural Boundaries of Science: Credibility on the Line*. Chicago: University of Chicago Press.
———. 2006. *City as Truth-Spot: Laboratories and Field-Sites in Urban Studies. Social Studies of Science*. Vol. 36. https://doi.org/10.1177/0306312705054526.
———. 2018. *Truth Spots: How Places Make People Believe*. Chicago: University of Chicago Press.
Gifford, Terry. 2012. "Pastoral, Anti-Pastoral and Post-Pastoral as Reading Strategies." In *Critical Insights: Nature and Environment*, edited by Scott Slovic, 42–61. Ipswich: Salam Press.
———. 2014. "Pastoral, Anti-Pastoral, and Post-Pastoral." In *The Cambridge Companion to Literature and the Environment*, edited by Louise Westling, 17–30. Cambridge: Cambridge University Press.
Gilbert, J. A., D. van der Lelie, and I. Zarraonaindia. 2014. "Microbial Terroir for Wine Grapes." *Proceedings of the National Academy of Sciences* 111 (1): 5–6. https://doi.org/10.1073/pnas.1320471110.
Gilbert, Scott F. 2014. "Symbiosis as the Way of Eukaryotic Life: The Dependent Co-Origination of the Body." *Journal of Biosciences* 39 (2): 201–9. https://doi.org/10.1007/s12038-013-9343-6.
Gilbert, Scott F., E. McDonald, N. Boyle, N. Buttino, L. Gyi, M. Mai, N. Prakash, and J. Robinson. 2010. "Symbiosis as a Source of Selectable Epigenetic Variation: Taking the Heat for the Big Guy." *Philosophical Transactions of the Royal Society B: Biological Sciences* 365 (1540): 671–78. https://doi.org/10.1098/rstb.2009.0245.
Gilbert, Scott F., Jan Sapp, and Alfred I. Tauber. 2012. "A Symbiotic View of Life: We Have Never Been Individuals." *The Quarterly Review of Biology* 87 (4): 325–41. https://doi.org/10.1086/668166.
Gilbert, Scott F., and Alfred I. Tauber. 2016. "Rethinking Individuality: The Dialectics of the Holobiont." *Biology and Philosophy* 31 (6): 839–53. https://doi.org/10.1007/s10539-016-9541-3.
Ginn, Franklin. 2013. "Sticky Lives: Slugs, Detachment and More-than-Human Ethics in the Garden." *Transactions of the Institute of British Geographers* 39 (4): 532–44. https://doi.org/10.1111/tran.12043.
Ginn, Franklin, Uli Beisel, and Maan Barua. 2014. "Flourishing with Awkward Creatures: Togetherness, Vulnerability, Killing." *Environmental Humanities* 4 (April): 113–23. https://doi.org/Flourishing with Awkward Creatures: Togetherness, Vulnerability, Killing.
Giraldo Herrera, César E. 2018. *Microbes and Other Shamanic Beings*. Berlin: Springer International Publishing.
Giraud, Eva. 2019. *What Comes After Entanglement?* Durham, NC: Duke University Press.
Goddard, Matthew R. 2016. "Microbiology: Mixing Wine, Chocolate, and Coffee." *Current Biology* 26 (7): R275–77. https://doi.org/10.1016/j.cub.2016.02.046.
Goffeau, André. 2005. "Genomics: Multiple Moulds." *Nature* 438 (7071): 1092–93. https://doi.org/10.1038/4381092b.
Goldenfeld, Nigel, and Carl Woese. 2007. "Biology's next Revolution." *Nature* 445 (January): 369. https://doi.org/10.1038/445369a.
Goldman, M J, P Nadasdy, and M D Turner. 2011. *Knowing Nature: Conversations at the Intersection of Political Ecology and Science Studies*. Chicago: University of Chicago Press.
Gonçalves, Margarida, Ana Pontes, Pedro Almeida, Raquel Barbosa, Marta Serra, Diego Libkind, Mathias Hutzler, Paula Gonçalves, and José Paulo Sampaio. 2016. "Distinct Domestication Trajectories in Top-Fermenting Beer Yeasts and Wine Yeasts." *Current Biology* 26 (20): 2750–61. https://doi.org/10.1016/j.cub.2016.08.040.
Goodley, Dan, Rebecca Lawthom, Kirsty Liddiard, and Katherine Runswick-Cole. 2019. "Provocations for Critical Disability Studies." *Disability and Society* 34 (6): 972–97. https://doi.org/10.1080/09687599.2019.1566889.
Goodman, A H, D Heath, and M S Lindee. 2003. *Genetic Nature/Culture: Anthropology and Science*

Beyond the Two-Culture Divide. Berkeley: University of California Press.
Goodman, D, E M DuPuis, and M K Goodman. 2012. *Alternative Food Networks: Knowledge, Practice, and Politics*. Online Access with Subscription: Proquest Ebook Central. Abingdon: Taylor & Francis.
Goodman, David. 1999. "Agro-Food Studies in the 'Age of Ecology': Nature, Corporeality, Bio-Politics." *Sociologia Ruralis* 39 (1): 17–38. https://doi.org/10.1111/1467-9523.00091.
———. 2002. "Rethinking Food Production-Consumption: Integrative Perspectives." *Sociologia Ruralis* 42 (4): 271–77. https://doi.org/10.1111/1467-9523.00216.
Goodman, David, and E. Melanie DuPuis. 2002. "Knowing Food and Growing Food: Beyond the Production-Consumption Debate in the Sociology of Agriculture." *Sociologia Ruralis* 42 (1): 5–22. https://doi.org/10.1111/1467-9523.00199.
Goodman, Michael K. 2016. "Food Geographies I: Relational Foodscapes and the Busy-Ness of Being More-than-Food." *Progress in Human Geography* 40 (2): 257–66. https://doi.org/10.1177/0309132515570192.
Goodman, Ruth. 2013. *How to Be a Victorian*. London: Penguin Books Limited.
Gora, L. Sasha. 2021. "A Cultural History of Indigenous Restaurants in Canada." Rachel Carson Center; Ludwig-Maximilians-Universität München.
Gora, L Sasha. 2017. "Eating the North: An Analysis of the Cookbook 'NOMA: Time & Place in Nordic Cuisine.'" *Graduate Journal of Food Studies* 04 (02). https://doi.org/10.21428/92775833.6c60dbc4.
Goward, Trevor. 2011. *Twelve Readings on the Lichen Thallus*. Clearwater, BC, Canada.
Grainger, S. 2020. *The Story of Garum: Fermented Fish Sauce and Salted Fish in the Ancient World*. London: Taylor & Francis.
Grand, Karina Lykke, Lise Pennington, and Anne Mette Thomsen, eds. 2013. *Guld: Skatte Fra Den Danske Guldalder / Gold: Treasures from the Danish Golden Age*. Aarhus: Systime.
Green, Barry G. 2012. "Chemesthesis and the Chemical Senses as Components of a 'Chemofensor Complex.'" *Chemical Senses* 37 (3): 201–6. https://doi.org/10.1093/chemse/bjr119.
Greenhough, Beth. 2010. "Vitalist Geographies: Life and the More-Than-Human." In *Taking-Place: Non-Representational Theories and Geography*. Routledge.
Greenhough, Beth, Cressida Jervis Read, Jamie Lorimer, Javier Lezaun, Carmen McLeod, Amber Benezra, Sally Bloomfield, et al. 2020. "Setting the Agenda for Social Science Research on the Human Microbiome." *Palgrave Communications* 6 (18): 1–11. https://doi.org/10.1057/s41599-020-0388-5.
Gross, Matthias. 2009. "Collaborative Experiments: Jane Addams, Hull House and Experimental Social Work." *Social Science Information* 48 (1): 81–95. https://doi.org/10.1177/0539018408099638.
———. 2010. *Ignorance and Surprise: Science, Society, and Ecological Design*. Inside Technology. Cambridge, MA: MIT Press.
Grosz, E. 2011. *Becoming Undone: Darwinian Reflections on Life, Politics, and Art*. Durham, NC: Duke University Press.
Gruber, Ansgar. 2019. "What's in a Name? How Organelles of Endosymbiotic Origin Can Be Distinguished from Endosymbionts." *Microbial Cell* 6 (2): 123–33. https://doi.org/10.15698/mic2019.02.668.
Guerrini, Anita. 2016. "The Ghastly Kitchen." *History of Science* 54 (1): 71–97. https://doi.org/10.1177/0073275315617769.
Guetté, Adrien, Pierre Gaüzère, Vincent Devictor, Frédéric Jiguet, and Laurent Godet. 2017. "Measuring the Synanthropy of Species and Communities to Monitor the Effects of Urbanization on Biodiversity." *Ecological Indicators* 79 (March): 139–54. https://doi.org/10.1016/j.ecolind.2017.04.018.
Guggenheim, Michael. 2012. "Laboratizing and De-Laboratizing the World: Changing Sociological Concepts for Places of Knowledge Production." *History of the Human Sciences* 25 (1): 99–118. https://doi.org/10.1177/0952695111422978.

Guha, Ramachandra. 2017. “Radical American Environmentalism and Wilderness Preservation: A Third World Critique.” *The Ethics of the Environment* 8 (8): 179–91. https://doi.org/10.4324/9781315239897-12.
Günther, Catrin S., and Matthew R. Goddard. 2019. “Do Yeasts and Drosophila Interact Just by Chance?” *Fungal Ecology* 38: 37–43. https://doi.org/10.1016/j.funeco.2018.04.005.
Guthman, Julie. 2019. *Wilted: Pathogens, Chemicals, and the Fragile Future of the Strawberry Industry*. Critical Environments. Oakland: University of California Press.
Hacking, Ian. 1983. *Representing and Intervening: Introductory Topics in the Philosophy of Natural Sciences*. Cambridge: Cambridge University Press.
Hagiwara, Daisuke, Kanae Sakai, Satoshi Suzuki, Myco Umemura, Toshihiko Nogawa, Naoki Kato, Hiroyuki Osada, et al. 2017. “Temperature during Conidiation Affects Stress Tolerance, Pigmentation, and Trypacidin Accumulation in the Conidia of the Airborne Pathogen Aspergillus Fumigatus.” *PLoS ONE* 12 (5): 1–20. https://doi.org/10.1371/journal.pone.0177050.
Hall, Brian K. 2012. “Lamarck, Lamarckism, Epigenetics and Epigenetic Inheritance.” *Metascience* 21 (2): 375–78. https://doi.org/10.1007/s11016-012-9661-6.
Hall, Matthew. 2011. *Plants as Persons: A Philosophical Botany*. SUNY Series on Religion and the Environment. New York: State University of New York Press.
Hanski, Ilkka, Leena Von Hertzen, Nanna Fyhrquist, Kaisa Koskinen, Kaisa Torppa, Tiina Laatikainen, Piia Karisola, et al. 2012. “Environmental Biodiversity, Human Microbiota, and Allergy Are Interrelated.” *Proceedings of the National Academy of Sciences of the United States of America* 109 (21): 8334–39. https://doi.org/10.1073/pnas.1205624109.
Haraway, Donna J. 1988. “Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective.” *Feminist Studies* 14 (3): 575–99.
———. 1989. *Primate Visions: Gender, Race, and Nature in the World of Modern Science*. Ann Arbor: University of Michigan Press.
———. 1991. *Simians, Cyborgs, and Women: The Reinvention of Nature*. *Contemporary Sociology*. New York: Routledge. https://doi.org/10.2307/2076334.
———. 1997. *Modest_Witness@Second_Millennium.FemaleMan_Meets_OncoMouse: Feminism and Technoscience*. New York, London: Routledge.
———. 2003. *The Companion Species Manifesto: Dogs, People, and Significant Otherness*. Chicago: Prickly Paradigm Press.
———. 2008. *When Species Meet*. Minneapolis: University of Minnesota Press.
———. 2010. “When Species Meet: Staying with the Trouble.” *Environment and Planning D: Society and Space* 28 (1): 53–55. https://doi.org/10.1068/d2706wsh.
———. 2015. “Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin.” *Environmental Humanities* 6: 159–65.
———. 2016. *Staying with the Trouble: Making Kin in the Chthulucene*. Durham and London: Duke University Press.
Haraway, Donna J., Noboru Ishikawa, Scott F. Gilbert, Kenneth Olwig, Anna L. Tsing, and Nils Bubandt. 2016. “Anthropologists Are Talking – About the Anthropocene.” *Ethnos* 81 (3): 535–64. https://doi.org/10.1080/00141844.2015.1105838.
Harper, A B. 2009. *Sistah Vegan: Black Female Vegans Speak on Food, Identity, Health, and Society*. New York: Lantern Books.
Harper, Amie Breeze. 2010. “Race as a ‘Feeble Matter’ in Veganism: Interrogating Whiteness, Geopolitical Privilege, and Consumption Philosophy of ‘Cruelty-Free’ Products.” *Journal for Critical Animal Studies* VIII (3): 5–27.
Harris, D. 1996. “Domesticatory Relationships of People, Plants and Animals.” In *Redefining Nature: Ecology, Culture and Domestication*, edited by R. Ellen and F. Katsuyoshi, 437–63. Routledge.
Haudricourt, André G. 1969. “Domestication of Animals, Cultivation of Plants and Human Relations.” *Social Science Information* 8 (3): 163–72.

https://doi.org/10.1177/053901846900800310.
Hauptmann, Aviaja L., Petronela Paulová, Josué L. Castro-Mejía, Lars H. Hansen, Thomas Sicheritz-Pontén, Gert Mulvad, and Dennis S. Nielsen. 2020. "The Microbial Composition of Dried Fish Prepared According to Greenlandic Inuit Traditions and Industrial Counterparts." *Food Microbiology* 85 (August). https://doi.org/10.1016/j.fm.2019.103305.
Hauptmann, Aviaja Lyberth, Natuk Lund Olsen, and Inge Høst Seiding. n.d. "Food Sovereignty and Colonialism in Greenland: A Case for Indigenous and Local Perspectives in Food Policies [in Review]." *Food and Foodways*.
Hayden, Brian. 2003. "Were Luxury Foods the First Domesticates? Ethnoarchaeological Perspectives from Southeast Asia." *World Archaeology* 34 (3): 458–69. https://doi.org/10.1080/0043824021000026459a.
Hayes-Conroy, Allison. 2010. "Feeling Slow Food: Visceral Fieldwork and Empathetic Research Relations in the Alternative Food Movement." *Geoforum* 41 (5): 734–42. https://doi.org/10.1016/j.geoforum.2010.04.005.
Hayes-Conroy, Allison, and Jessica Hayes-Conroy. 2008. "Taking Back Taste: Feminism, Food and Visceral Politics." *Gender, Place and Culture* 15 (5): 461–73. https://doi.org/10.1080/09663690802300803.
———. 2010. "Visceral Difference: Variations in Feeling (Slow) Food." *Environment and Planning A* 42 (12): 2956–71. https://doi.org/10.1068/a4365.
Hayes-Conroy, Jessica, and Allison Hayes-Conroy. 2010. "Visceral Geographies: Mattering, Relating, and Defying." *Geography Compass* 4 (9): 1273–83. https://doi.org/10.1111/j.1749-8198.2010.00373.x.
Hayes-Conroy, Jessica S. 2009. "Visceral Reactions: Alternative Food and Social Difference in Two North American Schools." Pennsylvania State University.
He, Bin, Yayi Tu, Chunmiao Jiang, Zhe Zhang, Yongkai Li, and Bin Zeng. 2019. "Functional Genomics of Aspergillus Oryzae: Strategies and Progress." *Microorganisms* 7 (4). https://doi.org/10.3390/microorganisms7040103.
Hecker, Howard Michael. 1982. "Domestication Revisited: Its Implications for Faunal Analysis." *Journal of Field Archaeology* 9 (No. 2 (Summer, 1982)): 217–36. https://doi.org/10.1179/009346982791504733.
Helmreich, Stefan. 2003. "Trees and Seas of Information." *American Ethnologist* 30: 340–58.
———. 2008. "Species of Biocapital." *Science as Culture* 17 (4): 463–78. https://doi.org/10.1080/09505430802519256.
———. 2009. *Alien Ocean: Anthropological Voyages in Microbial Seas*. Berkeley: University of California Press.
———. 2014. "Homo Microbis: The Human Microbiome, Figural, Literal, Political." *Thresholds* 42: 52–59.
Helmreich, Stefan, Sophia Roosth, and Michele Friedner. 2015. *Sounding the Limits of Life: Essays in the Anthropology of Biology and Beyond*. Princeton Studies in Culture and Technology. Princeton, NJ: Princeton University Press.
Hemmer, H. 1990. *Domestication: The Decline of Environmental Appreciation*. Translated by N Beckhaus. Cambridge University Press.
Hennion, Antoine. 2005. "Pragmatics of Taste." In *The Blackwell Companion to the Sociology of Culture*, edited by Mark D. Jacobs and Nancy Weiss Hanrahan, 131–44. Blackwell Publishing Ltd.
———. 2007. "Those Things That Hold Us Together: Taste and Sociology." *Cultural Sociology* 1 (1): 97–114. https://doi.org/10.1177/1749975507073923.
Herman, Agatha. 2015. "Enchanting Resilience: Relations of Care and People-Place Connections in Agriculture." *Journal of Rural Studies* 42: 102–11. https://doi.org/10.1016/j.jrurstud.2015.10.003.
Hermansen, Mark Emil Tholstrup. 2012. "Creating Terroir. An Anthropological Perspective on New Nordic Cuisine as an Expression of Nordic Identity." *Anthropology of Food* S7.

https://doi.org/10.1177/053901847901800604.
Hesseltine, C W. 1983. "Microbiology of Oriental Fermented Foods." *Annual Review of Microbiology* 37 (1): 575–601. https://doi.org/10.1146/annurev.mi.37.100183.003043.
Hey, Maya. 2020. "Fermentation and Kitchen/Laboratory Spaces." In *Fermented Landscapes: Lively Processes of Socio-Environmental Transformation*, edited by Colleen C. Myles, 390. Lincoln, Nebraska: University of Nebraska Press.
Hey, Maya, and Alex Ketchum. 2018a. "Fermentation as Agitation: Transforming How We Live Together." *Cuizine* 9 (2). https://doi.org/https://doi.org/10.7202/1055215ar.
———. 2018b. "Fermentation as Engagement: On More-than-Human Connections and Materiality." *Cuizine* 9 (1). https://id.erudit.org/iderudit/1052113ar.
Heys, C., A. M. Fisher, A. D. Dewhurst, Z. Lewis, and A. Lizé. 2021. "Exposure to Foreign Gut Microbiota Can Facilitate Rapid Dietary Shifts." *Scientific Reports* 11 (1): 1–6. https://doi.org/10.1038/s41598-021-96324-5.
Hinchliffe, Steve, John Allen, Stephanie Lavau, Nick Bingham, and Simon Carter. 2013. "Biosecurity and the Topologies of Infected Life: From Borderlines to Borderlands." *Transactions of the Institute of British Geographers* 38 (4): 531–43. https://doi.org/10.1111/j.1475-5661.2012.00538.x.
Hinchliffe, Steve, Matthew B. Kearnes, Monica Degen, and Sarah Whatmore. 2005. "Urban Wild Things: A Cosmopolitical Experiment." *Environment and Planning D: Society and Space* 23 (5): 643–58. https://doi.org/10.1068/d351t.
Hinchliffe, Steve, and Sarah Whatmore. 2006. "Living Cities: Towards a Politics of Conviviality." *Science as Culture* 15 (2): 123–38. https://doi.org/10.1080/09505430600707988.
Hird, Myra J. 2008. "Coevolution, Symbiosis and Sociology." *Ecological Economics* 69 (4): 737–42. https://doi.org/10.1016/j.ecolecon.2008.10.011.
———. 2009. *The Origins of Sociable Life*. New York: Palgrave Macmillan. https://doi.org/10.1057/9780230242210.
———. 2010. "Indifferent Globality: Gaia, Symbiosis and 'Other Worldliness.'" *Theory, Culture & Society* 27 (2–3): 54–72. https://doi.org/10.1177/0263276409355998.
Hobart, Hiʻilei Julia, and Stephanie Maroney. 2019. "On Racial Constitutions and Digestive Therapeutics." *Food, Culture and Society* 22 (5): 576–94. https://doi.org/10.1080/15528014.2019.1638120.
Hobbs, R. J., Eric Higgs, and Carol M. Hall. 2013. *Novel Ecosystems: Intervening in the New Ecological World Order*. Ebook Central. Chichester: Wiley-Blackwell.
Hodder, I. 1991. *The Domestication of Europe*. New York: Wiley.
Hodgetts, Timothy, and Jamie Lorimer. 2015. "Methodologies for Animals' Geographies: Cultures, Communication and Genomics." *Cultural Geographies* 22 (2): 285–95. https://doi.org/10.1177/1474474014525114.
Hodson, Derek. 2014. "Learning Science, Learning about Science, Doing Science: Different Goals Demand Different Learning Methods." *International Journal of Science Education* 36 (15): 2534–53. https://doi.org/10.1080/09500693.2014.899722.
Holm, Ulla. 2011. "Noma Er Fascisme i Avantgardistiske Klær [Noma Is Fascism in Avant-Gardist Clothes]." *Politiken*, May 8, 2011.
Hoover, Kara C. 2010. "Smell with Inspiration: The Evolutionary Significance of Olfaction." *American Journal of Physical Anthropology* 143 Suppl (January): 63–74. https://doi.org/10.1002/ajpa.21441.
Horie, Masayuki, Tomoyuki Honda, Yoshiyuki Suzuki, Yuki Kobayashi, Takuji Daito, Tatsuo Oshida, Kazuyoshi Ikuta, et al. 2010. "Endogenous Non-Retroviral RNA Virus Elements in Mammalian Genomes." *Nature* 463 (7277): 84–87. https://doi.org/10.1038/nature08695.
Hustak, Carla, and Natasha Myers. 2012. "Involutionary Momentum: Affective Ecologies and the Sciences of Plant/Insect Encounters." *Differences* 23 (3): 74–118. https://doi.org/10.1215/10407391-1892907.
Huxley, Julian S. (1942) 2010. *Evolution: The Modern Synthesis*. Mit Press. Cambridge, England:

MIT Press.
Hyldtoft, Ole. 2010. *Syn På Mad Og Drikke i 1800-Tallet*. København: Museum Tusculanum.
Illich, Ivan. 1973. *Tools for Conviviality*. Open Forum. New York: Harper & Row.
Ingold, Tim. 1980. *Hunters, Pastoralists and Ranchers: Reindeer Economies and Their Transformations*. Cambridge Studies in Social and Cultural Anthropology. Cambridge: Cambridge University Press.
———. 1986a. *Evolution and Social Life*. Cambridge: Cambridge University Press.
———. 1986b. *The Appropriation of Nature: Essays on Human Ecology and Social Relations*. Manchester: Manchester University Press.
———. 2000. *The Perception of the Environment: Essays in Livelihood, Dwelling, and Skill*. London and New York: Routledge. https://doi.org/10.1207/S15327884MCA0902.
———. 2011. *Being Alive: Essays on Movement, Knowledge and Description*. London: Taylor & Francis.
———. 2013. *Making: Anthropology, Archaeology, Art and Architecture*. London: Taylor & Francis.
———. 2017. "On Human Correspondence." *Journal of the Royal Anthropological Institute* 23 (1): 9–27. https://doi.org/10.1111/1467-9655.12541.
Ingraham, J L. 2010. *March of the Microbes: Sighting the Unseen*. Cambridge MA: Harvard University Press.
Ingram, Mrill. 2011. "Fermentation, Rot, and Other Human-Microbial Performances." In *Knowing Nature: Conversations at the Intersection of Political Ecology and Science Studies*, edited by Mara J. Goldman, Paul Nadasdy, and Matthew D. Turner, 99–112. Chicago: University of Chicago Press.
Inness, S A. 2001. *Cooking Lessons: The Politics of Gender and Food*. G - Reference, Information and Interdisciplinary Subjects Series. Lanham, MD: Rowman & Littlefield Publishers.
Irigaray, Luce. (1977) 1985. *This Sex Which Is Not One*. Ithaca, NY: Cornell University Press. https://doi.org/10.1007/978-1-349-22098-4_20.
———. (1994) 2000. *Democracy Begins Between Two*. Athlone Contemporary European Thinkers. London: Bloomsbury Academic.
Irving-Pease, Evan K., Laurent A. F. Frantz, Naomi Sykes, Cécile Callou, and Greger Larson. 2018. "Rabbits and the Specious Origins of Domestication." *Trends in Ecology & Evolution* 33 (3): 149–52. https://doi.org/10.1016/j.tree.2017.12.009.
Isaac, Erich. 1962. "On the Domestication of Cattle." *American Association for the Advancement of Science* 137 (3525): 195–204.
———. 1970. *Geography of Domestication*. Englewood Cliffs, N.J.: Prentice-Hall.
Ito, Hiroshi, and Koumei Dou. 1994. "Microorganisms of Miso and Shoyu." *Japan Journal of Food Microbiology* 11 (3).
Ito, Kiyoshi, Kazushi Yoshida, Takeaki Ishikawa, and Shinya Kobayashi. 1990. "Volatile Compounds Produced by the Fungus Aspergillus Oryzae in Rice Koji and Their Changes during Cultivation." *Journal of Fermentation and Bioengineering* 70 (3): 169–72. https://doi.org/10.1016/0922-338X(90)90178-Y.
Jackson, Peter. 2004. "Local Consumption Cultures in a Globalizing World." *Transactions of the Institute of British Geographers* 29 (2): 165–78.
———. 2017. "Eating Well." *Geoforum* 84 (June): 239–40. https://doi.org/10.1016/j.geoforum.2017.06.018.
Jankuhn, Herbert. 1982. "Trade and Settlement in Central and Northern Europe up to and during the Viking Period." *Journal of the Royal Society of Antiquaries of Ireland* 112: 18–50.
Jarman, M R, and P F Wilkinson. 1972. "Criteria of Animal Domestication." In *Papers in Economic Prehistory: Studies by Members and Associates of the British Academy Major Research Project in the Early History of Agriculture*, edited by E. S. Higgs, 83–96. Cambridge: Cambridge University Press.
Jasanoff, Sheila. 2003. "Breaking the Waves in Science Studies: Comment on H.M. Collins and Robert Evans, 'The Third Wave of Science Studies.'" *Social Studies of Science* 33 (3): 389–400.

https://doi.org/10.1177/03063127030333004.
Jasarevic, Larisa. 2015. “The Thing in a Jar: Mushrooms and Ontological Speculations in Post-Yugoslavia.” *Cultural Anthropology* 30 (1): 36–64. https://doi.org/10.14506/ca30.1.04.
Jellis, Thomas. 2012. “Reclaiming Experiment.” University of Oxford.
Jeon, Junhyun, Jaeyoung Choi, Gir Won Lee, Ralph A. Dean, and Yong Hwan Lee. 2013. “Experimental Evolution Reveals Genome-Wide Spectrum and Dynamics of Mutations in the Rice Blast Fungus, Magnaporthe Oryzae.” *PLoS ONE* 8 (5). https://doi.org/10.1371/journal.pone.0065416.
Jiménez-Aleixandre, M. Pilar, Anxela Bugallo Rodríguez, and Richard A. Duschl. 2000. “‘Doing the Lesson’ or ‘Doing Science’: Argument in High School Genetics.” *Science Education* 84 (6): 757–92. https://doi.org/10.1002/1098-237X(200011)84:6<757::AID-SCE5>3.0.CO;2-F.
Johnson, Arielle. 2020. “Marxist Analysis, in My Food Technology? Fuzzy Legibility, Flavor Connections, and the Recent Dialectical Emergence of Post-Modernity in Cuisine.” In *Food and Power: Proceedings of the Oxford Symposium on Food and Cookery 2019*, 136–46. London: Prospect Books.
Johnson, Arielle, and Lars Williams. 2016. *A Field Guide to Fermentation*. Copenhagen, Denmark.
Johnson, Elizabeth, Harlan Morehouse, Simon Dalby, Jessi Lehman, Sara Nelson, Rory Rowan, Stephanie Wakefield, and Kathryn Yusoff. 2014. “After the Anthropocene: Politics and Geographic Inquiry for a New Epoch.” *Progress in Human Geography* 38 (3): 439–56. https://doi.org/10.1177/0309132513517065.
Johnston, Josee, and Shyon Baumann. 2007. “Democracy versus Distinction: A Study of Omnivorousness in Gourmet Food Writing.” *American Journal of Sociology* 113 (1): 165–204. https://doi.org/10.1086/518923.
Jørgensen, Dolly. 2015. “Rethinking Rewilding.” *Geoforum* 65: 482–88. https://doi.org/10.1016/j.geoforum.2014.11.016.
Jung, Mi Ja, Min Soo Kim, Ji Hyun Yun, June Young Lee, Pil Soo Kim, Hae Won Lee, Ji Hyoung Ha, Seong Woon Roh, and Jin Woo Bae. 2018. “Viral Community Predicts the Geographical Origin of Fermented Vegetable Foods More Precisely than Bacterial Community.” *Food Microbiology* 76 (February): 319–27. https://doi.org/10.1016/j.fm.2018.06.010.
Kalamara, Margarita, Mihael Spacapan, Ines Mandic-Mulec, and Nicola R. Stanley-Wall. 2018. “Social Behaviours by Bacillus Subtilis: Quorum Sensing, Kin Discrimination and Beyond.” *Molecular Microbiology* 110 (6): 863–78. https://doi.org/10.1111/mmi.14127.
Kant, Immanuel. (1790) 1951. *Critique of Judgment*. Translated by J. H. Bernard. New York: Hafner.
———. (1785) 1998. *Groundwork of the Metaphysics of Morals*. Edited by Mary J Gregor, Christine M Korsgaard, Karl Ameriks, and Desmond M Clarke. Translated by Mary J Gregor. Cambridge Texts in the History of Philosophy. Cambridge: Cambridge University Press.
Kassam, Karim Aly S., Morgan L. Ruelle, Cyrus Samimi, Antonio Trabucco, and Jianchu Xu. 2018. “Anticipating Climatic Variability: The Potential of Ecological Calendars.” *Human Ecology* 46 (2): 249–57. https://doi.org/10.1007/s10745-018-9970-5.
Katz, Sandor Ellix. 2002. *Wild Fermentation: A DIY Guide to Cultural Manipulation*.
———. 2003. *Wild Fermentation: The Flavor, Nutrition, and Craft of Live-Culture Foods*. Hartford, VT: Chelsea Green Publishing.
———. 2012. *The Art of Fermentation: An In-Depth Exploration of Essential Concepts and Processes from around the World*. Hartford, VT: Chelsea Green Publishing.
———. 2020. *Fermentation as Metaphor*. White River Junction, VT: Chelsea Green Publishing.
Kaufman, James H., Christopher A. Elkins, Matthew Davis, Allison M. Weis, Bihua C. Huang, Mark K. Mammel, Isha R. Patel, et al. 2020. “Insular Microbiogeography: Three Pathogens as Exemplars.” *Current Issues in Molecular Biology* 36: 89–108. https://doi.org/10.21775/cimb.036.089.
Keller, Evelyn Fox. 2012. “Genes, Genomes, and Genomics.” *Biological Theory*, no. 2011: 132–40. https://doi.org/10.1007/s13752-012-0014-x.

———. 2014. “From Gene Action to Reactive Genomes.” *Journal of Physiology* 11: 2423–29. https://doi.org/10.1113/jphysiol.2014.270991.
Keller, Evelyn Fox, and David Harel. 2007. “Beyond the Gene.” *PLoS ONE*, no. 11. https://doi.org/10.1371/journal.pone.0001231.
Kelly, Ann H., and Javier Lezaun. 2014. “Urban Mosquitoes, Situational Publics, and the Pursuit of Interspecies Separation in Dar Es Salaam.” *American Ethnologist* 41 (2): 368–83. https://doi.org/10.1111/amet.12081.Urban.
Keulartz, Jozef. 2012. “The Emergence of Enlightened Anthropocentrism in Ecological Restoration.” *Nature and Culture* 7 (1): 48–71. https://doi.org/10.3167/nc.2012.070104.
Kim, Tae Woon, Jun Hwa Lee, Min Hee Park, and Hae Yeong Kim. 2010. “Analysis of Bacterial and Fungal Communities in Japanese and Chinese-Fermented Soybean Pastes Using Nested PCR-DGGE.” *Current Microbiology* 60 (5): 315–20. https://doi.org/10.1007/s00284-009-9542-4.
Kimmerer, Robin Wall. 2013. *Braiding Sweetgrass. Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge and the Teachings of Plants*. Minneapolis: Milkweed Editions. https://doi.org/10.1017/CBO9781107415324.004.
Kindon, S L, R Pain, and M Kesby. 2007. *Participatory Action Research Approaches and Methods: Connecting People, Participation and Place*. Routledge Studies in Human Geography. Abingdon: Routledge.
Kingsolver, B, C Kingsolver, and S L Hopp. 2009. *Animal, Vegetable, Miracle: A Year of Food Life*. New York: HarperCollins.
Kinpaisby, Mrs. 2008. “Taking Stock of Participatory Geographies: Envisioning the Communiversity.” *Transactions of the Institute of British Geographers* 33 (3): 292–99.
Kirksey, Eben. 2014. *The Multispecies Salon*. Durham: Duke University Press.
———. 2015a. “Emergent Ecologies,” no. May 2017. https://doi.org/10.1215/9780822374800.
———. 2015b. “Species: A Praxiographic Study.” *Journal of the Royal Anthropological Institute* 21 (4): 758–80. https://doi.org/10.1111/1467-9655.12286.
———. 2020a. “EPILOGUE: We Have Never Been Human.” In *The Mutant Project: Inside the Global Race to Genetically Modify Humans*, 247–60. New York: St. Martin’s Press.
———. 2020b. *The Mutant Project: Inside the Global Race to Genetically Modify Humans*. New York: St. Martin’s Press.
Kirksey, S. Eben, and Stefan Helmreich. 2010. “The Emergence of Multispecies Ethnography.” *Cultural Anthropology* 25 (4): 545–76. https://doi.org/10.1111/j.1548-1360.2010.01069.x.
Kjærgaard, Thorkild. 2006. “A Seaborne Society. The Greenlandic Neo-Eskimoes and Their Forerunners.” In *Ricchezza Del Mare*, 489–498. Settimane di Studi.
Klocker, Natascha. 2012. “Doing Participatory Action Research and Doing a PhD: Words of Encouragement for Prospective Students.” *Journal of Geography in Higher Education* 36 (1): 149–63. https://doi.org/10.1080/03098265.2011.589828.
Knight, Sarah, Steffen Klaere, Bruno Fedrizzi, and Matthew R. Goddard. 2015. “Regional Microbial Signatures Positively Correlate with Differential Wine Phenotypes: Evidence for a Microbial Aspect to Terroir.” *Scientific Reports* 5 (September): 1–10. https://doi.org/10.1038/srep14233.
Knox, Hannah. 2020. *Thinking Like a Climate: Governing a City in Times of Environmental Change*. Durham and London: Duke University Press.
Kohler, R. 2002. *Landscapes and Labscapes: Exploring the Lab–Field Border in Biology*. Chicago: University of Chicago Press.
Kohn, E. 2013. *How Forests Think: Toward an Anthropology Beyond the Human*. Berkeley, CA: University of California Press.
Koonin, Eugene V. 2009. “The Origin at 150: Is a New Evolutionary Synthesis in Sight?” *Trends in Genetics* 25 (11): 473–475. https://doi.org/10.1016/j.tig.2009.09.007.
Korsmeyer, C. 1999. *Making Sense of Taste: Food and Philosophy*. G - Reference, Information and Interdisciplinary Subjects Series. Ithaca, NY: Cornell University Press.
Krzywoszynska, Anna. 2019. “Caring for Soil Life in the Anthropocene: The Role of Attentiveness

in More-than-Human Ethics." *Transactions of the Institute of British Geographers* 44 (4): 661–75. https://doi.org/10.1111/tran.12293.
———. 2020. "Nonhuman Labor and the Making of Resources Making Soils a Resource through Microbial Labor." *Environmental Humanities* 12 (1): 227–49. https://doi.org/10.1215/22011919-8142319.
Krzywoszynska, Anna, and Greta Marchesi. 2020. "Toward a Relational Materiality of Soils Introduction." *Environmental Humanities* 12 (1): 190–204. https://doi.org/10.1215/22011919-8142297.
Kullman, Kim. 2013. "Geographies of Experiment/Experimental Geographies: A Rough Guide." *Geography Compass* 7 (12): 879–94. https://doi.org/10.1111/gec3.12087.
Kurtzman, C. P., M. J. Smiley, C. J. Robnett, and D. T. Wicklow. 1986. "DNA Relatedness among Wild and Domesticated Species in the Aspergillus Flavus Group." *Mycological Society of America* 78: 955–59.
la Cadena, Marisol de. 2015. *Earth Beings: Ecologies of Practice across Andean Worlds*. The Lewis Henry Morgan Lectures. Durham, NC: Duke University Press.
Lahne, Jacob, and Christy Spackman. 2018. "Introduction to Accounting for Taste." *Senses and Society* 13 (1): 1–5. https://doi.org/10.1080/17458927.2018.1427361.
Laland, Kevin N., John Odling-Smee, and Sean Myles. 2010. "How Culture Shaped the Human Genome: Bringing Genetics and the Human Sciences Together." *Nature Reviews. Genetics* 11 (2): 137–48. https://doi.org/10.1038/nrg2734.
Lamar, Kendrick. 2017. "DNA." Top Dawg Entertainment, Aftermath Entertainment, Interscope Records. https://www.youtube.com/watch?v=NLZRYQMLDW4.
Landecker, Hannah. 2007. *Culturing Life: How Cells Became Technologies*. ACLS Fellows' Publications. Cambridge MA: Harvard University Press.
———. 2015. "Antibiotic Resistance and the Biology of History." *Body & Society* 22 (4): 1–34. https://doi.org/10.1177/1357034X14561341.
Landis, Elizabeth A, Angela M Oliverio, Erin A Mckenney, Lauren M Nichols, Nicole Kfoury, Megan Biango-daniels, Leonora K Shell, et al. 2021. "The Diversity and Function of Sourdough Starter Microbiomes." *ELife*, 1–24.
Lane, Christel. 2014. *The Cultivation of Taste: Chefs and the Organization of Fine Dining*. Oxford: Oxford University Press.
Lane, S. N., N. Odoni, C. Landström, S. J. Whatmore, N. Ward, and S. Bradley. 2011. "Doing Flood Risk Science Differently: An Experiment in Radical Scientific Method." *Transactions of the Institute of British Geographers* 36 (1): 15–36. https://doi.org/10.1111/j.1475-5661.2010.00410.x.
Langford, Jean M. 2017. "Avian Bedlam." *Environmental Humanities* 9 (1): 84–107. https://doi.org/10.1215/22011919-3829145.
Larsen, Soren C, and Jay T Johnson. 2012. "In between Worlds: Place, Experience, and Research in Indigenous Geography." *Journal of Cultural Geography* 29 (1): 1–13. https://doi.org/10.1080/08873631.2012.646887.
Larson, Greger. 2015a. "Crop Domestication: Corn in the USA." *Nature Plants* 1 (1): 14009. https://doi.org/10.1038/nplants.2014.9.
———. 2015b. "Investigating Domestication through an Evolutionary Lens." *BioScience* 65 (9): 940–41. https://doi.org/10.1093/biosci/biv103.
Larson, Greger, Umberto Albarella, Keith Dobney, Peter Rowley-Conwy, Jörg Schibler, Anne Tresset, Jean-Denis Vigne, et al. 2007. "Ancient DNA, Pig Domestication, and the Spread of the Neolithic into Europe." *Proceedings of the National Academy of Sciences of the United States of America* 104 (39): 15276–81. https://doi.org/10.1073/pnas.0703411104.
Larson, Greger, and Joachim Burger. 2013. "A Population Genetics View of Animal Domestication." *Trends in Genetics* 29 (4): 197–205. https://doi.org/10.1016/j.tig.2013.01.003.
Larson, Greger, Keith Dobney, Umberto Albarella, Meiying Fang, Elizabeth Matisoo-Smith, Judith Robins, Stewart Lowden, et al. 2005. "Worldwide Phylogeography of Wild Boar Reveals

Multiple Centers of Pig Domestication." *Science* 307 (5715): 1618–21. https://doi.org/10.1126/science.1106927.
Larson, Greger, and Dorian Q. Fuller. 2014. "The Evolution of Animal Domestication." *Annual Review of Ecology, Evolution, and Systematics* 45 (1): 115–36. https://doi.org/10.1146/annurev-ecolsys-110512-135813.
Larson, Greger, E. K. Karlsson, A. Perri, M. T. Webster, S. Y. W. Ho, J. Peters, P. W. Stahl, et al. 2012. "Rethinking Dog Domestication by Integrating Genetics, Archeology, and Biogeography." *Proceedings of the National Academy of Sciences* 109 (23): 8878–83. https://doi.org/10.1073/pnas.1203005109.
Larson, Greger, Ranran Liu, Xingbo Zhao, Jing Yuan, Dorian Fuller, Loukas Barton, Keith Dobney, et al. 2010. "Patterns of East Asian Pig Domestication, Migration, and Turnover Revealed by Modern and Ancient DNA." *Proceedings of the National Academy of Sciences* 107 (17): 7686–91. https://doi.org/10.1073/pnas.0912264107.
Larson, Greger, D. R. Piperno, R. G. Allaby, M. D. Purugganan, L. Andersson, M. Arroyo-Kalin, L. Barton, et al. 2014. "Current Perspectives and the Future of Domestication Studies." *Proceedings of the National Academy of Sciences* 111 (17): 6139–46. https://doi.org/10.1073/pnas.1323964111.
Last, Angela. 2012. "Experimental Geographies." *Geography Compass* 6 (12): 706–24. https://doi.org/10.1111/gec3.12011.
Latimer, Joanna, and Mara Miele. 2013. "Naturecultures? Science, Affect and the Non-Human." *Theory, Culture & Society* 30 (7–8): 5–31. https://doi.org/10.1177/0263276413502088.
Latour, Bruno. 1987. *Science in Action: How to Follow Scientists and Engineers Through Society*. Cambridge MA: Harvard University Press.
———. 1988. *The Pasteurization of France*. Cambridge MA: Harvard University Press.
———. 1990. "Technology Is Society Made Durable." *The Sociological Review* 38 (1): 103–31. https://doi.org/10.5040/9781474282901.0013.
———. 1993. *We Have Never Been Modern*. Cambridge MA: Harvard University Press.
———. 1998a. "From the World of Science to the World of Research?" *Science* 280 (5361): 208. https://doi.org/10.1126/science.280.5361.208.
———. 1998b. "To Modernize or to Ecologize? That's the Question." *Remaking Reality: Nature at the Millenium*, 221–42.
———. 2000. "Circulating Reference: Sampling the Soil in the Amazon Forest." In *Pandora's Hope: Essays on the Reality of Science*, 24–79. Cambridge MA: Harvard University Press. https://doi.org/10.1017/CBO9781107415324.004.
———. 2004a. "Atmosphère, Atmosphère." In *Olafur Eliasson: The Weather Project*, edited by S. May, 29–41. London: Tate.
———. 2004b. "How to Talk About the Body? The Normative Dimension of Science Studies." *Body & Society* 10 (2–3): 205–29. https://doi.org/10.1177/1357034X04042943.
———. 2004c. *Politics of Nature: How to Bring the Sciences into Democracy*. Cambridge MA: Harvard University Press.
———. 2004d. "Why Has Critique Run out of Steam? From Matters of Fact to Matters of Concern." *Critical Inquiry* 30 (2): 225–48. https://doi.org/10.1086/421123.
———. 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.
———. 2009. "Perspectivism: 'Type' or 'Bomb'?" *Anthropology Today* 25 (2): 1–2.
———. 2011. "From Multiculturalism to Multinaturalism: What Rules of Method for the New Socio-Scientific Experiments?" *Nature and Culture* 6 (1): 1–17. https://doi.org/10.3167/nc.2011.060101.
———. 2014a. "Agency at the Time of the Anthropocene." *New Literary History* 45 (1): 1–18. https://doi.org/10.1353/nlh.2014.0003.
———. 2014b. "Some Advantages of the Notion of 'Critical Zone' for Geopolitics." *Procedia Earth and Planetary Science* 00 (0): 3–6. https://doi.org/10.1016/j.proeps.2014.08.002.

———. 2018. *Down to Earth: Politics in the New Climatic Regime*. Hoboken, NJ: Wiley.
Latour, Bruno, and Steve Woolgar. (1979) 2013. *Laboratory Life: The Construction of Scientific Facts*. Edited by Jonas Salk. Princeton, NJ: Princeton University Press.
Laurent, Justine, and Maja de Langen. 2017. "Science and the Senses: Betrayal." Society for Cultural Anthropology. 2017. https://culanth.org/fieldsights/science-and-the-senses-betrayal.
Law, John. 1992. "Notes on the Theory of the Actor Network: Ordering, Strategy and Heterogeneity." *Centre for Science Studies, Lancaster University*. https://doi.org/10.1007/BF01059830.
———. 1998. *Aircraft Stories: Decentering the Object in Technoscience*. Keele: Mimeo.
Leach, Helen M. 2003. "Human Domestication Reconsidered." *Current Anthropology* 44 (3): 349–68. https://doi.org/10.1086/368119.
Lee, Victoria. 2015. "Mold Cultures: Traditional Industry and Microbial Studies in Early Twentieth-Century Japan." In *New Perspectives on the History of Life Sciences and Agriculture*, edited by D. Phillips and S. Kingsland, 40:231–52. Switzerland: Springer International Publishing. https://doi.org/10.1007/978-3-319-12185-7_12.
———. 2018. "The Microbial Production of Expertise in Meiji Japan." *Osiris* 33 (1): 171–90. https://doi.org/10.1086/699405.
———. 2019. "Wild Toxicity, Cultivated Safety: Aflatoxin and Kōji Classification as Knowledge Infrastructure." *History and Technology* 35 (4): 405–24. https://doi.org/10.1080/07341512.2019.1694127.
———. 2021. *The Arts of the Microbial World: Fermentation Science in Twentieth-Century Japan*. Synthesis (University of Chicago. Press). Chicago: University of Chicago Press.
Leer, Jonatan. 2016. "The Rise and Fall of the New Nordic Cuisine." *Journal of Aesthetics & Culture* 8. https://doi.org/10.3402/jac.v8.33494.
———. 2019. "New Nordic Men: Cooking, Masculinity and Nordicness in René Redzepi's Noma and Claus Meyer's Almanak." *Food, Culture and Society* 22 (3): 316–33. https://doi.org/10.1080/15528014.2019.1582250.
Leer, Jonatan, and S G S Krogager. 2021. *Research Methods in Digital Food Studies*. Abingdon: Taylor & Francis.
Legras, Jean Luc, Virginie Galeote, Frederic Bigey, Carole Camarasa, Souhir Marsit, Thibault Nidelet, Isabelle Sanchez, et al. 2018. "Adaptation of s. Cerevisiae to Fermented Food Environments Reveals Remarkable Genome Plasticity and the Footprints of Domestication." *Molecular Biology and Evolution* 35 (7): 1712–27. https://doi.org/10.1093/molbev/msy066.
Legras, Jean Luc, Didier Merdinoglu, Jean Marie Cornuet, and Francis Karst. 2007. "Bread, Beer and Wine: Saccharomyces Cerevisiae Diversity Reflects Human History." *Molecular Ecology* 16 (10): 2091–2102. https://doi.org/10.1111/j.1365-294X.2007.03266.x.
Leopold, Aldo. 1949. *A Sand County Almanac, and Sketches Here and There*. Outdoor Essays & Reflections. New York: Oxford University Press.
Leschziner, Vanina. 2015. *At the Chef's Table: Culinary Creativity in Elite Restaurants*. Palo Alto: Stanford University Press.
Lévi-Strauss, Claude. 1966. "The Culinary Triangle." Translated by Peter Brooks. *The Partisan Review* 33: 586–96.
———. 1983. *The Raw and the Cooked*. Mythologiques. Chicago: University of Chicago Press.
Libkind, Diego, Chris Todd Hittinger, Elisabete Valério, Carla Gonçalves, Jim Dover, Mark Johnston, Paula Gonçalves, and José Paulo Sampaio. 2011. "Microbe Domestication and the Identification of the Wild Genetic Stock of Lager-Brewing Yeast." *Proceedings of the National Academy of Sciences of the United States of America* 108 (35): 14539–44. https://doi.org/10.1073/pnas.1105430108.
Lien, Marianne Elisabeth. 2015. *Becoming Salmon, Aquaculture and the Domestication of a Fish*. University of California Press.
Lien, Marianne Elisabeth, Heather Anne Swanson, and Gro B Ween. 2018. "Introduction: Naming the Beast—Exploring the Otherwise." In *Domestication Gone Wild*, edited by Heather Anne

Swanson, Marianne Elisabeth Lien, and Gro B. Ween, 1–30. Durham, N.C.: Duke University Press. https://doi.org/10.1515/9780822371649-002.
Liti, Gianni, David M. Carter, Alan M. Moses, Jonas Warringer, Leopold Parts, Stephen A. James, Robert P. Davey, et al. 2009. "Population Genomics of Domestic and Wild Yeasts." *Nature* 458 (7236): 337–41. https://doi.org/10.1038/nature07743.
Livingstone, David N. 1995. "The Spaces of Knowledge: Contributions towards a Historical Geography of Science." *Environment & Planning D: Society & Space* 13 (1): 5–34. https://doi.org/10.1068/d130005.
Locke, Piers, and Ursula Münster. 2015. "Multispecies Ethnography." *Oxford Bibliographies*.
Longhurst, Robyn, Elsie Ho, and Lynda Johnston. 2008. "Using 'the Body' as an 'Instrument of Research': Kimch'i and Pavlova." *Area* 4 (2): 208–17.
Longhurst, Robyn, Lynda Johnston, and Elsie Ho. 2009. "A Visceral Approach: Cooking 'at Home' with Migrant Women in Hamilton, New Zealand." *Transactions of the Institute of British Geographers* 34 (3): 333–45. https://doi.org/10.1111/j.1475-5661.2009.00349.x.
Lorenz, Edward. 1963. "Deterministic Nonperiodic Flow." *Journal of the Atmospheric Sciences* 20: 130–141. https://doi.org/10.1201/9780203734636-38.
Lorimer, Jamie. 2007. "Nonhuman Charisma." *Environment and Planning D: Society and Space* 25 (5): 911–32. https://doi.org/10.1068/d71j.
———. 2012. "Multinatural Geographies for the Anthropocene." *Progress in Human Geography* 36 (5): 593–612. https://doi.org/10.1177/0309132511435352.
———. 2013. "Aesthetics for Post-Human Worlds: Difference, Expertise and Ethics." *Dialogues in Human Geography* 2 (3): 284–87. https://doi.org/10.1177/2043820612468646.
———. 2014. "On Auks and Awkwardness." *Environmental Humanities* 4 (2011): 195–205.
———. 2015. *Wildlife in the Anthropocene: Conservation After Nature*. Minneapolis: University of Minnesota Press.
———. 2016a. "Gut Buddies: Multispecies Studies and the Microbiome." *Environmental Humanities* 8 (1): 57–76. https://doi.org/10.1215/22011919-3527722.
———. 2016b. "The Anthropo-Scene: A Guide for the Perplexed." *Social Studies of Science*, 1–26. https://doi.org/10.1177/0306312716671039.
———. 2017. "Parasites, Ghosts and Mutualists: A Relational Geography of Microbes for Global Health." *Transactions of the Institute of British Geographers*. https://doi.org/10.1111/tran.12189.
———. 2018. "Hookworms Make Us Human: The Microbiome, Eco-Immunology, and a Probiotic Turn in Western Health Care." *Medical Anthropology Quarterly* 33 (1): 60–79. https://doi.org/10.1111/maq.12466.
———. 2020. *The Probiotic Planet: Using Life to Manage Life*. Posthumanities. Minneapolis, MN: University of Minnesota Press.
Lorimer, Jamie, and Clemens Driessen. 2014. "Wild Experiments at the Oostvaardersplassen: Rethinking Environmentalism in the Anthropocene." *Transactions of the Institute of British Geographers* 39 (2): 169–81. https://doi.org/10.1111/tran.12030.
———. 2016. "From 'Nazi Cows' to Cosmopolitan 'Ecological Engineers': Specifying Rewilding Through a History of Heck Cattle." *Annals of the American Association of Geographers* 106 (3): 631–52. https://doi.org/10.1080/00045608.2015.1115332.
Lorimer, Jamie, Timothy Hodgetts, Richard Grenyer, Beth Greenhough, Carmen Mcleod, and Andrew Dwyer. 2019. "Making the Microbiome Public: Participatory Experiments with DNA Sequencing in Domestic Kitchens." *Transactions of the Institute of British Geographers* 44: 524–41. https://doi.org/10.1111/tran.12289.
Lorimer, Jamie, Chris Sandom, Paul Jepson, Christopher E Doughty, Maan Barua, and Keith J Kirby. 2015. "Rewilding: Science, Practice, and Politics." *Annual Review of Environment and Resources* 40 (1). https://doi.org/10.1146/annurev-environ-102014-021406.
Lundström, Johan N, Sanne Boesveldt, and Jessica Albrecht. 2011. "Central Processing of the Chemical Senses: An Overview." *ACS Chemical Neuroscience* 2 (1): 5–16.

https://doi.org/10.1021/cn1000843.
Machida, Masayuki, Kiyoshi Asai, Motoaki Sano, Toshihiro Tanaka, Toshitaka Kumagai, Goro Terai, Ken-Ichi Kusumoto, et al. 2005. "Genome Sequencing and Analysis of Aspergillus Oryzae." *Nature* 438 (7071): 1157–61. https://doi.org/10.1038/nature04300.
Machida, Masayuki, Osamu Yamada, and Katsuya Gomi. 2008. "Genomics of Aspergillus Oryzae: Learning from the History of Koji Mold and Exploration of Its Future." *DNA Research: An International Journal for Rapid Publication of Reports on Genes and Genomes* 15 (4): 173–83. https://doi.org/10.1093/dnares/dsn020.
MacKenzie, Donald. 1981. "Interests, Positivism and History." *Social Studies of Science* 11 (4): 498–504. https://doi.org/10.1177/030631278101100405.
MAD. 2016. "MAD5." MADFeed. 2016. www.madfeed.co/event/mad5.
———. 2018. "MAD6." MADFeed. 2018. www.madfeed.co/event/mad-in-2018.
Majid, Asifa, Laura Speed, Ilja Croijmans, and Artin Arshamian. 2017. "What Makes a Better Smeller?" *Perception* 46 (3–4): 406–30. https://doi.org/10.1177/0301006616688224.
Malovichko, Lyubov' V., Viktoriya V. Yufereva, Viktor A. Tel'pov, and Dmitrii P. Yuferev. 2021. "The Distribution and Dynamics of Synanthropisation of the Common Wood Pigeon in the Stavropol Region." *South of Russia: Ecology, Development* 16 (3): 33–46. https://doi.org/10.18470/1992.
Mann, Anna. 2018. "Sensory Science Research on Taste. An Ethnography of Two Laboratory Experiments in Western Europe." *Food and Foodways* 26 (1): 23–39. https://doi.org/10.1080/07409710.2017.1420352.
Mann, Anna M., Annemarie M. Mol, Priya Satalkar, Amalinda Savirani, Nasima Selim, Malini Sur, and Emily Yates-Doerr. 2011. "Mixing Methods, Tasting Fingers: Notes on an Ethnographic Experiment." *Hau: Journal of Ethnographic Theory* 1 (1): 221–43. https://doi.org/10.14318/2fhau.v1i1.6.
Mansfield, Becky. 2012. "Gendered Biopolitics of Public Health: Regulation and Discipline in Seafood Consumption Advisories." *Environment and Planning D: Society and Space* 30 (4): 588–602. https://doi.org/10.1068/d11110.
Mapes, Gwynne. 2018. "(De)Constructing Distinction: Class Inequality and Elite Authenticity in Mediatized Food Discourse." *Journal of Sociolinguistics* 22 (3): 265–87. https://doi.org/10.1111/josl.12285.
Marder, Michael. 2012. "The Life of Plants and the Limits of Empathy." *Dialogue-Canadian Philosophical Review* 51 (2): 259–73. https://doi.org/10.1017/S0012217312000431.
Margulis, L, and D Sagan. 1995. *What Is Life?* A Peter N. Nevraumont Book. Berkeley, CA: University of California Press.
———. 2002. *Acquiring Genomes: A Theory Of The Origin Of Species*. New York: Basic Books.
Marhendraswari, M. B.D., K. Mondylaksita, R. Millati, W. Budhijanto, J. A. Ferreira, C. Niklasson, and M. J. Taherzadeh. 2020. "Production of Edible Fungal (Rhizopus Delemar CBS 145940) Biomass from Organosolv-Pretreated Oil Palm Empty Fruit Bunch (OPEFB) in Submerged Fermentation." *IOP Conference Series: Materials Science and Engineering* 991 (1). https://doi.org/10.1088/1757-899X/991/1/012041.
Marinetti, Filippo Tommaso. (1932) 2014. *The Futurist Cookbook*. Edited by Lesley Chamberlain. Translated by Suzanne Brill. London: Penguin Books.
Maroney, Stephanie. 2019. "Sandor Katz and the Possibilities of a Queer Fermentive Praxis." *Cuizine* 9 (2). https://doi.org/10.7202/1055217ar.
Marris, E. 2011. *Rambunctious Garden: Saving Nature in a Post-Wild World*. London: Bloomsbury Publishing.
Marshall, F. B., K. Dobney, T. Denham, and J. M. Capriles. 2014. "Evaluating the Roles of Directed Breeding and Gene Flow in Animal Domestication." *Proceedings of the National Academy of Sciences* 111 (17): 6153–58. https://doi.org/10.1073/pnas.1312984110.
Martin, A., N. Myers, and A. Viseu. 2015. "The Politics of Care in Technoscience." *Social Studies of Science* 45 (5): 625–41. https://doi.org/10.1177/0306312715602073.

Maruyama, Yutaka, Reiko Yasuda, Motonaka Kuroda, and Yuzuru Eto. 2012. "Kokumi Substances, Enhancers of Basic Tastes, Induce Responses in Calcium-Sensing Receptor Expressing Taste Cells." *PloS One* 7 (4): e34489. https://doi.org/10.1371/journal.pone.0034489.

Marx, K. (1867) 2004. *Capital: Volume I*. Edited by E Mandel and B Fowkes. Capital. London: Penguin Books Limited.

Massey, D. 2005. *For Space*. London: SAGE Publications.

McCormack, D P. 2018. *Atmospheric Things: On the Allure of Elemental Envelopment*. Elements. Durham, N.C.: Duke University Press.

McDonald, Shane T, David Bolliet, John Hayes, and J Prescott. 2016. *Chemesthesis: Chemical Touch in Food and Eating*. Ebook Central. Chichester, West Sussex, England: Wiley Blackwell.

McFall-Ngai, Margaret. 2017. "Noticing Microbial Worlds." In *Arts of Living on a Damaged Planet: Ghosts and Monsters of the Anthropocene*, edited by Anna Tsing, Heather Swanson, Elaine Gan, and Nils Bubandt, M51–70. Minneapolis, MN: University of Minnesota Press.

McFall-Ngai, Margaret, Michael G Hadfield, Thomas C G Bosch, V Hannah, Tomislav Domazet-lošo, Angela E Douglas, Nicole Dubilier, et al. 2013. "Animals in a Bacterial World, a New Imperative for the Life Sciences." *Proceedings of the National Academy of Science of the United States of America* 110 (9). https://doi.org/10.1073/pnas.1218525110.

McGee, Harold. 2007. *On Food and Cooking: The Science and Lore of the Kitchen*. New York: Simon and Schuster.

McGovern, Patrick E., Juzhong Zhang, Jigen Tang, Zhiqing Zhang, Gretchen R. Hall, Robert A. Moreau, Alberto Nuñez, et al. 2004. "Fermented Beverages of Pre- and Proto-Historic China." *Proceedings of the National Academy of Sciences of the United States of America* 101 (51): 17593–98. https://doi.org/10.1073/pnas.0407921102.

McLeod, Carmen, Brigitte Nerlich, and Alison Mohr. 2017. "Working with Bacteria and Putting Bacteria to Work: The Biopolitics of Synthetic Biology for Energy in the United Kingdom." *Energy Research and Social Science* 30 (June): 35–42. https://doi.org/10.1016/j.erss.2017.06.017.

McLoon, Anna L., Sarah B. Guttenplan, Daniel B. Kearns, Roberto Kolter, and Richard Losick. 2011. "Tracing the Domestication of a Biofilm-Forming Bacterium." *Journal of Bacteriology* 193 (8): 2027–34. https://doi.org/10.1128/JB.01542-10.

McRuer, Robert. 2006. *Crip Theory: Cultural Signs of Queerness and Disability*. Cultural Front. New York: NYU Press.

McRuer, Robert, and Merri Johnson. 2014. "Proliferating Cripistemologies." *Journal of Literary & Cultural Disability Studies* 8 (2): 149–70. https://doi.org/10.3828/jlcds.2014.13.

Meah, Angela, and Peter Jackson. 2013. "Crowded Kitchens: The 'Democratisation' of Domesticity?" *Gender, Place and Culture* 20 (5): 578–96. https://doi.org/10.1080/0966369X.2012.701202.

———. 2016. "Re-Imagining the Kitchen as a Site of Memory." *Social and Cultural Geography* 17 (4): 511–32. https://doi.org/10.1080/14649365.2015.1089587.

Meyer, Matthias, and Martin Kircher. 2010. "Illumina Sequencing Library Preparation for Highly Multiplexed Target Capture and Sequencing." *Cold Spring Harbor Protocols* 5 (6): 1–11. https://doi.org/10.1101/pdb.prot5448.

Micheelsen, Arun, Lotte Holm, and Katherine O'Doherty Jensen. 2013. "Consumer Acceptance of the New Nordic Diet. An Exploratory Study." *Appetite* 70: 14–21. https://doi.org/10.1016/j.appet.2013.06.081.

Micheelsen, Arun, Lotte Holm, and Katherine O'Doherty Jensen. 2014. "Living with the New Nordic Diet." *British Food Journal* 116 (8): 1247–58. https://doi.org/10.1108/BFJ-03-2013-0058.

Miele, Mara. 2011. "The Taste of Happiness: Free-Range Chicken." *Environment and Planning A* 43 (9): 2076–90. https://doi.org/10.1068/a43257.

Mill, John Stuart. (1863) 2002. *Utilitarianism*. Indianapolis: Hackett.

Milton, Kay. 2005. “Anthropomorphism or Egomorphism? The Perception of Non-Human Persons by Human Ones.” In *Animals in Person*. Routledge.
Mintz, Sidney W., and Christine M. Du Bois. 2002. “The Anthropology of Food and Eating.” *Annual Review of Anthropology* 31: 99–119. https://doi.org/10.1146/annurev.anthro.32.032702.131011.
Mintz, Sidney W. 1986. *Sweetness and Power: The Place of Sugar in Modern History*. New York: Penguin Books.
Mitchiner, Michael. 1987. “Evidence for Viking-Islamic Trade Provided by Samanid Silver Coinage.” *Annali. Istituto Orientale Di Napoli* 37 (1/4): 139–50.
Moeran, Brian. 2009. “Organizational Ethnography: Studying the Complexities of Everyday Life.” In *Organizational Ethnography: Studying the Complexities of Everyday Life*, edited by Sierk Ybema, Dvora Yanow, Harry Wels, and Frans Kamsteeg, 139–155. London: Sage Publications Ltd. https://doi.org/10.4135/9781849209526.
Mol, Annemarie. 1999. “Ontological Politics. A Word and Some Questions.” *The Sociological Review* 47 (1_suppl): 74–89. https://doi.org/10.1111/j.1467-954x.1999.tb03483.x.
———. 2002. *The Body Multiple: Ontology in Medical Practice*. Durham: Duke University Press.
———. 2009. “Good Taste.” *Journal of Cultural Economy* 2 (3): 269–83. https://doi.org/10.1080/17530350903345504.
———. 2011. “Tasting Food: Tasting between the Laboratory and the Clinic.” In *A Companion to the Anthropology of the Body and Embodiment*, edited by Frances E. Mascia-Lees. Hoboken, NJ: Blackwell Publishing Ltd.
———. 2012. “Layers or Versions? Human Bodies and the Love of Bitterness.” In *Routledge Handbook of Body Studies*, 119–29. London: Routledge.
———. 2013. “Mind Your Plate! The Ontonorms of Dutch Dieting.” *Social Studies of Science* 43 (3): 379–96. https://doi.org/10.1177/0306312712456948.
———. 2021. *Eating in Theory*. Durham and London: Duke University Press. https://doi.org/10.4324/9780203646915-11.
Møller, Marie-Louise Monrad. 2019. “Dahls Norwegen Die Künstlerische Erfindung Einer Norwegischen Nationalkultur.” Universität Leipzig.
Money, Nicholas P. 2018. *The Rise of Yeast: How the Sugar Fungus Shaped Civilisation*. Oxford: Oxford University Press.
Montenegro de Wit, Maywa. 2016. “Are We Losing Diversity? Navigating Ecological, Political, and Epistemic Dimensions of Agrobiodiversity Conservation.” *Agriculture and Human Values* 33 (3): 625–40. https://doi.org/10.1007/s10460-015-9642-7.
Moore, Sam, and Alex Roberts. 2022. *The Rise of Ecofascism: Climate Change and the Far Right*. Oxford: Polity Press.
Morgan, E David. 2008. “Chemical Sorcery for Sociality: Exocrine Secretions of Ants (Hymenoptera: Formicidae),” no. August: 79–90.
Morris, Kieran. 2020. “What Noma Did next: How the ‘New Nordic’ Is Reshaping the Food World.” *The Guardian*, February 28, 2020. https://www.theguardian.com/food/2020/feb/28/what-noma-did-next-new-nordic-food-rene-redzepi-claus-meyer-locavore-foraging.
Mueller, Ulrich G., Nicole M. Gerardo, Duur K. Aanen, Diana L. Six, and Ted R. Schultz. 2005. “The Evolution of Agriculture in Insects.” *Annual Review of Ecology, Evolution, and Systematics* 36 (1): 563–95. https://doi.org/10.1146/annurev.ecolsys.36.102003.152626.
Müller, R. 1906. *Vildtet og Jagten I Sydgrønland [The Game and the Hunt in South Greenland]*. Copenhagen, Denmark: H. Hagerups Forlag.
Munk, Anders Kristian, and Anne-Kristine Bøcher Ellern. 2016. “Mapping the New Nordic Issue-Scape: How to Navigate a Diffuse Controversy with Digital Methods.” In *Tourism Encounters and Controversies: Ontological Politics of Tourism Development*, edited by Gunnar Thór Jóhannesson, Carina Ren, and René van der Duim. Abingdon.
Murdoch, Johnathan, and Mara Miele. 2004. “A New Aesthetic of Food? Relational Reflexivity in

the ‘alternative’ Fod Movement.” In *Qualities of Food*, 156–75. Manchester: Manchester University Press.
Murdoch, Jonathan, Terry Marsden, and Jo Banks. 2000. “Quality, Nature, and Embeddedness: Some Theoretical Considerations in the Context of the Food Sector.” *Economic Geography* 76 (2): 107–25. https://doi.org/10.4324/9781315237213-6.
Myers, Natasha. 2012. “Dance Your PhD: Embodied Animations, Body Experiments, and the Affective Entanglements of Life Science Research.” *Body and Society* 18 (1): 151–89. https://doi.org/10.1177/1357034X11430965.
Myers, Natasha, and Ayelen Liberona. n.d. “Becoming Sensor.” https://becomingsensor.com/.
Myles, Colleen C., ed. 2020. *Fermented Landscapes: Lively Processes of Socio-Environmental Transformation*. Lincoln, Nebraska: University of Nebraska Press.
Mysterud, Atle. 2010. “Still Walking on the Wild Side? Management Actions as Steps towards ‘semi-Domestication’ of Hunted Ungulates.” *Journal of Applied Ecology* 47 (4): 920–25. https://doi.org/10.1111/j.1365-2664.2010.01836.x.
Nabhan, Gary Paul. 2006. *Why Some Like It Hot: Food, Genes, and Cultural Diversity*. Washington, D.C.: Island Press.
———. 2010. “Ethnobiology for a Diverse World: Microbial Ethnobiology and the Loss of Distinctive Food Cultures.” *Journal of Ethnobiology* 30 (2): 181–83. https://doi.org/10.2993/0278-0771-30.2.181.
Nam, Young Do, So Young Lee, and Seong Il Lim. 2012. “Microbial Community Analysis of Korean Soybean Pastes by Next-Generation Sequencing.” *International Journal of Food Microbiology* 155 (1–2): 36–42. https://doi.org/10.1016/j.ijfoodmicro.2012.01.013.
Nancy, J.-L. 1991. “‘Eating Well’, or Calculation of the Subject: An Interview with Jacques Derrida.” In *Who Comes after the Subject?*, edited by E. Cadava, P. Connor, and J.-L. Nancy. New York: Routledge.
Nelson, Alondra. 2016. *The Social Life of DNA: Race, Reparations, and Reconciliation After the Genome*. Boston, MA: Beacon Press.
Neuman, Nicklas, and Christina Fjellström. 2014. “Gendered and Gendering Practices of Food and Cooking: An Inquiry into Authorisation, Legitimisation and Androcentric Dividends in Three Social Fields.” *Norma* 9 (4): 269–85. https://doi.org/10.1080/18902138.2014.967985.
Neuman, Nicklas, and Jonatan Leer. 2018. “Nordic Cuisine but National Identities: ‘New Nordic Cuisine’ and the Gastronationalist Projects of Denmark and Sweden.” *Anthropology of Food* 13.
Ngai, Sianne. 2008. “Merely Interesting.” *Critical Inquiry* 34 (4): 777–817. https://doi.org/10.1086/592544.
———. 2010. “Our Aesthetic Categories.” *PMLA* 125 (4): 948–58. https://doi.org/10.1632/pmla.2010.125.4.948.
———. 2012. *Our Aesthetic Categories: Zany, Cute, Interesting*. Cambridge MA: Harvard University Press.
Nimmo, Richie. 2013. “From Monarchists to Communists: Bees in the Socio-Political Imagination.” Sociological Insect. 2013. https://sociologicalinsect.com/2013/10/10/from-monarchists-to-communists-bees-in-the-socio-political-imagination/.
Noma. 2016. “A Short Film about the Past, Present and Future of Noma.” 2016. https://noma.dk/the-weather-report/a-very-short-film-about-the-past-present-and-future-of-noma/.
Noonan, Thomas S. 1992. “Fluctuations in Islamic Trade with Eastern Europe during the Viking Age.” *Harvard Ukrainian Studies* 16 (3/4): 237–59.
Nordic Council. 2004. “The New Nordic Food Manifesto.” Nordic Co-Operation. 2004. https://www.norden.org/en/information/new-nordic-food-manifesto.
O’Connor, Terry. 1997. “Working at Relationships: Another Look at Animal Domestication.” *Antiquity* 71 (271): 149–56. https://doi.org/10.1017/S0003598X00084635.
O’Malley, Maureen A. 2008. “‘Everything Is Everywhere: But the Environment Selects’: Ubiquitous

Distribution and Ecological Determinism in Microbial Biogeography." *Studies in History and Philosophy of Science Part C :Studies in History and Philosophy of Biological and Biomedical Sciences* 39 (3): 314–25. https://doi.org/10.1016/j.shpsc.2008.06.005.
———. 2010. "What Microbes Can Do: A Sensory Guide to Microbiology." *Biological Theory* 5 (2): 182–86. https://doi.org/10.1162/BIOT_r_00031.
———. 2014. *Philosophy of Microbiology*. Cambridge: Cambridge University Press.
———. 2015. "Endosymbiosis and Its Implications for Evolutionary Theory." *Proc Natl Acad Sci U S A* 112 (33): 10270–77. https://doi.org/10.1073/pnas.1421389112.
O'Malley, Maureen A., and John Dupré. 2007. "Size Doesn't Matter: Towards a More Inclusive Philosophy of Biology." *Biology and Philosophy* 22 (2): 155–91. https://doi.org/10.1007/s10539-006-9031-0.
O'Malley, Maureen A., William Martin, and John Dupré. 2010. "The Tree of Life: Introduction to an Evolutionary Debate." *Biology and Philosophy* 25 (4): 441–53. https://doi.org/10.1007/s10539-010-9208-4.
Oborník, Miroslav. 2019. "In the Beginning Was the Word: How Terminology Drives Our Understanding of Endosymbiotic Organelles." *Microbial Cell* 6 (2): 134–41. https://doi.org/10.15698/mic2019.02.669.
OED. 2021a. "Interest, N." *Oxford English Dictionary*. https://www.oed.com/view/Entry/97735.
———. 2021b. "Interest, V." *Oxford English Dictionary*. https://www.oed.com/view/Entry/97736.
———. 2021c. "Wilder, V." *Oxford English Dictionary*. https://www.oed.com/view/Entry/228998.
Oelsner, Gertrud. 2012. "The Democracy of Nature." *Romantik* 1 (1): 69–101.
Ogunseitan, Oladele. 2005. *Microbial Diversity: Form and Function in Prokaryotes*. Oxford: Blackwell.
Ohsu, Takeaki, Yusuke Amino, Hiroaki Nagasaki, Tomohiko Yamanaka, Sen Takeshita, Toshihiro Hatanaka, Yutaka Maruyama, Naohiro Miyamura, and Yuzuru Eto. 2010. "Involvement of the Calcium-Sensing Receptor in Human Taste Perception." *The Journal of Biological Chemistry* 285 (2): 1016–22. https://doi.org/10.1074/jbc.M109.029165.
Olaczek, Romuald. 1982. "Synanthropization of Phytocoenoses." *Memorabilia Zoologica* 37: 93–112.
Onda, Takumi, F. Yanagida, M. Tsuji, T. Shinohara, and K. Yokotsuka. 2003. "Time Series Analysis of Aerobic Bacterial Flora during Miso Fermentation." *Letters in Applied Microbiology* 37 (2): 162–68. https://doi.org/10.1046/j.1472-765X.2003.01371.x.
Onda, Takumi, F. Yanagida, T. Uchimura, M. Tsuji, S. Ogino, T. Shinohara, and K. Yokotsuka. 2002. "Widespread Distribution of the Bacteriocin-Producing Lactic Acid Cocci in Miso-Paste Products." *Journal of Applied Microbiology* 92 (4): 695–705. https://doi.org/10.1046/j.1365-2672.2002.01573.x.
Onda, Takumi, Fujitoshi Yanagida, Tai Uchimura, Masao Tsuji, Satoshi Ogino, Takashi Shinohara, and Koki Yokotsuka. 2003. "Analysis of Lactic Acid Bacterial Flora during Miso Fermentation." *Food Science and Technology Research* 9 (1): 17–24. https://doi.org/10.3136/fstr.9.17.
Orlando, Ludovic, M Thomas P Gilbert, and Eske Willerslev. 2015. "Reconstructing Ancient Genomes and Epigenomes." *Nature Reviews. Genetics* 16 (7): 395–408. https://doi.org/10.1038/nrg3935.
Paasi, Anssi. 2011. "Geography, Space and the Re-Emergence of Topological Thinking." *Dialogues in Human Geography* 1 (3): 299–303. https://doi.org/10.1177/2043820611421547.
Parada, Alma E., David M. Needham, and Jed A. Fuhrman. 2016. "Every Base Matters: Assessing Small Subunit RRNA Primers for Marine Microbiomes with Mock Communities, Time Series and Global Field Samples." *Environmental Microbiology* 18 (5): 1403–14. https://doi.org/10.1111/1462-2920.13023.
Park, Seong Eun, Seung Ho Seo, Eun Ju Kim, Sunghoon Byun, Chang Su Na, and Hong Seok Son. 2019. "Changes of Microbial Community and Metabolite in Kimchi Inoculated with Different Microbial Community Starters." *Food Chemistry* 274: 558–65.

https://doi.org/10.1016/j.foodchem.2018.09.032.
Parke, Carol S. 2012. "Factorial Design." *Encyclopedia of Research Design*. SAGE Publications.
Pascoe, Bruce. 2014. *Dark Emu, Black Seeds: Agriculture or Accident?* Broome, WA: Magabala Books.
Passerini, Delphine, Charlotte Beltramo, Michele Coddeville, Yves Quentin, Paul Ritzenthaler, Marie Line Daveran-Mingot, and Pascal Le Bourgeois. 2010. "Genes but Not Genomes Reveal Bacterial Domestication of Lactococcus Lactis." *PLoS ONE* 5 (12): 1–12. https://doi.org/10.1371/journal.pone.0015306.
Paterson, Mark. 2009. "Haptic Geographies: Ethnography, Haptic Knowledges and Sensuous Dispositions." *Progress in Human Geography* 33 (6): 766–88. https://doi.org/10.1177/0309132509103155.
Paxson, Heather. 2008. "Post-Pasteurian Cultures: The Microbiopolitics of Raw-Milk Cheese in the United States." *Cultural Anthropology* 23 (1): 15–47. https://doi.org/10.1525/can.2008.23.1.15.2008.
———. 2010. "Locating Value in Artisan Cheese: Reverse Engineering Terroir for New-World Landscapes." *American Anthropologist* 112 (3): 444–57. https://doi.org/10.1111/j.1548-1433.2010.01251.x.
———. 2012. *The Life of Cheese: Crafting Food and Value in America*. Berkeley: University of California Press.
Paxson, Heather, and Stefan Helmreich. 2014. "The Perils and Promises of Microbial Abundance: Novel Natures and Model Ecosystems, from Artisanal Cheese to Alien Seas." *Social Studies of Science* 44 (2): 165–93. https://doi.org/10.1177/0306312713505003.
Pearce, Fred. 2015. *The New Wild: Why Invasive Species Will Be Nature's Salvation*. London: Icon Books.
Pearlman, Alison. 2013. *Smart Casual: The Transformation of Gourmet Restaurant Style in America*. Chicago: University of Chicago Press.
Pelchat, Marcia L. 2002. "Of Human Bondage: Food Craving, Obsession, Compulsion, and Addiction." *Physiology & Behavior* 76 (3): 347–52. http://www.ncbi.nlm.nih.gov/pubmed/12117571.
Perseus Digital Library. n.d. "Experior." *Latin Word Study Tool*. http://www.perseus.tufts.edu/hopper/morph?l=experior&la=la#Perseus:text:1999.04.0059:entry=experior-contents.
———. n.d. "Sapio." *Latin Word Study Tool*. http://www.perseus.tufts.edu/hopper/morph?l=sapio&la=la'.
Petrini, Carlo. 2003. *Slow Food: The Case for Taste*. Translated by William McCuaig. Arts and Traditions of the Table: Perspectives on Culinary History. New York: Columbia University Press.
Pink, Sarah. 2010. *Doing Sensory Ethnography*. London: SAGE.
Plumwood, Val. 1993. *Feminism and the Mastery of Nature*. Feminism for Today. Abingdon: Routledge.
———. 2006. "The Concept of a Cultural Landscape: Nature, Culture and Agency in the Land." *Ethics and the Environment* 11 (2): 115–50.
———. 2009. "Nature in the Active Voice." *Australian Humanities Review*, no. 46. https://doi.org/10.4324/9781315728964-54.
Polanyi, Michael. 1962. *Personal Knowledge: Towards a Post-Critical Philosophy*. ISSR Library. Chicago: University of Chicago Press.
———. 2009. *The Tacit Dimension*. Chicago: University of Chicago Press.
Pollan, Michael. 2002. *The Botany of Desire: A Plant's-Eye View of the World*. Bloomsbury Paperbacks. London and New York: Bloomsbury.
———. 2006. *The Omnivore's Dilemma: A Natural History of Four Meals*. New York: Penguin Publishing Group.
———. 2013. *Cooked: A Natural History of Transformation*. New York: Penguin Publishing Group.

———. 2018. *How to Change Your Mind: What the New Science of Psychedelics Teaches Us About Consciousness, Dying, Addiction, Depression, and Transcendence*. New York: Penguin Publishing Group.
Povinelli, E A. 2016. *Geontologies: A Requiem to Late Liberalism*. Durham, NC: Duke University Press.
Powell, Richard C., and Alexander Vasudevan. 2007. "Geographies of Experiment." *Environment and Planning A* 39 (8): 1790–93. https://doi.org/10.1068/a3927.
Preston, Claire. 2006. *Bee*. London: Reaktion Books.
Proctor, Robert, and Londa L Schiebinger. 2008. *Agnotology: The Making and Unmaking of Ignorance*. Stanford, Calif.: Stanford University Press.
Puig de la Bellacasa, Maria. 2011. "Matters of Care in Technoscience: Assembling Neglected Things." *Social Studies of Science* 41 (1): 85–106.
———. 2017. *Matters of Care: Speculative Ethics in More Than Human Worlds*. PostHumanities (Paperback) Series. Minneapolis: University of Minnesota Press.
Purdy, J. 2015. *After Nature: A Politics for the Anthropocene*. Harvard University Press.
Quintero-Galvis, Julian F., Rocío Paleo-López, Jaiber J. Solano-Iguaran, María Josefina Poupin, Thomas Ledger, Juan Diego Gaitan-Espitia, Andrzej Antoł, Michael Travisano, and Roberto F. Nespolo. 2018. "Exploring the Evolution of Multicellularity in Saccharomyces Cerevisiae under Bacteria Environment: An Experimental Phylogenetics Approach." *Ecology and Evolution* 8 (9): 4619–30. https://doi.org/10.1002/ece3.3979.
Rao, Hayagreeva, Philippe Monin, and Rodolphe Durand. 2005. "Border Crossing: Bricolage and the Erosion of Categorical Boundaries in French Gastronomy." *American Sociological Association* 70 (6): 968–91.
Ray, Krishnendu. 2018. "Culinary Difference Makes a Difference." In *You And I Eat The Same*, 151–159. New York: Artisan Books.
Reade, Benedict, Justine de Valicourt, and Josh Evans. 2015. "Fermentation Art and Science at the Nordic Food Lab." In *The Routledge Handbook of Sustainable Food and Gastronomy*, 228–42. https://doi.org/10.4324/9780203795699.
Reardon, Jenny. 2001. "The Human Genome Diversity Project: A Case Study in Coproduction." *Social Studies of Science* 31 (3): 357–88.
Reckem, Emiel Van, Wim Geeraerts, Christina Charmpi, David Van der Veken, Luc De Vuyst, and Frédéric Leroy. 2019. "Exploring the Link Between the Geographical Origin of European Fermented Foods and the Diversity of Their Bacterial Communities: The Case of Fermented Meats." *Frontiers in Microbiology* 10 (October): 1–11. https://doi.org/10.3389/fmicb.2019.02302.
Redzepi, René. 2010. *Noma: Time and Place in Nordic Cuisine*. London and New York: Phaidon Press.
———. 2014a. *Noma: A Work in Progress: Journal*. London and New York: Phaidon Press.
———. 2014b. *Noma: A Work in Progress: Recipes*. London and New York: Phaidon Press.
Redzepi, René, and Claus Meyer. 2006. *Noma: Nordisk Mad*. København: Politiken Forlag.
Redzepi, René, and David Zilber. 2018. *The Noma Guide to Fermentation*. New York: Artisan.
Reese, Aspen T., Anne A. Madden, Marie Joossens, Guylaine Lacaze, and Robert R. Dunn. 2020. "Influences of Ingredients and Bakers on the Bacteria and Fungi in Sourdough Starters and Bread." *MSphere* 5 (1): 1–15. https://doi.org/10.1128/msphere.00950-19.
Rheinberger, Hans-Jörg. 1997. *Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube*. Writing Science. Stanford, CA: Stanford University Press.
Riel Müller, Anders, and Jonatan Leer. 2018. "Mainstreaming New Nordic Cuisine?: Alternative Food Politics and the Problems of Scale Jumping and Scale Bending." In *Alternative Food Politics: From the Margins to the Mainstream*. Abingdon: Routledge.
Risvik, Einar, Claus Meyer, Eivind Hålien, and Patrik Edman. 2008. *New Nordic Cuisine*. Copenhagen, Denmark: Nordic Council of Ministers.
Robertson, Roland. 1995. "Glocalization: Time–Space and Homogeneity–Heterogeneity." In *Global*

Modernities, edited by Mike Featherstone, Scott Lash, and Roland Robertson, 25–44. London: SAGE.
Roe, Emma J. 2006a. "Material Connectivity, the Immaterial and the Aesthetic of Eating Practices: An Argument for How Genetically Modified Foodstuff Becomes Inedible." *Environment and Planning A* 38 (3): 465–81. https://doi.org/10.1068/a3835.
———. 2006b. "Things Becoming Food and the Embodied, Material Practices of an Organic Food Consumer." *Sociologia Ruralis* 46 (2): 104–21. https://doi.org/10.1111/j.1467-9523.2006.00402.x.
Roe, Emma J., and Michael Buser. 2016. "Becoming Ecological Citizens: Connecting People through Performance Art, Food Matter and Practices." *Cultural Geographies* 23 (4): 581–98. https://doi.org/10.1177/1474474015624243.
Roe, Emma J., and Beth Greenhough. 2014. "Experimental Partnering: Interpreting Improvisatory Habits in the Research Field." *International Journal of Social Research Methodology* 17 (1): 45–57. https://doi.org/10.1080/13645579.2014.854014.
Rokas, Antonis. 2009. "The Effect of Domestication on the Fungal Proteome." *Trends in Genetics* 25 (2): 60–63. https://doi.org/10.1016/j.tig.2008.11.003.
Rolls, E T, and A W L de Waal. 1985. "Long-Term Sensory-Specific Satiety: Evidence from an Ethiopian Refugee Camp." *Physiology & Behavior* 34 (6): 1017–20. https://doi.org/10.1016/0031-9384(85)90032-0.
Ronell, A. 2003. "Proving Grounds: On Nietzsche and the Test Drive." *Modern Language Notes* 118: 653–669.
Roosth, Sophia. 2010. "Crafting Life: A Sensory Ethnography of Fabricated Biologies." MIT.
———. 2013. "Of Foams and Formalisms: Scientific Expertise and Craft Practice in Molecular Gastronomy." *American Anthropologist* 115 (1): 4–16. https://doi.org/10.1111/j.1548-1433.2012.01531.x.
Rose, Deborah Bird. 2004. *Reports from a Wild Country: Ethics for Decolonisation*. Sydney, NSW: University of NSW Press.
Rose, Gillian. 1993. *Feminism and Geography: The Limits of Geographical Knowledge*. Ebook Central. Cambridge, England: Polity Press.
———. 1997. "Situating Knowledges: Positionality, Reflexivities and Other Tactics." *Progress in Human Geography* 21 (3): 305–20. https://doi.org/10.1191/030913297673302122.
———. 2011. *Visual Methodologies: An Introduction to Researching with Visual Materials*. 3rd ed. Thousand Oaks, CA: SAGE Publications.
Russell, Edmund. 2011. *Evolutionary History: Uniting History and Biology to Understand Life on Earth*. New York: Cambridge University Press. https://doi.org/10.1017/CBO9780511974267.
Russell, Nerissa. 2002. "The Wild Side of Animal Domestication." *Society & Animals* 10 (3): 285–302. https://doi.org/10.1163/156853002320770083.
Sage, Colin. 2011. *Environment and Food*. Routledge Introductions to Environment: Environment and Society Texts. Abingdon: Taylor & Francis.
Sangbae, Jee. 2018. "Food Appropriation. Why Do You Need to Take It Seriously?" Medium. 2018. https://medium.com/gbc-college-english-lemonade/food-appropriation-why-do-you-need-to-take-it-seriously-83d91321108.
Sarran, Michel, and Géraldine Pellé. 2017. *Michel Sarran - Itinéraires de Goûts*. Paris: Glénat.
Satsuka, Shiho. 2011. "Eating Well With Others / Eating Others Well." *Kroeber Anthropological Society Journal* 99/100 (1): 134–8.
Sauer, Carl Ortwin. 1956. *The Agency of Man on the Earth*. Chicago: University of Chicago Press.
———. 1969. *Agricultural Origins and Dispersals: The Domestication of Animals and Foodstuffs*. 2d ed. Cambridge: M.I.T. Press.
Saussure, Ferdinand de. (1916) 1986. *Course in General Linguistics*. Edited by Charles Bally and Albert Sechehaye. Chicago: Open Court.
Schoustra, S. E., A. J. M. Debets, M. Slakhorst, and R. F. Hoekstra. 2006. "Reducing the Cost of Resistance; Experimental Evolution in the Filamentous Fungus Aspergillus Nidulans."

Journal of Evolutionary Biology 19 (4): 1115–27. https://doi.org/10.1111/j.1420-9101.2006.01102.x.
———. 2007. "Mitotic Recombination Accelerates Adaptation in the Fungus Aspergillus Nidulans." *PLoS Genetics* 3 (4): 648–53. https://doi.org/10.1371/journal.pgen.0030068.
Schubotz, Dirk. 2019. *Participatory Research: Why and How to Involve People in Research*. London: SAGE Publications.
Scollon, Ron, and Suzie Wong Scollon. 2005. "Fast English, Slow Food, and Intercultural Exchanges: Social Problems and Problems for Discourse Analysis." In *Identity, Community, Discourse: English in Intercultural Settings*, edited by G Cortese and A Duszak. Linguistic Insights : Studies in Language and Communication. Bern: Peter Lang.
Scott, James. 2011. "Four Domestications: Fire, Plants, Animals, and... Us." *The Tanner Lectures on Human Values*.
Scott, James C. 2017. *Against the Grain: A Deep History of the Earliest States*. Yale Agrarian Studies. New Haven: Yale University Press.
Secord, Anne. 1994. "Science in the Pub: Artisan Botanists in Early Nineteenth-Century Lancashire." *History of Science* 32 (3): 269–315.
Seeley, Thomas D. 2010. *Honeybee Democracy*. Princeton, NJ: Princeton University Press.
Sender, Ron, Shai Fuchs, and Ron Milo. 2016. "Revised Estimates for the Number of Human and Bacteria Cells in the Body." *PLoS Biology* 14 (8): 036103. https://doi.org/10.1101/036103.
Sennett, Richard. (1997) 2009. *The Craftsman*. London: Penguin Books Limited.
Serlin, David. 2017. "Science and the Senses: Deviation." Society for Cultural Anthropology. 2017.
Sexton, AE, T Garnett, and Jamie Lorimer. 2021. "Vegan Food Geographies and the Rise of Big Veganism." *Progress in Human Geography*.
Sexton, Alexandra E. 2018. "Eating for the Post-Anthropocene: Alternative Proteins and the Biopolitics of Edibility." *Transactions of the Institute of British Geographers* 43 (4): 586–600. https://doi.org/10.1111/tran.12253.
Sexton, Alexandra E, Tara Garnett, and Jamie Lorimer. 2019. "Framing the Future of Food: The Contested Promises of Alternative Proteins." *Environment and Planning E: Nature and Space* 2 (1): 47–72. https://doi.org/10.1177/2514848619827009.
Shank, Elizabeth A. 2018. "Considering the Lives of Microbes in Microbial Communities." *MSystems* 3 (2): 3–6. https://doi.org/10.1128/msystems.00155-17.
Shapin, Steven. 1988. "The House of Experiment in Seventeenth-Century England." *Isis* 79 (3): 373–404. https://doi.org/10.1086/354773.
———. 1998. "Placing the View from Nowhere: Historical and Sociological Problems in the Location of Science." *Transactions of the Institute of British Geographers* 23 (1): 5–12. https://doi.org/10.1111/j.0020-2754.1998.00005.x.
———. 2012a. "The Sciences of Subjectivity." *Social Studies of Science* 42 (2): 170–84. https://doi.org/10.1177/0306312711435375.
———. 2012b. "The Tastes of Wine: Towards a Cultural History." *Rivista Di Estetica* 51 (51): 49–94. https://doi.org/10.4000/estetica.1395.
———. 2016. "A Taste of Science: Making the Subjective Objective in the California Wine World." *Social Studies of Science* 46 (3): 436–60. https://doi.org/10.1177/0306312716651346.
Shapin, Steven, and Simon Schaffer. 1985. *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*. Princeton, NJ: Princeton University Press.
Shapiro, Nicholas, and Eben Kirksey. 2017. "Chemo-Ethnography: An Introduction." *Cultural Anthropology* 32 (4): 481–93. https://doi.org/10.14506/ca32.4.01.
Sheldrake, Merlin. 2020. *Entangled Life: How Fungi Make Our Worlds, Change Our Minds & Shape Our Futures*. London: Penguin Random House LLC.
Shepherd, Gordon. 2013. *Neurogastronomy: How the Brain Creates Flavor and Why It Matters*. New York: Columbia University Press.
Shi, Peng, and Jianzhi Zhang. 2006. "Contrasting Modes of Evolution between Vertebrate Sweet/Umami Receptor Genes and Bitter Receptor Genes." *Molecular Biology and Evolution*

23 (2): 292–300. https://doi.org/10.1093/molbev/msj028.
Shiva, V. 1991. *The Violence of Green Revolution: Third World Agriculture, Ecology and Politics*. London: Zed Books.
———. 2001. *Stolen Harvest: The Hijacking of the Global Food Supply*. Hijacking of the Global Food Supply. London: Zed.
Shotwell, Alexis. 2016. *Against Purity: Living Ethically in Compromised Times*. Minneapolis, MN: University of Minnesota Press.
Shurtleff, William, and Akiko Aoyagi. 1983. *The Book of Miso*. Berkeley: Ten Speed Press. https://doi.org/10.1017/S0003598X00017725.
———. 2012. *History of Koji*. Lafayette, CA: Soyinfo Center.
Sicard, Delphine, and Jean Luc Legras. 2011. "Bread, Beer and Wine: Yeast Domestication in the Saccharomyces Sensu Stricto Complex." *Comptes Rendus - Biologies* 334 (3): 229–36. https://doi.org/10.1016/j.crvi.2010.12.016.
Simberloff, Daniel. 2003. "Confronting Introduced Species: A Form of Xenophobia?" *Biological Invasions* 5 (3): 179–92. https://doi.org/10.1023/A:1026164419010.
Sirén, Kimmo, Sarah Siu Tze Mak, Ulrich Fischer, Lars Hestbjerg Hansen, and M. Thomas P. Gilbert. 2019. "Multi-Omics and Potential Applications in Wine Production." *Current Opinion in Biotechnology* 56: 172–78. https://doi.org/10.1016/j.copbio.2018.11.014.
Sivamaruthi, Bhagavathi Sundaram, Periyanaina Kesika, and Chaiyavat Chaiyasut. 2018. "Impact of Fermented Foods on Human Cognitive Function—A Review of Outcome of Clinical Trials." *Scientia Pharmaceutica* 86 (2): 1–6. https://doi.org/10.3390/scipharm86020022.
Skougaard, Mette. 1984. *Bondens Køkken: Madlavning Og Måltider i 1800-Tallets Landbosamfund*. København: Nationalmuseet.
Slavich, Barbara, Silviya Svejenova, M. Pilar Opazo, and Gerardo Patriotta. 2019. "Politics of Meaning in Categorizing Innovation: How Chefs Advanced Molecular Gastronomy by Resisting the Label." *Organization Studies*. https://doi.org/10.1177/0170840619835268.
Smith, A, and J B MacKinnon. 2009. *The 100-Mile Diet: A Year of Local Eating*. Toronto: Random House of Canada.
Smith, Bruce D. 2001a. "Documenting Plant Domestication: The Consilience of Biological and Archaeological Approaches." *Proceedings of the National Academy of Sciences* 98 (4): 1324–26.
———. 2001b. "Low-Level Food Production." *Journal of Archaeological Research* 9 (1): 1–43. https://doi.org/10.1023/A:1009436110049.
Smith, F M. 2009. "Translation." In *International Encyclopedia of Human Geography*, 361–67.
Smithers, Gregory D. 2015. "Beyond the 'Ecological Indian': Environmental Politics and Traditional Ecological Knowledge in Modern North America." *Environmental History*. https://doi.org/10.1093/envhis/emu125.
Spackman, Christy. 2017. "Formulating Citizenship: The Microbiopolitics of the Malfunctioning Functional Beverage." *BioSocieties*. https://doi.org/10.1057/s41292-017-0051-6.
Spackman, Christy, and Gary A. Burlingame. 2018. "Sensory Politics: The Tug-of-War between Potability and Palatability in Municipal Water Production." *Social Studies of Science* 48 (3): 350–71. https://doi.org/10.1177/0306312718778358.
Spackman, Christy, and Marianne DeLaet. 2017a. "Science and the Senses: Integration." Society for Cultural Anthropology. 2017.
———. 2017b. "Science and the Senses." Society for Cultural Anthropology. 2017.
Spackman, Christy, and Jacob Lahne. 2019. "Sensory Labor: Considering the Work of Taste in the Food System." *Food, Culture and Society* 22 (2): 142–51. https://doi.org/10.1080/15528014.2019.1573039.
Spence, Charles. 2017. *Gastrophysics: The New Science of Eating*. London: Penguin Books Limited.
Spence, Charles, Betina Piqueras-Fiszman, and Heston Blumenthal. 2014. *The Perfect Meal: The Multisensory Science of Food and Dining*. EBL-Schweitzer. New York: Wiley.
Spence, Mark David. 1999. *Dispossessing the Wilderness: Indian Removal and the Making of the*

National Parks. Oxford and New York: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195142433.001.0001.
Stanier, R. Y., and C. B. van Niel. 1962. "The Concept of a Bacterium." *Archiv Für Mikrobiologie* 42 (1): 17–35. https://doi.org/10.1007/BF00425185.
Star, Susan Leigh, and James R Griesemer. 1989. "Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39." *Social Studies of Science* 19 (3): 387–420.
Steensels, Jan, Brigida Gallone, Karin Voordeckers, and Kevin J. Verstrepen. 2019. "Domestication of Industrial Microbes." *Current Biology* 29 (10): R381–93. https://doi.org/10.1016/j.cub.2019.04.025.
Stefanoudis, Paris V., Wilfredo Y. Licuanan, Tiffany H. Morrison, Sheena Talma, Joeli Veitayaki, and Lucy C. Woodall. 2021. "Turning the Tide of Parachute Science." *Current Biology* 31 (4): R184–85. https://doi.org/10.1016/j.cub.2021.01.029.
Steinkraus, Keith. 1995. *Handbook of Indigenous Fermented Foods*. 2nd Editio. Food Science and Technology. Boca Raton: Taylor & Francis.
———. 2004. *Industrialization of Indigenous Fermented Foods*. Food Science and Technology. Boca Raton: Taylor & Francis.
Stengers, Isabelle. 1997. *Power and Invention: Situating Science*. Translated by Paul Bains. Theory out of Bounds. Minneapolis; London: University of Minnesota Press.
———. (1993) 2000. "The Invention of Modern Science," 185. https://doi.org/10.2307/3089544.
———. 2002. *Penser Avec Whitehead*. Paris: Gallimard.
———. 2005. "Introductory Notes on an Ecology of Practices." *Cultural Studies Review* 11 (1): 183–196. https://doi.org/10.1055/s-0028-1112381.
———. 2008. "A Constructivist Reading of Process and Reality." *Theory, Culture & Society* 25 (4): 91–110. https://doi.org/10.1177/0263276408091985.
———. (1997) 2010. *Cosmopolitics*. Translated by Robert Bononno. Vol. I. Cosmopolitics. Minneapolis; London: University of Minnesota Press.
Strathern, M. 1992. *After Nature: English Kinship in the Late Twentieth Century*. Lewis Henry Morgan Lectures. Cambridge: Cambridge University Press.
Strohl, Matthew. 2019. "On Culinary Authenticity." *Journal of Aesthetics and Art Criticism* 77 (2): 157–67. https://doi.org/10.1111/jaac.12631.
Sutton, David E. 2010. "Food and the Senses." *Annual Review of Anthropology* 39 (1): 209–23. https://doi.org/10.1146/annurev.anthro.012809.104957.
Swanson, Heather Anne. 2017. "Methods for Multispecies Anthropology: Thinking with Salmon Otoliths and Scales." *Social Analysis* 61 (2): 81–99. https://doi.org/10.3167/sa.2017.610206.
Swanson, Heather Anne, Nils Bubandt, and Anna L. Tsing. 2015. "Less than One but More than Many: Anthropocene as Science Fiction and Scholarship-in-the-Making." *Environment and Society: Advances in Research* 6 (1): 149–66. https://doi.org/10.3167/ares.2015.060109.
Swanson, Heather Anne, John Law, and Marianne E. Lien. 2018. "Modes of Naturing: Or Stories of Salmon." *The SAGE Handbook of Nature: Three Volume Set*, no. March: 868–90. https://doi.org/10.4135/9781473983007.n46.
Swanson, Heather Anne, Marianne Elisabeth Lien, and Gro B. Ween, eds. 2018. *Domestication Gone Wild: Politics and Practices of Multispecies Relations*. Durham, NC: Duke University Press.
Swinbank, Vicki A. 2002. "The Sexual Politics of Cooking: A Feminist Analysis of Culinary Hierarchy in Western Culture." *Journal of Historical Sociology* 15 (4): 464–94. https://doi.org/10.1111/1467-6443.00188.
Szymanski, Erika Amethyst. 2018. "What Is the Terroir of Synthetic Yeast?" *Environmental Humanities* 10 (1): 40–62. https://doi.org/10.1215/22011919-4385462.
———. 2020. "Constructing Science in Public: Framing Synthetic Yeast in News Media." In *Exploring Science Communication: A Science and Technology Studies Approach*, edited by Ulrike Felt and Sarah R. Davies, 150–169. Thousand Oaks, CA: SAGE.

https://doi.org/10.4324/9781315270050-20.
Szymanski, Erika, and Jane Calvert. 2018. "Designing with Living Systems in the Synthetic Yeast Project." *Nature Communications* 9 (1). https://doi.org/10.1038/s41467-018-05332-z.
TallBear, Kim. 2012. "Beyond the Life / Not-Life Binary: A Feminist-Indigenous Reading of Cryopreservation, Interspecies Thinking, and the New Materialisms."
———. 2013. *Native American DNA: Tribal Belonging and the False Promise of Genetic Science*. Minneapolis, MN: University of Minnesota Press.
Tamang, Jyoti P, Koichi Watanabe, and Wilhelm H Holzapfel. 2016. "Review: Diversity of Microorganisms in Global Fermented Foods and Beverages." *Frontiers in Microbiology* 7 (March). https://doi.org/10.3389/fmicb.2016.00377.
Tan, Vaughn. 2020. *The Uncertainty Mindset: Innovation Insights from the Frontiers of Food*. New York: Columbia University Press.
Tanaka, Yasushi, Jun Watanabe, and Yoshinobu Mogi. 2012. "Monitoring of the Microbial Communities Involved in the Soy Sauce Manufacturing Process by PCR-Denaturing Gradient Gel Electrophoresis." *Food Microbiology* 31 (1): 100–106. https://doi.org/10.1016/j.fm.2012.02.005.
Teil, Geneviève, and Antoine Hennion. 2002. "Discovering Quality or Performing Taste? A Sociology of the Amateur." In *Qualities of Food*, 19–37. Manchester: Manchester University Press. https://doi.org/10.1017/CBO9781107415324.004.
Terrell, John Edward, John P Hart, Sibel Barut, Nicoletta Cellinese, Antonio Curet, Tim Denham, Chapurukha M Kusimba, et al. 2003. "Domesticated Landscapes: The Subsistence Ecology of Plant and Animal Domestication." *Journal of Archaeological Method and Theory* 10 (4): 323–68. https://doi.org/10.1023/B:JARM.0000005510.54214.57.
Theis, Kevin R, Nolwenn M Dheilly, Jonathan L Klassen, Robert M. Brucker, John F. Baines, Thomas C. G. Bosch, John F. Cryan, et al. 2016. "Getting the Hologenome Concept Right: An Eco-Evolutionary Framework for Hosts and Their Microbiomes." *MSystems* 1 (2): e00028-16. https://doi.org/10.1128/mSystems.00028-16.
This, Hervé. 2006. *Molecular Gastronomy: Exploring the Science of Flavor*. Arts and Traditions of the Table Perspectives on Culinary History. New York: Columbia University Press.
Thomas, C D. 2017. *Inheritors of the Earth: How Nature Is Thriving in an Age of Extinction*. London: Allen Lane.
Thompson, Charis. 2005. *Making Parents: The Ontological Choreography of Reproductive Technologies*. EBSCO Ebook Academic Collection. Cambridge MA: MIT Press.
Thrift, Nigel. 2000. "Non-Representational Theory." Edited by R.J. Johnston, D. Gregory, G. Pratt, and M. Watts. *The Dictionary of Human Geography*. Oxford: Blackwell Publishing Ltd.
———. 2003. "All Nose." In *Handbook of Cultural Geography*, edited by Kay Anderson, Mona Domosh, Steve Pile, and Nigel Thrift, 9–14. London; Thousand Oaks; New Delhi: SAGE.
———. 2004. "Intensities of Feeling: Towards a Spatial Politics of Affect." *Geografiska Annaler* 86 (1): 57–78.
———. 2006. "Space." *Theory, Culture & Society* 23 (3): 139–46. https://doi.org/10.1177/0263276406063780.
———. 2007. *Non-Representational Theory: Space, Politics, Affect*. London: Routledge.
Thrift, Nigel, and John David Dewsbury. 2000. "Dead Geographies - And How to Make Them Live." *Environment and Planning D: Society and Space* 18 (4): 411–32. https://doi.org/10.1068/d1804ed.
Todd, Zoe. 2016. "An Indigenous Feminist's Take On The Ontological Turn: 'Ontology' Is Just Another Word For Colonialism." *Journal of Historical Sociology* 29 (1): 4–22. https://doi.org/10.1111/johs.12124.
Toju, Hirokazu, Akifumi S. Tanabe, Satoshi Yamamoto, and Hirotoshi Sato. 2012. "High-Coverage ITS Primers for the DNA-Based Identification of Ascomycetes and Basidiomycetes in Environmental Samples." *PLoS ONE* 7 (7). https://doi.org/10.1371/journal.pone.0040863.
Trubek, Amy B. 2004. "Incorporating Terroir: L'Affaire Mondavi Reconsidered." *Gastronomica:*

The Journal of Critical Food Studies 4 (3): 90–99.
———. 2008. *The Taste of Place: A Cultural Journey into Terroir*. California Studies in Food and Culture. Berkeley, CA: University of California Press.
Trubek, Amy B., and Sarah Bowen. 2008. "Creating the Taste of Place in the United States: Can We Learn from the French?" *GeoJournal* 73 (1): 23–30. https://doi.org/10.1007/s10708-008-9175-3.
Tsing, Anna L. 2010. "Arts of Inclusion, or How to Love a Mushroom." *Australian Humanities Review*, no. 50: 5–21. https://doi.org/10.1353/man.2010.0000.
———. 2012. "Unruly Edges: Mushrooms as Companion Species." *Environmental Humanities* 1 (November): 141–54.
———. 2017. "The Buck, the Bull, and the Dream of the Stag: Some Unexpected Weeds of the Anthropocene." In *Suomen Antropologi*, 42:3–21.
Tsing, Anna Lowenhaupt. 2014. "Strathern beyond the Human: Testimony of a Spore." *Theory, Culture & Society* 31 (3): 221–41. https://doi.org/10.1177/0263276413509114.
———. 2015. *The Mushroom at the End of the World: On the Possibility of Life in Capitalist Ruins*. Princeton: Princeton University Press.
———. 2017. "A Threat to Holocene Resurgence Is a Threat to Livability." In *The Anthropology of Sustainability*, edited by Marc BrightmanJerome Lewis, 51–65. New York: Palgrave Macmillan. https://doi.org/10.1057/978-1-137-56636-2.
———. 2018. "Nine Provocations for the Study of Domestication." In *Domestication Gone Wild: Politics and Practices of Multispecies Relations*, edited by Heather Anne Swanson, Marianne Elisabeth Lien, and Gro B. Ween. Durham: Duke University Press.
Tsing, Anna Lowenhaupt, Andrew S. Mathews, and Nils Bubandt. 2019. "Patchy Anthropocene: Landscape Structure, Multispecies History, and the Retooling of Anthropology: An Introduction to Supplement 20." *Current Anthropology* 60 (S20): S186–97. https://doi.org/10.1086/703391.
Tsing, Anna, Heather Swanson, Elaine Gan, and Nils Bubandt, eds. 2017. *Arts of Living on a Damaged Planet: Ghosts and Monsters of the Anthropocene*. Minneapolis, MN: University of Minnesota Press. https://doi.org/10.1080/14688417.2019.1586149.
Tuck, Eve, and K. Wayne Yang. 2012. "Decolonization Is Not a Metaphor." *Decolonization: Indigeneity, Education & Society* 1 (1): 1–40.
Turner, Nancy J. 1999. "'Time to Burn': Traditional Use of Fire to Enhance Resource Production by Aboriginal Peoples in British Columbia." In *Indians, Fire, and the Land in the Pacific Northwest*, edited by Robert Boyd, 185–218. Corvallis, Oregon: Oregon State University Press.
Uexküll, Jakob von. (1934) 2010. *A Foray Into the Worlds of Animals and Humans: With a Theory of Meaning*. Posthumanities. Minneapolis; London: University of Minnesota Press.
Ulloa, Ana María, Josep Roca, and Hèloïse Vilaseca. 2017. "From Sensory Capacities to Sensible Skills: Experimenting with El Celler de Can Roca." *Gastronomica* 17 (2): 26–38. https://doi.org/10.1525/gfc.2017.17.2.26.
Ulmer, Simone. 2016. "Earth's Magnetic Field Under the 'Simulation Magnifying Glass.'" Swiss National Supercomputing Centre. 2016. https://www.cscs.ch/science/earth-env-science/2016/earths-magnetic-field-under-the-simulation-magnifying-glass/.
USDL. 2021. "Child Labor in the Production of Cocoa." 2021. https://www.dol.gov/agencies/ilab/our-work/child-forced-labor-trafficking/child-labor-cocoa.
Vega, C, J Ubbink, and E van der Linden. 2012. *The Kitchen as Laboratory: Reflections on the Science of Food and Cooking*. Arts and Traditions of the Table: Perspectives on Culinary History. New York: Columbia University Press.
Velasquez-Manoff, M. 2013. *An Epidemic of Absence: A New Way of Understanding Allergies and Autoimmune Diseases*. New York: Scribner.
Venuti, Lawrence. 2004. *The Translation Studies Reader*. New York: Routledge.
Verité. 2012. "Research on Indicators of Forced Labor in the Supply Chain of Coffee in

Guatemala.” Amherst, MA. https://www.verite.org/wp-content/uploads/2016/11/Research-on-Indicators-of-Forced-Labor-in-the-Guatemala-Coffee-Sector__9.16.pdf.
Verran, H. 2001. *Science and an African Logic*. Science and an African Logic. Chicago: University of Chicago Press.
Viana, Félix. 2011. “Chemosensory Properties of the Trigeminal System.” *ACS Chemical Neuroscience* 2 (1): 38–50. https://doi.org/10.1021/cn100102c.
Viveiros de Castro, Eduardo. 1998. “Cosmological Deixis and Amerindian Perspectivism.” *The Journal of the Royal Anthropological Institute* 4 (3): 469–88.
Vontrobová, Eva, Petra Kubizniakova, Jaromír Fiala, Jiří Sochor, and Dagmar Matoulková. 2019. “Autochthonous Yeasts as One of the Tools to Produce Wines by Original Technologies.” *Kvasny Prumysl* 65 (1): 38–45. https://doi.org/10.18832/kp2019.65.38.
Wada, Ryuta, Jun Ichi Maruyama, Haruka Yamaguchi, Nanase Yamamoto, Yutaka Wagu, Mathieu Paoletti, David B. Archer, Paul S. Dyer, and Katsuhiko Kitamoto. 2012. “Presence and Functionality of Mating Type Genes in the Supposedly Asexual Filamentous Fungus Aspergillus Oryzae.” *Applied and Environmental Microbiology* 78 (8): 2819–29. https://doi.org/10.1128/AEM.07034-11.
Walsh, Michael James, and Stephanie Alice Baker. 2020. “Clean Eating and Instagram: Purity, Defilement, and the Idealization of Food.” *Food, Culture and Society* 23 (5): 570–88. https://doi.org/10.1080/15528014.2020.1806636.
Warren, Charles R. 2007. “Perspectives on the ‘alien’ versus ‘Native’ Species Debate: A Critique of Concepts, Language and Practice.” *Progress in Human Geography* 31 (4): 427–46. https://doi.org/10.1177/0309132507079499.
Wasserstein, Ronald L., Allen L. Schirm, and Nicole A. Lazar. 2019. “Moving to a World Beyond ‘p < 0.05.’” *American Statistician* 73 (S1): 1–19. https://doi.org/10.1080/00031305.2019.1583913.
Watarai, Naoki, Nozomi Yamamoto, Kazunori Sawada, and Takuji Yamada. 2019. “Evolution of Aspergillus Oryzae before and after Domestication Inferred by Large-Scale Comparative Genomic Analysis.” *DNA Research : An International Journal for Rapid Publication of Reports on Genes and Genomes* 26 (6): 465–472. https://doi.org/10.1093/dnares/dsz024.
Watson, Annette, and Orville H. Huntington. 2008. “They’re Here—I Can Feel Them: The Epistemic Spaces of Indigenous and Western Knowledges.” *Social and Cultural Geography* 9 (3): 257–81. https://doi.org/10.1080/14649360801990488.
Watson, Duika L. Burges, and Chris M. Cooper. 2019. “Visceral Geographic Insight through a ‘Source to Senses’ Approach to Food Flavour.” *Progress in Human Geography*, 1–25. https://doi.org/10.1177/0309132519890913.
Whatmore, Sarah. 2002. *Hybrid Geographies: Natures, Cultures, Spaces*. London: SAGE. https://doi.org/10.1017/CBO9781107415324.004.
———. 2006. “Materialist Returns: Practising Cultural Geography in and for a More-than-Human World.” *Cultural Geographies* 13 (4): 600–609. https://doi.org/10.1191/1474474006cgj377oa.
Whewell, William. 1840. *The Philosophy of the Inductive Sciences*. London: John W. Parker.
White, T.J., T. Bruns, S. Lee, and J. Taylor. 1990. “Amplification and Direct Sequencing of Fungal Ribosomal RNA Genes for Phylogenetics.” In *PCR Protocols: A Guide to Methods and Applications*, edited by M.A. Innis, D.H. Gelfand, J.J. Sninsky, and T.J. White, 315–22. San Diego, CA: Academic Press. https://doi.org/10.1016/b978-0-12-372180-8.50042-1.
Williams, Montrischa M., and Casey E. George-Jackson. 2014. “Using and Doing Science: Gender, Self-Efficacy, and Science Identity of Undergraduate Students in Stem.” *Journal of Women and Minorities in Science and Engineering* 20 (2): 99–126. https://doi.org/10.1615/JWomenMinorScienEng.2014004477.
Williams, Stacy J. 2014. “A Feminist Guide to Cooking.” *Contexts* 13 (3): 59–61. https://doi.org/10.1177/1536504214545763.
Wilson, Bee. 2004. *The Hive*. London: John Murray.
Wilson, E O. 1999. *Consilience: The Unity of Knowledge*. A Borzoi Book. New York: Vintage Books.
Wittgenstein, Ludwig. 1922. *Tractatus Logico-Philosophicus: Logisch-Philosophische Abhandlung*.

London: Kegan Paul.
———. 1969. *Notebooks 1914-1916*. Translated by G. E. M. Anscombe. Oxford: Basil Blackwell.
Wolfe, Benjamin E., Julie E. Button, Marcela Santarelli, and Rachel J. Dutton. 2014. "Cheese Rind Communities Provide Tractable Systems for in Situ and in Vitro Studies of Microbial Diversity." *Cell* 158 (2): 422–33. https://doi.org/10.1016/j.cell.2014.05.041.
Wolfe, Benjamin E., and Rachel J. Dutton. 2015. "Fermented Foods as Experimentally Tractable Microbial Ecosystems." *Cell* 161 (1): 49–55. https://doi.org/10.1016/j.cell.2015.02.034.
Wolfe, Cary. 2009. *What Is Posthumanism?* Posthumanities Series. Minneapolis, MN: University of Minnesota Press.
Woolgar, Steve. 1981a. "Critique and Criticism: Two Readings of Ethnomethodology." *Social Studies of Science* 11 (4): 504–14. https://doi.org/10.1177/030631278101100406.
———. 1981b. "Interests and Explanation in the Social Study of Science." *Social Studies of Science* 11 (3): 365–94. https://doi.org/10.1177/030631278101100304.
Wrangham, Richard W., James Holland Jones, Greg Laden, David Pilbeam, and N. Conklin-Brittain. 1999. "The Raw and the Stolen: Cooking and the Ecology of Human Origins." *Current Anthropology* 40 (5): 567–94. https://doi.org/10.1086/300083.
Wynne, Brian. 1992. "Misunderstood Misunderstanding: Social Identities and Public Uptake of Science." *Public Understanding of Science* 1 (3): 281–304. https://doi.org/10.1088/0963-6625/1/3/004.
———. 2003. "Seasick on the Third Wave? Subverting the Hegemony of Propositionalism: Response to Collins & Evans (2002)." *Social Studies of Science* 33 (3): 401–17.
———. 2006. "Public Engagement as a Means of Restoring Public Trust in Science - Hitting the Notes, but Missing the Music?" *Community Genetics* 9 (3): 211–20. https://doi.org/10.1159/000092659.
Yamin-Pasternak, Sveta, Andrew Kliskey, Lilian Alessa, Igor Pasternak, and Peter Schweitzer. 2014. "The Rotten Renaissance in the Bering Strait." *Current Anthropology* 55 (5): 619–46. https://doi.org/10.1086/678305.
Yan, Yin Zhuo, Yu Lin Qian, Feng Di Ji, Jing Yu Chen, and Bei Zhong Han. 2013. "Microbial Composition during Chinese Soy Sauce Koji-Making Based on Culture Dependent and Independent Methods." *Food Microbiology* 34 (1): 189–95. https://doi.org/10.1016/j.fm.2012.12.009.
Yang, Juan, Weidong Bai, Xiaofang Zeng, and Chun Cui. 2019. "Gamma Glutamyl Peptides: The Food Source, Enzymatic Synthesis, Kokumi-Active and the Potential Functional Properties – A Review." *Trends in Food Science and Technology* 91 (May): 339–46. https://doi.org/10.1016/j.tifs.2019.07.022.
Ye, Mao, Ying Lin, Wenbiao Huang, and Jinhua Wei. 2014. "Comparative Analysis of Aspergillus Oryzae with Normal and Abnormal Color Conidia." *Indian Journal of Microbiology* 54 (1): 108–10. https://doi.org/10.1007/s12088-013-0416-x.
Ying, Chris, René Redzepi, and MAD. 2018. *You and I Eat the Same*. New York: Artisan Books.
Yong, Ed. 2016. *I Contain Multitudes: The Microbes Within Us and a Grander View of Life*. New York: Random House.
Yoshizaki, Yumiko, Hiroaki Yamato, Kazunori Takamine, Hisanori Tamaki, Kiyoshi Ito, and Yoshihiro Sameshima. 2010. "Analysis of Volatile Compounds in Shochu Koji, Sake Koji, and Steamed Rice by Gas Chromatography-Mass Spectrometry." *Journal of the Institute of Brewing* 116 (1): 49–55. https://doi.org/10.1002/j.2050-0416.2010.tb00397.x.
Young, Kenneth R. 2016. "Biogeography of the Anthropocene: Domestication." *Progress in Physical Geography* 40 (1): 161–74. https://doi.org/10.1177/0309133315598724.
Yu, Kristie B., and Elaine Y. Hsiao. 2021. "Roles for the Gut Microbiota in Regulating Neuronal Feeding Circuits." *Journal of Clinical Investigation* 131 (10). https://doi.org/10.1172/JCI143772.
Yusoff, Kathryn. 2016. "Anthropogenesis: Origins and Endings in the Anthropocene." *Theory, Culture & Society* 33 (2): 3–28. https://doi.org/10.1177/0263276415581021.

Zawadzka, Dorota, and Grzegorz Zawadzki. 2016. “Synanthropisation And Synurbisation Of Raven Corvus Corax In Poland: A Review.” *International Studies on Sparrows* 38 (1): 11–16. https://doi.org/10.1515/isspar-2015-0025.

Zeder, Melinda A. 2009. “The Neolithic Macro-(r)Evolution: Macroevolutionary Theory and the Study of Culture Change.” *Journal of Archaeological Research* 17 (1): 1–63. https://doi.org/10.1007/s10814-008-9025-3.

———. 2012a. “Pathways to Animal Domestication.” In *Biodiversity in Agriculture: Domestication, Evolution, and Sustainability*, 227–59. https://doi.org/10.1017/CBO9781139019514.013.

Zeder, Melinda A., Eve Emshwiller, Bruce D. Smith, and Daniel G. Bradley. 2006. “Documenting Domestication: The Intersection of Genetics and Archaeology.” *Trends in Genetics* 22 (3): 139–55. https://doi.org/10.1016/j.tig.2006.01.007.

Zeder, Melinda A. 2012b. “The Domestication of Animals.” *Journal of Anthropological Research* 68 (2): 161–90.

Zeuner, F E. 1963. *A History of Domesticated Animals*. New York: Harper & Row.

Zhao, Guozhong, Yunping Yao, Wei Chen, and Xiaohong Cao. 2013. “Comparison and Analysis of the Genomes of Two Aspergillus Oryzae Strains.” *Journal of Agricultural and Food Chemistry* 61 (32): 7805–9. https://doi.org/10.1021/jf400080g.

Zimmerman, Jordan. 2011. “René Redzepi Talks Life-Changing Roast Chicken, Making Denmark a ‘Spicy’ Nation.” Boston Magazine. 2011. https://www.bostonmagazine.com/restaurants/2011/10/27/rene-redzepi-talks-life-changing-roast-chicken-making-denmark-spicy-nation/.

Zimmerman, Michael E. 1995. “The Threat of Ecofascism.” *Social Theory and Practice* 21 (2): 207–38.

Zuss, Mark. 2000. “Genomics: Technics and Writing the ‘Posthuman.’” *Dialectical Anthropology* 25 (3): 255–79.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