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ACCESSING MICROBIAL LIFEWORLDS

Weird Entanglements and Strange Symbionts

ABSTRACT

Beginning with an analysis of the discovery of endosymbiosis—the finding that the mitochondria of eukaryotic cells are derived from a once free-living bacterial ancestor—this paper is concerned with the sense of weirdness that certain findings in microbiology have the capacity to evoke. However, as the story of endosymbiotic theory unfolds, it becomes evident that the weirdness of microbial life is not to be found only in the organisms' biological characteristics themselves, but also in the dynamics of how these characteristics have been successively framed and reframed in scientific discourse. In this sense I argue that the weirdness of the microbial world is to be found in its recalcitrance and difficulty to be contained. This view is further supported through reference to contemporary perspectives on the dependence of humans upon microbes that displaces relations of symbiosis in favour of a less symmetrical vision. The scale, complexity and unceasing transpositions of microbial worlds means they are constitutively withdrawn from human access. The paper concludes with a discussion of the relationships between the biological features of microbial life worlds, the onto-epistemological dynamics of our apprehension of these worlds, and the conception of the object-oriented ontology (OOO). Rather than subsuming the weirdness of microbial worlds within a generalised frame of weirdness, as gestured by OOO, I suggest that an alternative ontology—that of subtending relations—may more productively encompass human-microbe relations.

KEY WORDS: endosymbiosis, microbial life, the weird, object-oriented ontology, Anthropocene

ANTHROPOCENE WEIRDNESS

In 1917 Sigmund Freud declared he dealt another blow to the notion of human exceptionalism when, after Copernicus had decentred humanity's position in the universe and Darwin had decentred its position in relation to animals, he did so to the human with respect to itself.[2] Indeed, the 'separation' of humanity from the nonhuman realm, as well as its alleged centrality has never been more in doubt, although the compass indicating this has swung back the other way; it is again findings in biology, and particularly microbiology, that are remaking what it is to be 'human'. A host of contemporary work in the natural and social sciences is highlighting our deep links to the microbial[3] world, and our onto- and phylogenetic dependence upon a class of microscopic biological life whose existence at large has been known for only about three centuries. This reconceptualisation of what it is to be human at the embedded-material-cellular level has come at a point in time when the place of humanity within the wider planetary system is also being called into question. The 'Anthropocene' denotes that period of geological history in which the effects of human activity have clearly registered in the stratigraphic record, and human agency has reached planetary proportions.[4] The notion of the Anthropocene mixes things up, but does so in a slightly different way than the insights of Copernicus, Darwin and Freud—the Anthropocene seems to *affirm* the might and expanse of human agency, whilst simultaneously casting significant doubts on the exactitude and predictability of that agency. Additionally, this epoch signals humanity's entanglement with the wider biotic and abiotic world and raises questions about where the 'natural'

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2 With the discovery of the unconscious, Freud announced that not even our psychic lives are our own, but the product of unseen forces, and therefore the very thing separating 'Man' from the animals, his transcendental consciousness, was no longer so, but merely the tip of an iceberg of animal drives and punitive restrictions. Sigmund Freud, *A General Introduction to Psycho-Analysis (*New York: Liveright Publishing, 1965), 296.

3 'Microbial' is a rather loose term, referring to any organism that is invisible to the naked eye and must be resolved by microscopic techniques. Taxonomically, the term can refer to bacteria, fungi, archaea, protists, and even viruses. The term 'microbial' is used in this relatively loose sense throughout, except where a more specific usage is indicated.

4 The term 'Anthropocene' was first coined by Eugene Stoermer in the 1980s and popularised in conjunction with Paul Crutzen in the 2000s. It highlights that the effects of human activity have been registered in the very stratum of the Earth itself, as deposited plastics, radionuclides, and heavy metals. Humans have thus acquired geological agency, and human history has become natural history.

ends and the 'human/social/cultural' begins. Once clear distinctions between humans and nonhumans now appear to have been supported by shaky foundations, and the certainty of the very earth beneath our feet has itself been called into question.

Eco-philosopher Timothy Morton argues that there is a certain uncanniness, or an intrinsic weirdness,[5] to finding ourselves on these shaky foundations of the Anthropocene, or what he refers to as an "age of mass extinction": "Can you think of anything more uncanny," he asks,"than realising that you are in a whole new geological period, one marked by humans becoming a geophysical force on a planetary scale?"[6] In referring to the strangely familiar, or familiarly strange—the uncanny or *the unheimlich*—Morton is pointing towards how the peculiar fact of (re)cognising that we live and depend on a planet has occurred only through our disruptions of that planet.[7] However, although Morton points to the destabilising effects of the Anthropocene by using the terms weird and uncanny somewhat interchangeably, a number of other scholars sharply differentiate these two affects in their work.

For instance, through his analysis of Lovecraft's fiction, H. G. Wells' stories, and David Lynch's film (among others), Mark Fisher suggests that whilst the uncanny is "about the strange *within* the familiar, the strangely familiar, the familiar as strange," the weird, on the other hand, "brings to the familiar something which ordinarily lies beyond it."[8] According to Fisher, the weird has to do with that "which lies beyond standard perception, cognition, and experience,"[9] thus invoking a decentering of the human scale that speaks equally to the geological proportions of the Anthropocene as well as the microcosmic details of our biological existence. At the core of the affect of weirdness is also a kind of fascination for "the outside,"[10] one that may be, but is not necessarily, tied to a sense of dread and unease. The defining feature of weirdness, and its distinction from the uncanny (*unheimlich*) then is that it is "that *which does not belong*."[11] Whilst the uncanny operates through reducing phenomena to the economy of familiarity and strangeness, the weird, by contrast, is that which is impenetrably outside: "The weird . . . cannot be reconciled with the 'homely' (even as its negation)."[12] Literary theorist Roger

5 Timothy Morton, *Being Ecological* (London: Pelican, 2018), 43.

6 Morton, 5.

7 This 'recognition' has occurred primarily in Western thought. Morton speculates that human thought 'severed' itself from the planet (and what he terms the symbiotic real) with the advent of agriculture some 12000 years ago. His work is therefore (self-reflexively) positioned in relation to the Western canon which he critiques as anthropocentric.

8 Mark Fisher, *The Weird and the Eerie* (London: Repeater Books, 2016), 10.

9 Fisher, 10.

10 Fisher, 10.

11 Fisher, 10.

12 Fisher, 11 (emphasis in original).

Luckhurst offers a theoretically similar differentiation of the weird from the uncanny, arguing that "the monstrous breaches of the weird do not return us to something familiar but repressed, but instead veer away to invoke a dread that is irreducible, that cannot be reductively interpreted, translated or returned."[13] The hallmark of the weird seems to coincide with a kind of elusiveness, and in his writing on weird fiction Luckhurst is forced to circle around the weird, gesture towards it, and offer only tentative definitions. Perhaps these efforts are 'diagrams' of the weird in some way—not simple representations, but tools and texts that render us more sensitive to what the weird 'is.' The weird is necessarily slippery in this sense, resistive of definition, as highlighted by the penultimate statement of Luckhurst's dis/orientation of the weird, in which he likens the genre of weirdness itself to a mutating territory "that mobilises boundaries, spins compasses, dethrones the human, hybridises taxonomic categories and bewilderingly shifts beyond any static cartographic plan."[14]

This mobilisation of boundaries and shifting of the stable ground brings us back to the idea of the Anthropocene and its attendant 'weirdness.' Indeed, Luckhurst suggests that, due to its focus on "unnerving edgelands," "weird writing . . . is a form peculiarly suited to addressing the hybrid world of the Anthropocene."[15] This is a world in which action and effectivity are exercised by hybrid forms and percolate through imbroglios, binding together social and natural forces, and human and nonhuman lifeforms. The result has been the disruption of long-held beliefs about the boundaries between the human and the nonhuman worlds, and between the social and the natural realms. As alluded to above, contemporary findings in microbiology both mirror and reinforce this disruption as they begin to hand human agency and sovereignty over to our microscopic nonhuman counterparts. The notion of a materially bounded, continuous and self-identical human 'organism' is now being challenged from within biology as 'individuals' are shown to be composites and mosaics of multiple macro- and microorganisms forming temporarily discrete nodes of activity and relationships.[16]

Thus, although weird fiction is full of "chimerical beasts,"[17] and the "conjoining of *one or more things that do not belong together*,"[18] as it turns out, so is the weird *reality* of the Anthropocene. Whilst the theories of weirdness

13 Roger Luckhurst, "The Weird: A Dis/orientation," *Textual Practice* 31, no. 6 (2017): 1052. Here Luckhurst mentions dread as closely related to the weird, whilst Fisher suggests that dread is not necessarily tied to the weird. Luckhurst discusses a number of technical concepts, including the 'abcanny' and Kierkegaard's notion of 'dread' in relation to weirdness.

14 Luckhurst, 1057.

15 Luckhurst, 1056.

16 See Scott Gilbert, et al., "A symbiotic view of life: we have never been individuals," *The Quarterly Review of Biology* 87, no. 4 (2012): 325–41.

17 Luckhurst, "The Weird," 1056.

18 Fisher, *The Weird and the Eerie*, 11 (emphasis in original).

offered by Fisher and Luckhurst were developed primarily with reference to literary and textual forms, the above considerations suggest that the evoking of a sense of weirdness is not restricted to these cultural artefacts, and I suggest that a similar sense of weirdness may be induced by findings in the natural sciences, and, specifically, microbiology. As Marijeta Bradić notes in her "Poetics of Weird Biology,"[19] the relationship between science 'fiction' (i.e., weird fiction) and science 'reality' is not always "straightforward" and can, in many cases, be seen as "reciprocal."[20] It is not the aim of this article to investigate the relationships between science 'fiction' and science 'reality,' but rather to suggest that theories of affects and genres developed primarily with reference to the former may be applied productively to 'findings,' stories, and narratives that would usually be described as being based primarily in the latter. The rest of this article is therefore concerned with an analysis of findings and narratives arising from within the biological sciences, and of their relation to the theory and affect of weirdness introduced above. Specifically, I look at certain examples of human-microbial entanglements in which the 'edge' between the human and the nonhuman realms is disrupted, as well as instances where findings in microbiology thoroughly "dethrone the human."[21] Ultimately, I suggest, the ongoing revelations of microbial life have the potential to cast us into a world of cosmic indifference, and leave us with "an expanded sense of what the material cosmos contains."[22] It is in this sense of disruption and indifference, too, that these onto-epistemological dynamics, and their associated affects, mirror the revelation(s) of the Anthropocene, therefore drawing a link between the Anthropocene, microbial life, and weirdness as an affect and "mode of being."[23]

There is a generalised sense in which the morphology and behaviour of certain microbes, as well as their proclivity for thriving in extreme environments gestures towards a sense of weirdness, at least insofar as these features occur within a spatio-temporal domain vastly removed from our everyday sensory apprehension of the world.[24] This sense of 'weirdness,' however, is often a non-technical, newsworthy contemplation on the 'discovery' of some extreme microorganism, or of how humans are related to such organisms.[25] Moreover, although the revelation of gut-microbes and humanity's deep

19 Marijeta Bradić, "Towards a Poetics of Weird Biology: Strange Lives of Nonhuman Organisms in Literature," *Pulse: the Journal of Science and Culture* 6 (2019): 1–22.

20 Bradić, 6.

21 Luckhurst, "The Weird," 1057.

22 Fisher, *The Weird and the Eerie*, 18.

23 Fisher, 9.

24 Marianne Gunderson, "Other Ethics: Decentering the Human in Weird Horror," *Kvinder, Køn & Forskning* 26, no. 2–3 (2017): 12–24, 18.

25 See Bradić, "Poetics of a Weird Biology," 1–2 and 6–7 for some examples. Searching Google News for "Weird Microbes" returns no shortage of stories about recently discovered microbes from extreme environments or with strange functions.

embeddedness in symbiotic relations with them is often noted in preambles to, and reflections on, weirdness from more theoretical stances,[26] there has, however, been fewer sustained reflections on the specific weirdness of microbial life and of human-microbial relations. The aim of this article, therefore, is to develop an argument about the specific weirdness of microbial worlds and of humanity's relation to these worlds. I argue that knowledge of microbial life evokes sensations of weirdness in us, and, through specific examples, I will attempt to offer understandings as to why and how. I will focus on the sense of weirdness these findings evoke, drawing on the definitions, framings, and renderings of the weird offered by Fisher, Luckhurst and Morton. This is not an attempt to synthesise a consistent theory of 'weirdness,' or to suggest that all microbiology is weird, but rather to focus on those instances where the sheer alterity, strangeness and 'outsideness' of microbial agency becomes evident and provokes a sense of weirdness in 'us.' The next section presents an analysis of the discovery of endosymbiosis—the finding that humans harbour relics of what were once free-living microbes in all of our cells—which is followed by looking at how contemporary research suggests an even more radical dependence of humanity upon microbial agency, for both its being and becoming. The argument then circles back to analyse Morton's articulation of an ecological 'weirdness,' and suggests that this view erases the specific sense of weirdness evoked by microbial worlds. Instead of such erasure, I gesture towards a different ontology for understanding human-microbial relations.[27]

ENDOSYMBIOSIS—FROM THE INSIDE TO THE OUTSIDE, AND BACK AGAIN

Microbiologist Margaret McFall-Ngai points out in her history of biological classification and microbial life that our understanding of "the biological world has always been fundamentally linked to how we are able to perceive it."[28] Indeed, biological classification systems have developed primarily in relation to our visual perception of the biological world, with the earliest classification systems distinguishing only plants and animals. However, as McFall-Ngai continues: "Then, in the seventeenth century, Antonie Van Leeuwenhoek

26 An example is Timothy Morton's work, which frequently references the weirdness of humanity's symbiotic relationships with gut-microbes. See later in this paper.

27 This ontology is taken from Nigel Clark and Myra J. Hird, "Microontologies and the Politics of Emergent Life," in *Handbook on the Geographies of Power*, 245–258, eds. John A. Agnew and Mat Coleman (Cheltenham: Edward Elgar Publishing Limited, 2018).

28 Margaret McFall-Ngai, "Noticing microbial worlds," in *Arts of Living on a Damaged Planet*, 51–69, eds. Anna Tsing, Heather Swanson, Elaine Gan, and Nils Bubandt (Minneapolis: University of Minnesota Press, 2017), 53.

became the first person to actually see microbes. He scraped the inside of his cheek and looked at what he found there on an early microscope that he made himself."[29] Van Leeuwenhoek's experimental journeys revealed "a previously unimagined microcosmos"[30] containing myriad "animalcules" or "small animals" which, in addition to the inside of his own mouth, inhabited all manner of environments, including rain water from an "earthen pot" and from "water wherein pepper had lain infused."[31] Writing in 1677, Van Leeuwenhoek provided detailed descriptions of these 'little animals,' but as Nick Lane suggests, his "invisible world was teeming with as much varied life as a rainforest or a coral reef, and yet could be seen by none but [himself]."[32] Indeed, it wasn't until about the mid-nineteenth century, two hundred years after Van Leeuwenhoek's initial explorations, when microscopic analysis became quotidian amongst researchers, that biologists routinely "began to divide living things into three categories: animals, plants, and microbes."[33]

A place for Van Leeuwenhoek's animalcules in taxonomies of the biological world thus followed the development and widespread adoption of microscopy into biological study, and, as microscopy further developed, this taxonomy was once again disrupted. This time around, however, the disruption did not correspond to the addition of an extra branch to the 'tree of life'—as with microbes—but rather to a fundamental re-conceptualisation of how these branches related to one another. Central to this story is the use of light microscopy to investigate the structural and morphological features of microbes coming up against its own internal limits: any spatially discrete objects in closer proximity than the wavelength of visible light (~200nm) will be registered not as discrete entities, but as a single object when using this technology.[34] Electron microscopes, on the other hand, take advantage of the shorter wavelength of electrons (~0.01nm) to visualise samples and gives users the theoretical ability to resolve objects[35] on an atomic scale. During the 1960s and 1970s, the power of electron microscopy was absorbed wholesale into the field of biological study, giving novel insights into the fine

29 McFall-Ngai, 53.

30 Lane Nick, "The unseen world: reflections on Leeuwenhoek (1677) 'Concerning little animals'," *Philosophical transactions of the Royal Society of London. Series B, Biological sciences* 370, no. 1666 (2015): 1, doi: 10.1098/rstb.2014.0344.

31 Antonie van Leewenhoek, "Observations, Communicated to the Publisher by Mr. Antony Van Leewenhoek, in a Dutch Letter of the 9th of Octob. 1676. Here English'd: Concerning Little Animals by Him Observed in Rain-Well-Sea and Snow Water; as Also in Water Wherein Pepper Had Lain Infused," *Philosophical Transactions* (1665–1678), 12 (1677): 821–31, http://www.jstor.org/stable/101758.

32 Lane, "The unseen world," 3.

33 McFall-Ngai, "Noticing microbial worlds," 53.

34 See https://www.wikilectures.eu/w/Limit_of_resolution_of_optical_microscope.

35 This refers to the smallest distance between two features such that they will still be detected as separate features by the technology in question.

ultrastructure of cells and microbes, and consequently, new theories about their origins and functions.[36]

In a similar way to Van Leeuwenhoek's forays into the infinitesimal world with his single-lens microscope, it was the evolutionary biologist Lynn Margulis who was one of the first scientists to draw quite radical conclusions from the increased perceptual power afforded by the electron microscope. Margulis' 1967 paper "On the Origin of Mitosing Cells" published in *The Journal of Theoretical Biology,* proposed a new theory for the origin of the subcellular components of eukaryotic, or 'complex' cells, which departed from the Darwinian-inspired gradualist accounts prevalent at the time.[37] As McFall-Ngai states:

> Electron microscopes . . . allowed [her] to look closely at eukaryotic cells and theorize about their origins. Based on what she could see, Margulis hypothesised that the organelles of complex cells arose from endosymbiosis . . . the coordination and cooperation of simple bacteria were the foundation of more elaborate forms of life.[38]

This is Margulis's most widely known contribution to the discipline of biology: the theory of endosymbiosis, or serial endosymbiotic theory. (Neo)-Darwinian accounts of the origin of eukaryotic[39] life forms argue that the membrane-bound organelles distinguishing these cells from their comparably ancient prokaryotic counterparts must have evolved through gradual accumulation of changes (mutation) followed by natural selection. Endosymbiotic theory, on the other hand, states that the mitochondria, the organelles which produce energy in all eukaryotic cells, did not gradually accumulate inside cells piecemeal, but were actually once free-living microbes that existed in a spatially proximate and mutually beneficial relationship with another cell.[40] At some point, the microbes

36 See N. Rasmussen, *Picture Control: The Electron Microscope and the Transformation of Biology in America, 1940–1960* (Stanford; Stanford University Press, 1997).

37 Lynn Sagan, "On the Origin of Mitosing Cells," *Journal of Theoretical Biology* 14, no. 3 (1967): 225–74. This paper was authored under the surname 'Sagan' from her first marriage (with Carl Sagan, 1957–1965).

38 McFall-Ngai, "Noticing microbial worlds," 53.

39 Those with visually demarcated internal structure composed of membrane-bound organelles, including a nucleus and mitochondria. Prokaryotes, by contrast, although internally organised, do not exhibit membrane-bound organelles. It is the evolutionary origin of these organelles in eukaryotes that was the focus of Margulis' paper.

40 This 'other cell' is known as the last eukaryotic common ancestor (LECA), and is a theoretical entity inferred from the theory of endosymbiosis. The actual identity of the LECA is unknown, and may correspond more to a phylogenetic 'state' or population, rather than a discrete entity. See Maureen A. O'Malley, et al. "Concepts of the last eukaryotic common ancestor," *Nature Ecology and Evolution,* 3 (2020): 338–44, doi: 10.1038/s41559–019–0796–3.

and the other cell fused, and their relationship was made permanent—the two partners became obligate symbionts. The initial evolution of mitochondria occurred as a one-step process, a phase transition, in which one cell engulfed another. Endosymbiotic theory therefore argues that the origin of eukaryotic life is chimeric, and that 'complex cells' resulted from the socialising and promiscuity of separate elements, not the gradual evolution of cellular features through Darwinian competition and selection. Margulis developed these views because she identified visual similarities between the organelles of eukaryotic cells and free-living microbes. Her theories about potential material arrangements between organisms and organelles, their origins and consequences, were inferred firsthand from empirical study aided by the new powers brought by electron microscopy. Although it is now inscribed in textbooks and the biological canon, the theory of endosymbiosis was met with hostile reception from fellow biologists when it was first developed by Margulis.[41] This hostility lasted until Margulis was vindicated by genetic findings that linked mitochondrial genomes to alpha-proteobacteria,[42] providing somewhat irrefutable evidence for the endosymbiotic origin of these organelles. True to their origins as distinct from the eukaryotic ancestral cell, mitochondria in human cells retain a distinct genome, and their inheritance patterns differ from that of the nucleus,[43] although communication between these organelles and the nucleus is seamless.

However, although the bacterial origin of mitochondria is now beyond question, there are still many details of the process, as well as some fundamental questions about the pre-fusion relationship of 'hosts' to their 'mitochondria', that remain to be resolved. Contemporary issues cast doubt on the nature of the pre-eukaryotic (prokaryote) interaction with the would-become mitochondria and, although many commentators have implicitly assumed a mutually beneficial or symbiotic relationship between the two, this is by no means necessary. Parasitism is an equally legitimate form of relationship that may have formed the basis for this major evolutionary transition, as is the engulfment and incomplete digestion of the proto-mitochondria by the 'host' in an attempt to eat them. In other words, the finer details of endosymbiotic theory extend beyond cooperation and symbiosis, and tend to (re) implicate competitive features like the evolution of phagocytosis, digestion (heterotrophy), and predation.[44]

41 See A. Tao, "Lynn Margulis," *Britannica*. Available at https://www.britannica.com/biography/Lynn-Margulis.

42 Michael W. Gray, "Mitochondrial Evolution," *Cold Spring Harbor Perspectives in Biology* 4, no. 9 (2012): 1–17, doi: 10.1101/cshperspect.a011403.

43 Mitochondria are inherited from the mother, and replicate semi-autonomously from the nucleus.

44 See István Zachar, and Gergely Boza, "Endosymbiosis before eukaryotes: mitochondrial establishment in protoeukaryotes," *Cellular and Molecular Life Sciences* 77 (2020): 3503–3523; and Christian de Duve, "The origin of eukaryotes: a reappraisal," *Nature Reviews Genetics* 8, no. 5 (2007): 395–403.

Similar to Mark Fisher's articulation of weirdness, there is a sense in which the observations of endosymbiosis quite literally bring to our "familiar" (or "homely") bodies something that "ordinarily lies beyond [them.]"[45] However, as the narration of endosymbiotic theory makes clear, 'our' bodies did not pre-exist their bacterial-symbiont counterparts, but were (and are) always already co-constituted *with* them. Although 'we' may appear to ourselves as separate entities with free-will and agency, exhibiting only a peripheral relation to a messy biological world, endosymbiotic theory thoroughly dismantles this preconception. In highlighting our material embeddedness and our biological indebtedness with and to microbial life-forms, the contradiction between what we thought we were and what we have found out we *are*, is foregrounded. It is here that we can glimpse a sense of lost identity and, referencing Fisher again, something which "cannot be reconciled with the "homely."[46] As noted above, however, this finding also fails to leave the "homely," in this case our bodies, intact, but irrevocably alters it, making even the homely alien, foreign, strange. It may be possible to argue that this estranging of the familiar (or familiarising of the strange) presents this finding to be more uncanny than weird. However, I would suggest that the *unheimlich* fails to capture the dynamic and outcomes of endosymbiosis, because in this case the 'familiar' and the 'strange' both occupy part of the same object, with no clear line dividing the two—'familiarity' and 'strangeness' were both sensations generated by the illusion of being a separate, sovereign agent.

The inability to reconcile our apparent agency with the truth of our microbial origins also has the potential to stimulate sensations of unease and disgust, an affect also associated with the mode of weirdness.[47] As Margulis and Sagan suggest:

> Some people may find this notion [that] we . . . harbor remnants of [microbes], symbiotically subsumed within our cells [as] . . . disturbing, unsettling. Besides popping the overblown balloon that is our presumption of human sovereignty over the rest of nature, it challenges our ideas of individuality, of uniqueness and independence. It even violates our view of ourselves as discrete physical beings separated from the rest of nature. To think of ourselves and our environment as an evolutionary mosaic of microscopic life evokes imagery of being taken over, dissolved, annihilated.[48]

45 Fisher, *The Weird and the Eerie*, 10.

46 Fisher, 10.

47 Luckhurst, "The Weird," 1052.

48 Lynn Margulis, and Dorion Sagan, *Microcosms: Four Billion Years of Microbial Evolution* (California: University of California Press, 1986), 34–35.

The sense of 'unease' evoked by these findings then comes from notions of being 'annihilated' by microbial life. This may be because as we begin to look (spatially) more closely at what 'we' are made of, what we find is that what makes 'us' 'us,' isn't 'us' after all, but something else—microbial symbionts and bacterial fragments buried in the heart of 'our' cells. If, however, our entwinement with microbial life truly did reach this level of an 'annihilation,' there would be no subject left to feel a sense of unease or dread. We are left feeling uneasy precisely because we are left intact by this revelation, and yet are unsure of what it is that has been left—it is as if we have learned, as Fisher suggests in his rendering of the weird, that "There is no inside except as a folding of the outside; the mirror cracks, I am an other, and I always was."[49]

Morton also provides a reflection on the sensations evoked by our closeness to microbial life, suggesting that "part of our growing ecological awareness is a feeling of disgust that we are literally covered in and penetrated by nonhuman beings, not just by accident but in an irreducible way, a way that is crucial to our very existence."[50] Morton's rendering attempts to reduce this "disgust" to a symptom of a distorted relationship with the 'natural' world. Indeed, he links contemporary findings in microbiology and their correspondent affects to a wider "growing" ecological consciousness, suggesting that the uneasiness and disgust evoked by our own microbial-ness may diminish as we become more attuned to these facts, increase our 'ecological' awareness, and get used to our "immersion in the biosphere."[51] There is a teleology at play here, in which disgust becomes a contingent feature on a therapeutic journey towards a quasi-transcendental understanding of our place in the biosphere. In this model, the sensation of "disgust" is a propellant, or an indictment to reconfigure our notions of who and what we are. Although Morton's cosmology may capture something of the dynamics of our responses to, and recognition of, novel scientific findings, it somewhat relegates the experience of disgust to a secondary role in a wider 'plan.' There is a sense, however, in which the experience of disgust has utility, both evolutionarily and aesthetically, beyond its role in realigning ideas of biospheric interconnectedness. It is in this attempt to get rid of disgust that Morton's rendering gestures towards an 'internalisation' or 'familiarising' of weirdness into the framework of a growing ecological awareness and, I would suggest, is a rendering that de-weirds the weirdness of microbial-interconnections.

Indeed, there are certain other aspects of weirdness that both the narrative unfolding and content of endosymbiotic theory may evoke that, true to the weird, resist efforts to capture them in linear frameworks. For instance, in developing her theories of endosymbiosis and the origins of multicellular life, Margulis suggests we have come full circle:

49 Fisher, *The Weird and the Eerie,* 11.
50 Morton, *Being Ecological*, 77.
51 Morton, 77.

> It is not preposterous to postulate that the very consciousness that enables us to probe the workings of our cells may have been born of the concerted capacities of millions of microbes that evolved symbiotically to become the human brain.[52]

This thematisation, of how myriads of specialised microbial communities coalesced into thinking, acting bodies with the ability to probe the origins and workings of 'their' component parts also resonates with Fisher's conception of the weird, in that it demonstrates how "'we' 'ourselves' are caught up in the rhythms, pulsions and patternings of non-human forces."[53] However, elsewhere in their work, Margulis and Sagan question the "alleged uniqueness of human intelligent consciousness"[54] going on to claim, for instance, that in their mitigation of rising oxygen levels, "microbes . . . did what no governmental agency or bureaucracy on earth today could ever do."[55] Humans and their consciousness are here thoroughly decentred relative to microbial life, even being set apart from it as an aberration and mutation. In working to erase the distinction between human life and microbial life, to foreground how we are "recombined from powerful bacterial communities,"[56] what Margulis and Sagan actually achieve is their separation. Indeed, although their work gestures towards how 'we' are caught up in the forces and patterns of non-human life, and suggest that we may even be the effect of these non-human forces, their analogies and comparisons between humans and microbes rely on the very distinction they are calling into question. Thus, although their characterisation seems to valorise microbes over humans, at the same time it relies on the properties of the latter to highlight the ingenuity of the former. Usage of the phrase 'full circle' seems apt when discussing microbial life then, at least insofar as there appears to be no 'straight' story of how 'ours' and 'their' capacities are related.

There is another strange sense in which the unfolding of endosymbiotic theory and our penetration by microbial others (at least as presented here) has come 'full circle': although the weirdness of contemporary microbiology resides in the fact that it puts microbial fragments and relics into the heart of our cells (and selves), we must recall that Van Leeuwenhoek's initial visualisation of microbial life, with his rudimentary microscope, was from a sample taken *from his own body*. In a letter dated September 17th 1683, Van

52 Margulis and Sagan, *Microcosms,* 34.

53 Fisher, *The Weird and the Eerie,* 10.

54 Margulis and Sagan, *Microcosmos*, 35.

55 Margulis and Sagan, 111. Here they are referring to the microbially-mediated levelling-off of atmospheric oxygen after the Great Oxygen Event, which was catastrophic for many lifeforms, around two billion years ago.

56 Margulis and Sagan, 36.

Leeuwenhoek writes about his search for any "Animals dispersed in our Body." After previously failing to find such animals in "spittle," he observes:

> 'Tho my Teeth are kept usually very clean . . . I find growing between them a little white matter as thick as wetted flower . . . in this substance tho I could not perceive any motion, I judged there might probably be living Creatures. I therefore took some of this flower and mixt it either with pure rain water . . . or else with some of my spittle . . . and then to my great surprise [I] perceived that the aforesaid matter contained very many small living Animals, which moved themselves extravagantly.[57]

Though not quite 'endosymbiosis,' Van Leeuwenhoek discovered that we "coexist with present day microbes"[58] and within our bodies "many small living animals" are dispersed. The view of microbes as being somehow 'separate' from us has been tied up in a modernist antibiotic and antiseptic consciousness,[59] one that has put microbes as 'outsiders' and steeped our relationship to the microbial world in metaphors of invasion and warfare. It is with endosymbiotic theory (among other advances in microbiology not addressed here, primarily the microbiome) that the centrality of microbial life not just in human disease but in our very constitution has come to the fore. Through this rendering, microbial life's journey, within scientific activity and cultural imaginaries, has traced a path from the inside (Van Leeuwenhoek's mouth) to the outside (war on germs), and back to the inside again (endosymbiotic mitochondria and microbiomes), participating in a weirdly strange non-linear structure. This form of looping recalls that topological arrangement repeatedly called upon by Morton to evoke his characterisation of weirdness—the Möbius strip. The inside and the outside of this non-orientable surface form one continuous space, in which, apropos of Fisher's conception of the weird, it is impossible to decipher 'inside' from the 'outside'—the same appears to be true of microbial life.

FROM SYMBIOSIS TO DEPENDENCE

The revelation of endosymbiosis indicated that at the core of all cells there was a foreign element, something intrinsically different and 'other.' The so-called

57 Leeuwenhoeck, "An abstract of a letter," 568.

58 Margulis and Sagan, *Microcosmos*, 34.

59 See Penelope Ironstone, "Me, my self, and the multitude: Microbiopolitics of the human microbiome," *European Journal of Social Theory* 22, no. 3 (2019): 325–41.

powerhouse of our cells,[60] that organelle which literally drives movement through its transformation of matter-energy into a usable form, came from the *outside*. The modern cell-biological machinery has been built around rudimentary elements and fragments that are alien at their core, contingent hybrids formed through mere proximity and temporal endurance. Although argued above to be weird, there was also the sense in which this model of (endo)symbiosis is actually a model of *familiarisation*: a model in which two (or more) components unite their metabolism to form a consistent system with the alien 'other' being taken inside. As noted above, endosymbiotic theory, and its generalisation in the theory of symbiogenesis,[61] paints a picture of two (or more) cells (or cellular components) in mutual entanglement, relying on each other for metabolic and structural support. Indeed, even if at first the host-cell and mitochondria were different from one another, their fusion changed them both, leading them down a trajectory of mutual coevolution in which they become fully entwined and integrated. It is from this vantage point of billions of years of coevolution and biochemical compatibility that one may ask, what could be more familiar to the cell than its mitochondrion?

However, there is something that this thematisation of requited and complementary interaction between microbes and 'complex life' conceals. Taking as its point of departure the metabolic dependence of 'complex' lifeforms upon their 'simpler' counterparts, modern microbiology begins to inform a view of biological existence that decentres the notions of *inter*-dependence and symbiosis. This is a less symmetrical vision which places humanity and all 'complex' animals within the power of microorganisms, reinstalls the 'outsideness' of microbial life, and begins again to gesture towards the weirdness of the microbial world, a weirdness that cannot be contained. Regardless of the way endosymbiotic theory and its attendant affects are thematised and theorised—as weird, uncanny, disgusting, familiar, etc.—the point is that this process and theory occur only within a wider biological landscape, one that is by-and-large indifferent to human life, much grander in scale and, primarily microbial in foundation. Thus, from the vantage point of evolutionary deep time, and perhaps the most fundamental perspective regarding our own biological existence, Nigel Clark and Myra Hird remind us that "microbial life invented the basic metabolic processes, including photosynthesis and chemical conversion, that every other life form remains

60 I.e., the mitochondria.

61 According to Donna Harraway, symbiogenesis is the process in which "new *kinds* of cells, tissues, organs and species evolve primarily through the long lasting intimacy of strangers." Donna Harraway, "Symbiogenesis, Sympoiesis, and Art Science Activisms," in *Arts of Living on a Damaged Planet*, 25–50, eds. Anna Tsing, Heather Swanson, Elaine Gan, and Nils Bubandt (Minneapolis: University of Minnesota Press, 2017).

utterly dependent on."[62] The fact of mutuality, as in endosymbiosis and other forms of symbiosis, takes place only *after* microbes have evolved the ability to tap into and transform the matter energy of the sun and earth, and upon the wider base provided by microbial metabolism. This is not a question of hierarchy in the value laden sense, but as a matter of fact: you cannot build a house without an adequate foundation.

Indeed, Clark and Hird's reflections on the diversity, ancientness and extent of distribution of microbial life lead them to argue that "the power of microbial life is the condition of possibility of our own existence as social and political beings."[63] To account for this radical asymmetry—the dependence of human lives on microbial lives, but not vice versa—Clark and Hird forward a theory of *subtending* relations in which "one field of existence [the microbial] provides the conditions of possibility for that which emerges out of it or comes to pass within it [the human]."[64] This stance echoes the general sense of contemporary microbiology,[65] in that what "we have discovered . . . about them" is that "bacteria [and microbes in general] are the condition of our own possibility as multicellular beings: that they are at once our origin and our continuing vital support system."[66] In addition to this fundamental indebtedness of humanity (and indeed all animals) to microbial life, there is more to what our modern journey into the microcosmos 'reveals' (or *fails* to reveal):

> In an empirical sense, *we lack access* to the vast majority of bacterial losses, gains, and transformations: dynamics that are obscured by the scalar mismatch of bacteria and ourselves, by the immensity of their numbers, strangeness of their forms, and the difficulty of accessing many of the environments in which they thrive. In an ontological sense,

62 Nigel Clark, and Myra J. Hird, "Microontologies and the Politics of Emergent Life," in *Handbook on the Geographies of Power*, 245–58, eds. John A. Agnew and Mat Coleman (Cheltenham: Edward Elgar Publishing Limited, 2018). See also M. J. Hird, *The Origins of Sociable Life: Evolution after Science Studies* (Basingstoke: Palgrave Press, 2009), 21–57.

63 Clark and Hird, "Microontologies," 256.

64 Clark and Hird, 256.

65 Prior to the ascendancy of an antibiotic or antiseptic consciousness that conceived of microbes as primarily pathogenic and disruptive in nature, there were some microbiologists discussing the absolute dependence of our way of life on microbial functions. See, for example, Herbert W. Conn, *The Story of Germ Life* (New York: D. Appleton, 1897). Modern microbiology assumes the centrality of microorganisms in all environmental and biological processes, and has divided into sub-disciplines accordingly.

66 Nigel Clark, and M. J. Hird, "Deep Shit," *O-Zone: A Journal of Object-Oriented Studies* 1 (2013): 50.

> what it is to be a bacterium, or more appositely, a vast meshwork of interacting bacteria, is equally *beyond our grasp*.[67]

The asymmetry of our relation with microbes, then, extends beyond the biological dependence discussed above: it is an ontological and epistemological asymmetry in which the precise details of microbial existence recede ever further from understanding. Microbes evolve rapidly, share genes laterally between remote species (and even biological kingdoms) and proliferate on the order of hours—microbes can change faster than our ability to study them, occupying some inaccessible excess that is continually pointed towards but can never be fully exhausted. In a sense, this retreat (that of microbial dynamics from our apprehension of it) mirrors the weird and twisted-looping journey of microbial life sketched above, as it passed from the inside to the outside and back again in scientific discourse and cultural imaginaries. From a more specific perspective, however, these onto-epistemological dynamics of microbial life also correspond to Morton's articulation of an ecological weirdness, a weirdness based on the philosophical position of object-oriented ontology (OOO).[68]

Object-oriented ontology is a philosophically realist stance that claims no object "can be accessed all at once in its entirety,"[69] that objects are 'deep,' 'withdrawn' and "offer us a marvellous world of shadows and hidden corners."[70] The withdrawal of the microbial world from our apprehension, comprehension, and even access, therefore emulates Morton's articulation of OOO, in which "everything is like a black hole." Indeed, although (at least) millions of bacterial species are known to exist on this planet, the majority of them have never been cultured in laboratory settings. This appositely termed microbial 'dark matter'[71] certainly evokes Morton's astrophysical metaphors used to describe the qualities of objects. It could be argued then that the microbiological world and its attendant dizzying array of inaccessibility is the object par excellence of OOO, a kind of 'poster child' that reflects with outstanding clarity *the way everything else is*. Viewed from this perspective,

67 Clark and Hird, "Deep Shit," 51 (emphasis added).

68 This is termed 'object-oriented ontology', a philosophical stance holding that "everything, in many ways, is like a black hole . . . OOO [object-oriented ontology] argues that nothing can be accessed all at once in its entirety." Morton, 33. This ontology was developed by Graham Harman drawing on Martin Heidegger's philosophy, which, as Morton explains, argues "simply that *being is not presence*." Morton, 217 (emphasis in original).

69 Morton, *Being Ecological*, 33.

70 Morton, 34.

71 'Microbial dark matter' refers to microorganisms that are known to exist but have never been grown in a laboratory. This accounts for the majority of microbial species on earth. See Dana Najjar, "Most Microbial Species are Dark Matter," *Scientific American* (2019). Available at https://www.scientificamerican.com/article/most-microbial-species-are-dark-matter/.

microbes' withdrawal, recalcitrance, and 'depth' becomes a specific, albeit exemplary, instance of a general theory—that of OOO. Morton goes further than this, however, and equates the effect of this ontological withdrawnness of objects to an affect of weirdness and a sense of disorientation. According to Morton, this sense—of weirdness—comes to stand for "exactly how things are,"[72] which would mean that the weirdness evoked by microbial worlds, in addition to its ontology, is reduced to a vague comment about *all objects and relations*. Just as Morton reduced the strangeness evoked by our closeness with microbes to a feature of a growing ecological awareness, the position outlined here is similar insofar as it reduces the ontological withdrawal of microbes to a subservient role in the wider object-oriented ontology as "Theory of Everything."[73]

Is there a specific sense of the microbial withdrawn weirdness, however, one that cannot be captured by a philosophy that endows all objects with a somewhat equal depth? An alternative is the view of Margulis and Sagan, but as discussed above their position risks performing the opposite generalisation and producing a bacteriocentric vision, one which negates the real differences between humans and microbes upon which the very sensation and affect of weirdness depends.[74] I would tentatively offer the suggestion that Clark and Hird's elaboration of 'subtending relations,' as discussed above, may offer a way out of this. Although there may be a sense in which, as Morton argues, all objects are 'intrinsically weird,' I would suggest this perspective takes the assumption of a flat ontology too far: the design of a chair, an anthill and a specific succession of bacterial evolution that culminated in mitochondria may be similar in certain respects, but they are certainly differentiated by the fact that whilst human life may be merely enriched or irritated by the former two, it is emphatically *dependent* on the latter. Indeed, as Graham Harman suggests in his view of OOO, although the proposition of a flat ontology is a useful starting point, it is also a disappointing endpoint.[75] The view of humanity's dependence on microbial processes preserves the differences between human life and microbial life, whilst also beginning to articulate the specific relationships between them.

72 Morton, 49.

73 This is the subtitle of Graham Harman's 2018 book *Object Oriented Ontology: A New Theory of Everything* (London: Pelican, 2018).

74 See Pieter Vermeulen, and Kahn Faassen, "The Weird and the Ineluctable Human," *Collateral* 15 (2019): 1–9. In this article the authors argue that "the human is an ineluctable part of the weird." The erasure of the human, through the different tropes of bacterio-centrism and OOO's disanthropic orientation, therefore cannot shed much light on the weird.

75 Harman, *Object Oriented Ontology*, 54.

CONCLUSION

This paper has been about the strange world of microbial life, but also about how we relate to this world—the stories and interpretations we tell ourselves in order to 'understand' it. On the one hand, I have pointed to numerous instances where these stories and thematisations of microbial life have been internalised and familiarised. Yet on the other, microbial life has, in each case, exceeded these framings in its own strange way. These considerations suggest that, like the weird, the microbial is "recalcitrant, difficult and elusive"[76] and it is here, in its inability to be contained, I suggest, that the 'weirdness' of microbial life is to be found. This weirdness, therefore, points not only to the content of the discoveries of microbiology, but to how the conceptualisations of these discoveries have been repeatedly undone. Like the weird and its shifting borders, the boundaries of the microbial are continuously elusive[77] and unable to be pinned down. ⊡

76 Luckhurst, "The Weird," 1042.
77 Luckhurst, "The Weird," 1046.

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