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ARTICLE

What constitutes the health subject?

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Abstract

According to many philosophical accounts, health is related to the functions and capacities of biological parts. But how do we decide what constitutes the health subject (that is, the bearer of health and disease states) and its biological parts whose functions are relevant for assessing its health? Current science, especially microbiome science, complicating the boundaries between organisms and their environments undermines any straightforward answer. This article explains why this question matters, delineates a few broad options, offers arguments against one option, and draws some modest implications for philosophical accounts of human health.

Keywords: philosophy of biology; philosophy of medicine; health; microbiome science; individuality; ecology; ecosystem health; holobiont; relational theory

1. Introduction

According to many philosophical accounts, health is related to the functions and capacities of biological parts.[1] A human is said to be healthy when their parts are functioning at an adequate level of efficiency, in ways that are good for them, that allow them to achieve their goals, or that allow them to respond to the contingencies of their environment. There are a variety of competing proposals. What interests me in this article is that each of these proposals assumes an answer to a prior question, usually taken for granted: what constitutes the health subject (that is, the bearer of health and disease states) and its biological parts whose functions are relevant for assessing its health?[2] The tasks of this article are to explain why this question matters, to clearly delineate a few

[1]This is true for most naturalist and normativist theories of health and disease, e.g., see discussions in Barnes (2023), Boorse (2014), Broadbent (2019), Englehardt (1996), Ereshefsky (2009), Hausman (2012), Kingma (2020), Stegenga (2018), Thompson and Upshur (2017), and Wakefield (1992).

[2]Schroeder (2013, 143) acknowledges that there is a general problem created by the lack of clean distinction between an organism and its environment, but leaves it unaddressed. Barnes (2023, 27) notes in passing that microbiome science specifically complicates deciding what counts as a "part" of an organism, and that this might be a "tricky issue" for naturalistic health theories. Sholl (2016) goes further, arguing that the reciprocal nature of the organism-environment relation (as exemplified by phenotypic plasticity and niche construction) complicates traditional, Boorsean naturalistic theories of health and disease, and argues that a theory based (largely) on the work of Georges Canguilhem offers some promise. While Schroeder (2013), Sholl (2016), and even Canguilhem (2008)—see also the discussion in Griffiths and Matthewson (2018)—are concerned about problems for naturalistic theories stemming from the reciprocal nature of the organism-environment relation (such that organisms cannot be defined in absence of environments, and vice versa), the current paper is more concerned with cases where distinguishing between the activities of an organism's parts and the parts of its environment has led some to rethink the entity to which health or disease states is ascribed. Boorse (2002, 82), whose concern might be slightly closer to that raised in this paper, considers extended phenotypes, such as birds' nests, which might be conceived to provide functions constitutive of health, and which, therefore, might encourage us to enlarge the scope of the health subject to include these extended phenotypes. The most detailed consideration of this question is by Morar and Skorburg (2018), as I discuss below.

broad options, to offer arguments against one option, and to draw out some modest implications for philosophical accounts of human health.

Addressing the question of what constitutes the health subject matters for at least two reasons. First, as both biologists and philosophers have successfully argued, drawing a boundary between an organism (humans included!) and its environment is anything but straightforward.[3] This, in turn, means that there is some philosophically interesting leeway in how one defines the health subject. I will focus here on interpretations of the results of microbiome science, the study of microbiomes, which are communities of microorganisms (mostly bacteria) that live in a particular habitat.[4] I will be concerned with human microbiomes, and so the habitats of interest are on and within the human body—the skin, or the gut, or the mouth, for example.

Over the past two decades, and especially within the last ten years, microbiome science has provided ample evidence to demonstrate that animals (again, humans included) harbor persistent microbial communities that are essential for their functioning, health, and well-being.[5] Angela Douglas writes in *Fundamentals of Microbiome Science* (2018) that the animal…

> …is a multiorganismal entity, comprising animal cells and microbial cells. The phenotype of an animal is not the product of animal genes, proteins, cells, tissues, and organs alone, but the product of the interactions between all of these animal functions with communities of microorganisms, whose composition and function vary with the age, physiological condition, and genotype of their animal host. (2018, 2).

Inspired by evidence from microbiome science, some biologists and philosophers argue that microorganisms are so deeply integrated into basic human developmental and physiological processes that they can be considered parts of human individuals, perhaps like our organs, rather than features of our environment. Others argue that we humans are in fact better seen as ecosystems or "holobionts" or "metaorganisms," rather than individual organisms—entities consisting of a phylogenetically heterogeneous collection of integrated parts.[6] Some argue that what this all means is that human health is not just physiological, but ecological: a matter of being able to cultivate the communities of which one is composed.[7] Robinson et al. write that,

> With this new paradigm, the human body can be considered akin to a national park. The management of the ecology of the human microbiota becomes the focus of both prevention and therapeutics. (2010, 469).

Many seem to agree that these arguments mean something (even something radical) for understanding *our* health, but what exactly? The answer is unclear. Are the activities of some microorganisms (or some communities of microorganisms) partly constitutive of human health, like the activities of our organs? Morar and Skorburg (2018), for example, answer affirmatively: the bearers

[3]For a comprehensive overview of the large and complex literature about defining organisms, biological individuals, and their environments, see Wilson and Barker (2024).

[4]There are now many general introductions to microbiome science, but two insightful, philosophical overviews are Huss (2014) and O'Malley and Skillings (2018). A helpful breakdown of the different but rarely distinguished meanings of "microbiome," see Lynch, Parke, and O'Malley (Lynch, Parke, and O'Malley 2019, 10–11).

[5]Throughout this paper, I try to avoid commitment to any specific way of conceiving the contentious relations between functioning, health, and well-being.

[6]There is a huge and growing literature about these and other options and their merits and pitfalls (Baquero and Nombela 2012; Bazin, Chiu, and Pradeu 2022; Bourrat and Griffiths 2018; Chiu and Gilbert 2020; Doolittle and Booth 2017; Doolittle and Inkpen 2018; Evans, Morris, and Marchesi 2013; S. F. Gilbert, Sapp, and Tauber 2012; S. F. Gilbert and Tauber 2016; E. Lloyd 2017; E. A. Lloyd and Wade 2019; McFall-Ngai et al. 2013; Morar and Bohannan 2019; Pradeu 2016; Roughgarden 2020; Roughgarden et al. 2018; Schneider 2021; Skillings 2016; Stencel and Wloch-Salamon 2022; Suárez 2020; Suárez and Stencel 2020; Triviño and Suárez 2020)

[7]Two neat papers reviewing some of this work are Orr et al. (2018) and Foster et al (2017). See also Skillings (2018).

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of health and disease states are often "dynamic functional units," such as a human host *and* its microbes, rather than individual organisms. In a previous article, I too allowed that we might consider the human and its microbes as an ecosystem to which a health state is ascribed (Inkpen 2019).

The second reason why our central question matters is that it has implications for a wider set of long-standing debates—not considered directly here—about whether health and disease can be ascribed to ecological systems, such as communities or ecosystems (Lackey 2001). An article in *Science* (21 April 2017) explained that reductions in resource consumption "will lead to a *healthier* planetary ecosystem." Do we err in ascribing states of health to these systems? Is this metaphorical speech, akin to discussing a "healthy" relationship? What should guide our decisions about which kinds of biological systems can be health subjects—traditionally, individual organisms—and which cannot? Ecologists and environmental philosophers have argued along a few different lines, but there is little consensus (Callicott 1995; Jamieson 1995; McShane 2004; Norton, Faber, and Rapport 1992; Odenbaugh 2010; Rapport 1989; Rapport, Costanza, and McMichael 1998; Shrader-Frechette 2008; Suter 1993). And few of these arguments are even considered in the context of human health but should be if we are supposed to take seriously that humans *are* ecosystems.

This article is largely conceptual and aims to offer some clarity and guidance. I will first focus on clarifying a few of the coherent, available options for rethinking human health (§2–3). I then offer arguments against one of these options that shows a few of its weaknesses (§4). In the final section of the article (§5), I conclude with a short discussion and the brief evaluation of another option.

2. Distinctions and Options

Human microbiome science has produced a significant amount of evidence to support the conclusion that humans, like other animals, depend on interactions with microbes for proper development and functioning.[8] Evidence suggests that without such interactions our immune systems do not work properly, digestion suffers (for example, an estimated 6–10% of our human energy budget comes from the work of microbes), and we are more prone to illness and pathogens (Morar and Bohannan 2019). "The effects extend beyond local impacts, for example, the gut microorganisms on gut health," Douglas writes, "to microbial effects on cardiovascular health, the integrity of the circadian rhythm, and [even to] psychiatric health" (2018, 2). This suggests that microbes do much more than just cause infections. To say that microbes are "helpful" would be an underestimation—they are nearly essential to continuing to live well.[9]

Does this research support a philosophically interesting challenge to prevailing ideas about health?[10] Before we can decide we need to get clear on the challenge, or better, challenge*s*, themselves. To articulate and classify a few competing proposals—I will call them theories—I will

[8]For textbook overviews, see Douglas (2018) and Rosenberg (2021).

[9]I write "nearly" because many animals can survive (and in the case of mice, live longer) without microbes in very specialized environments. Studies of germ-free mice show this. But it is important that these environments are specialized: such animals would not survive long in the wild.

[10]Results from microbiome science have also and relatedly fed a growing literature in the philosophy of biology challenging traditional assumptions about organisms. This literature is vast and growing quickly, but a few nice summaries, relevant for the current discussion, can be found in: Clarke (2013), Kingma (2019), Skillings (2016). For example, Thomas Pradeu (2010) has argued that microbes tolerated by the human immune system are better seen as parts of the organism. He calls the new conglomerate organism, a "heterogeneous individual." Others use the title "holobiont" for these entities: a holobiont is an entity consisting of a "host" animal, or plant, or protist, and all of its associated microorganisms (Rosenberg and Zilber-Rosenberg 2018). The human holobiont, for example, consists of 40 trillion human cells and somewhere between 40 and 100 trillion bacterial cells. Still others use traditionally ecological terms, such as "superorganism" (Lederberg and McCray 2001), "community," or "ecosystem" (Orr, Kocurek, and Young 2018; Skillings 2016). Regardless, we are said to be more than we thought we were.

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need to draw two distinctions. These may be continuums, but for the present purposes this will not matter. And because what constitutes "the human" is a contentious part of the debate, I will simply refer to the health subject as that system to which ascriptions of health and disease are intended to apply.

Regarding the first distinction, I will call *parthood theories* those that treat some microbes as parts of the health subject (parts of the human holobiont, if you like); this is not to claim that they are parts of the human, but that the host–human and its associated microbes together make up a health subject. In contrast, I will call *environment theories* those that treat all microbes as features of the health subject's environment.

For the second distinction, I will call *causal theories* those that treat the activities of microbes as causally related to the health of a health subject, but not constitutive of health. According to these theories, microbes can help bring about health or disease states, but their activities are not constitutive of those states. They are determinants of health. I will call *constitutive theories* those that treat the activities of some microbes as constitutive of health.

The terminology for this second distinction I borrow from the literature about relational theories of autonomy.[11] However, the spirit of the distinction is already present in medicine and philosophy of medicine. For example, the commonplace distinction between pathogenic and pathological. This distinguishes causes of disease (the novel coronavirus is pathogenic) from what is constitutive of disease (certain heart rhythms are said to be pathological). Boorse (2014) uses a different terminology to mark the same distinction: healthful/unhealthful versus healthy/unhealthy. Organ function can be healthy or unhealthy (these functions are constitutive of human health), but aspects of the environment should only be described as healthful or unhealthful (as having the propensity to cause health or disease). I prefer the labels "causal" and "constitutive" because they are more descriptive.

Putting these two distinctions on separate axes allows us to classify alternatives (Figure 1). Let me say a few words about three of these options.

First, there are what I am calling *traditional theories* about the relation between microbes and humans. These are *environment-causal* theories. All microbes are aspects of a human's environment, and their activities can be causally related to the health and disease of their human hosts, but health and disease states are ascribed to the individual human host. More commonly put, microbes are here considered determinants of health and disease. Their activities are *not* constitutive of human health and disease. Until recently (until microbiome science, that is), this position would have seemed obviously true, with the small caveat that the causal effects of microbes were, for the greater part of medical history, treated as merely disease-causing or pathogenic.

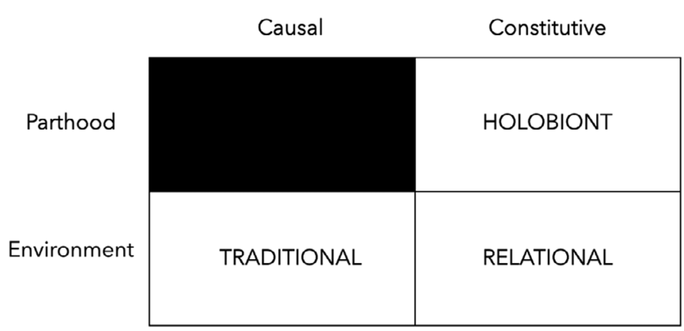

Figure 1. Three competing ways of understanding the philosophical challenge posed by microbiome science.

[11]For a summary, see Stoljar (2018).

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Traditional theories share a lot in common with, and might even be called, ecosystem service theories, as I argued previously (Inkpen 2019).[12] We treat the communities of microorganisms associated with humans as separate ecological systems that provide "services" or "functions" relevant to human health or well-being.

Secondly, there are *parthood-constitutive* theories. I will call all such theories as *holobiont theories.* One argument, considered below, is that at least some microbes are so functionally integrated into human physiology that they are treated as parts of holobionts whose activities are constitutive of the health of the holobiont. The health subject is this holobiont, and health is a property of this whole system (i.e., its capacities or functional profile).

Holobiont theories share a lot in common with, and might be called, ecosystem health theories, as I argued previously (Inkpen 2019).[13] According to ecosystem health analyses, we can ascribe health to a whole ecosystem. For the current purposes, we are imagining that the ecosystem is the human holobiont.

What makes this view philosophically interesting, and also distinct from the traditional view, is that it challenges *health individualism*: the thesis that health subjects are individual organisms, traditionally conceived. According to holobiont theories, however, health should be extended beyond the traditionally conceived organism to cover cases of human holobionts. Morar and Skorburg, seemingly advocating such a theory, write, "the individual—as the bearer of health and disease states—sometimes extends to include tightly integrated features of the biological and social environment" (2018, 342). (I write "seemingly" because the conceptual distinctions drawn here are not clearly drawn in their article—but a holobiont theory seems most consistent with their analysis).

Finally, there are what I will call *relational theories.* These are *environment-constitutive* theories. I do not know that anyone has actively pursued this option, but it is intriguing (see §5), and it coheres well with what I take to be the spirit of a few theoretical frameworks offered by biologists as alternatives to the holobiont idea; for example, that offered by Foster et al. (2017). According to relational theories, all microbes are features of our human environment, but activities of at least some microbes, those that interact with the processes of human development and physiology, are in fact constitutive of our human health. The bearer of health and disease states is, as traditional wisdom would have it, the human; it is just that human health is constituted by more than the internal functioning of human parts.

What makes this view philosophically interesting, and distinct from the traditional view, is that it challenges *health neutralism*, the thesis that health concerns only the internal functioning of an organism, usually the absence of disease.[14] Health, according to neutralism, is an internal state in which everything is functioning as it should. The relational view says that health is constituted by more than these functions—it is also constituted by the activities of features of our environment and involves being in the right kind of relation to those activities.[15]

[12]Traditionally, this is applied to "macrobial" ecosystems and services, like carbon sequestration (Daily and Matson 2008). But it has also been applied to the case of humans and their associated microorganisms, e.g., see: McKenney et al. (2018) and Douglas (2018, 7).

[13]For example, see the approach taken in Rapport et al. (1998), and for a philosophical defence of this approach, see McShane (2004).

[14]This thesis is discussed in relation to positive understandings of health, discussed below, but it seems to rarely be given a name. The name I use comes from Stegenga (2018, 8).

[15]One box is shaded in Fig. 1. I have not pursued this option because it seems to me incoherent. This option would treat microbes as parts of the health subject but would not treat their functions as constitutive of health. It's an awkward view because health seems, almost by definition, to be constituted by the activities of a system's parts. Prima facie, a counterargument seems to be the common idea that one part of the human body can cause a problem in another part: a deep vein thrombosis causes a pulmonary embolism. I think, though, even here, we consider the deep vein thrombosis to be itself constitutive of an unhealthy state, so it is *both* constitutive and a causal determinant of further problems elsewhere. It is less clear to me that something can be a part and yet not constitutive of health. Regardless of the veracity of my intuitions here, I will set this view aside for the remainder of the current paper.

This gives three distinct ways of thinking about humans, microbes and microbiomes, and health. I will spend much of the rest of this article discussing holobiont theories because (i) they are the challenge to which some people think microbiome science amounts (see citations in footnote 6) and (ii) my arguments against these theories have broader implications.

3. Arguments for Holobiont Theories

If microbiome science challenges human health in a philosophically interesting way, then it consists of a move from the traditional theory to a different option. What, then, supports a move from traditional theories to holobiont? There seem to be two distinct arguments supporting the move, though I find these to be implicit and entangled (and again, the current literature does not distinguish the options above).

The first appears to be pragmatic: an appeal to what is useful. The claim (a promise that requires empirical validation) is that by ascribing health states to the holobiont, we will better attend to what is often ignored at our peril: microbes are not all pathogenic. We will better respect the complexity of our relationships with microbes, and this will lead to the more effective treatment of illness. This is argued or implied in Inkpen (2019), Morar and Skorburg (2018), and Rosenberg (2021). In §4.2, I will question this appeal to usefulness, thus deflating the strength of the pragmatic argument.

The second argument I will explain in some detail now and then evaluate further below. This argument depends on an association between a living system's functional integration and its capacity for health. I will consider how Morar and Skorburg employ this argument (Morar and Skorburg 2018). Functional integration is a measure of the strength and frequency of causal interactions between the components of a complex system and their dependence on one another. The argument is that microbes are so deeply integrated into the development and functioning of humans that they should be considered a part of a holobiont whose states can be described as healthy or diseased. Morar and Skorburg offer two well-worn examples, both having to do with human digestion, to support their view that the holobiont is the bearer of health.

First, as shown a decade ago, some Japanese people carry in their guts a strain of a bacterium that boasts genes for carbohydrate metabolism of a particular kind. These genes were transferred from an ocean-dwelling bacterium that metabolizes similar compounds in marine red alga. Such algae include species used in the making of nori, frequently eaten in Japan. As Morar and Skorburg summarize,

> Because of this, the Japanese gut can *uniquely* derive energy from a certain algae-based diet. Crucially, this specific feature of digestion has little to do with human genetics. Thus, there is a strong sense in which the microbiome *extends* the physiological process of digestion and makes available to the human body a series of calories that the host could not have otherwise extracted by its own *internal* means. (2018, 347).

They take this as an example of a general rule, that the microbiome extends digestion, rather than a unique case applying to a specific set of people. Their second example has to do with obesity.[16] They write,

> studies on obesity have not only confirmed the central role of our gut microbiota in our caloric intake, but have also shown the tight connection between our gut [microbes], our diet, and certain physiological states, such that obesity cannot be simply reduced to abnormal host genetics or poor diet. (2018, 347).

[16]Discussions of obesity and the gut microbiome raise a host of important issues (such as about "healthism") that I will not discuss in this paper. See Dryden (2023) for a very helpful discussion.

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In other words, the composition of the gut microbiome needs to be considered as well.

These examples—and others like them, such as the proper development of the immune system—are meant to illustrate the claim that microbes are so functionally integrated with host physiology that we are justified in treating the entire holobiont as the health subject. I take it, then, that the argument, in general terms, should go something like this:

Argument from Functional Integration
Premise 1: *X* is a system that is highly functionally integrated.
Premise 2: All highly functionally integrated systems are health subjects.[17]
Conclusion: Therefore, *X* is a health subject.

The human holobiont is argued to be an instance of *X*, given the way it is shown to exemplify functional integration.

My attitude toward this work is critical sympathy. I feel the allure, but there are unacknowledged challenges to be overcome, and I do not find this central argument convincing.

4. Challenges

The most obvious weaknesses of holobiont theories might seem to be the conceptual and empirical puzzles (already well articulated in the philosophy of biology literature) surrounding how we characterize this holobiont individual and its parts. How should we decide what counts as a part of the holobiont and what does not? Which microbes do we count? Only those that provide us with activities that are helpful (surely not, given unhelpful human parts, like vestigial organs)? What about those that can also be harmful? Do ones with free-living populations that use us merely as stop-overs count? What about the many transient microbes that come and go but provide no benefits or costs? How do these differ from our "macrobial" ecological interaction partners, such as plants that provide oxygen?[18] And many people have been skeptical of the holobiont idea, in general, if this is meant to imply that humans and microbes make up a population of units that can undergo evolution by natural selection.[19] These are controversial and long-standing issues in the philosophy of biology, and they show that identifying this health subject by choosing a human and all the microbes making up its microbiomes is not a simple nor uncontroversial task.

I will not pursue this line of argument directly, in part because these issues are discussed, debated, and defended elsewhere. Regardless of whether they can be overcome, holobiont theories, when applied in the context of human health, face other problems as well. I will raise three, each demonstrating a slightly different point of weakness.

4.1. The human substitution

I call the first problem human substitution. It is a *reductio ad absurdum*. Like all *reductios*, it starts with an assumption: holobiont theories treat health as a property of the whole holobiont. According

[17]Below I will consider whether the modifier "living" should be added before "systems" in this premise. It would nicely constrain the scope of this argument, such that computers by definition do not count, thus avoiding an obvious weakness. But, at the same time, one might wonder what reason we have for such a restriction. This, I think, gets into trickier argumentative territory, likely, I would think, related to the scope of theories of well-being.

[18]See the citations in footnote 4. See also Kingma (2019) for a fruitful analysis of what counts as a part of an organism that is relevant in this context. Kingma's analysis would support the claim that microbes and microbiomes are not parts of humans, and this might be taken as an additional reason to be skeptical of holobiont theories, though the full argument would require more space than this paper allows.

[19]For example, see Doolittle and Inkpen (2018) and Moran and Sloan (2015).

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to these theories, the holobiont is the health subject. Its parts are both the human host and its associated microbes, and health is the persistence of its functional profile or capacities, such as digestion in the example above. This distinguishes holobiont theories from traditional and relational ones, which treat microbes as parts of our environment, and health as a property of the human. The holobiont theory, thus, purportedly treats health in a less anthropocentric way: it is holobiont health, not human health, after all. This assumption does not seem unfair given that part of the purported novelty and attractiveness of the holobiont view seems tied to it. The reductio questions this assumption.

A lot of research into human microbiomes has shown that a holobiont is not a stable thing, compositionally speaking (Lozupone et al. 2012). The microbes that make up healthy human microbiomes change over time, and different healthy people contain different microbial communities. In other words, the type of microbes present differs even for healthy humans. Many studies have documented this trend.[20] This is true even for microbes mostly protected from the outside world, such as those in our gut. The authors of a foundational and highly influential article put the point as follows:

> The hypothesis that there is a core human gut microbiome, definable by a set of *abundant* microbial organismal lineages that we all share, may be incorrect: by adulthood, no single bacterial phylotype [read: species] was detectable at an abundant frequency in the guts of all 154 sampled humans. Instead, it appears that a core gut microbiome exists at the level of metabolic functions. This conservation suggests a high degree of redundancy in the gut microbiome and supports an ecological view of each individual as an 'island' inhabited by unique collections of microbial phylotypes: as in actual islands, different species assemblages converge on shared core functions provided by distinctive components. (Turnbaugh et al. 2009, 484).

So, it is clear from an abundance of research that the health of the holobiont is maintained when unrelated microbes performing the same functions are substituted one for another, as long as they perform the (or nearly the) same functions.

But if health is a property of the collective, and microbes come and go, then why say that the human must stay constant for a state of holobiont health to be maintained? If bacteria, as individual organisms making up this holobiont, can be substituted one for another and holobiont health be maintained, why not allow the human organism to be substituted?

The possibility of that substitution is an absurdity, given the aims of medicine to treat a particular human individual. There is an obvious reason why we cannot perform this substitution: we care about the health and well-being of the human member of the holobiont. The human member is special. The absurdity of the human substitution shows that something must give, and most obviously, we might want to drop our initial assumption, that health is a property of the whole holobiont, rather than indexed to one member of the group. But now we have given up what seemed novel and attractive about the holobiont view. We have given up what seemed to set it apart. In fact, the view now seems nearly disingenuous: what is called holobiont health is just the health of one member of the holobiont community or ecosystem. Health is indexed to the human member. The view is, despite what it seems, anthropocentric.

To help motivate the objection, consider ecology, rather than microbiology. Similar reasoning has bothered many ecologists concerned about some uses of the phrase "ecosystem health": what sounds like it is about the whole is really about the health and well-being of one member of the community, predictably, again, this is the human (Lackey 2001). For example, following the publication of a high-impact 1998 piece summarizing an ecosystem health approach, there were

[20]For two reviews, see Gilbert et al. (2018) and Lloyd-Price et al. (2016).

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several letters to the editor. One ecologist responded that ecosystem health is "obviously being seen purely from the standpoint of trees and their human consumers, rather than from any more objective view of overall ecosystem health" (Wilkins 1999, 69). In such a case, "ecosystem health," it is argued, is a misnomer. The claim is that despite how it sounds, the concept is disingenuously anthropocentric. We might conclude similarly for holobiont health: it is not holobiont health we care about, but the health of the human component; health is indexed there.

It is important to clarify what I take this argument to show and what it does not show. It might be taken to prove too much. The argument shows that the health of the holobiont is indexed to the health of the human member of this community, and is thus not merely about the persistence of the capacities of this whole holobiont. However, the argument does *not* show, and is not intended to show, that microbes are not a part of the health subject. That would prove too much: we do not conclude, for example, from the fact that a person's heart can be successfully substituted for a pig's heart and yet the person's health maintained, that the human heart is not a part of the human health subject. This analogous argument shows only that health is not indexed to the heart. This raises a host of intriguing and unanalyzed ship-of-Theseus-style questions about how many human parts must persist for the claim that *a particular* human's health is maintained or improved to be sensible, and about which parts are substitutable and which not (the human brain, unlike the heart, seems nonsubstitutable).[21] Perhaps, this should even make us think differently about the commitments of traditional theories—though there is no absurdity or disingenuousness, in this case, in thinking that they are indexed in one place rather than another. But these intriguing questions notwithstanding, the point of the current section is to argue that, if you thought the novelty and attractiveness of the holobiont perspective lay partly in its being nonanthropocentric, then you would be mistaken. Holobiont health is human health. That is where health is indexed. I do not see how it could be otherwise without being led into an uncomfortable absurdity.

This, it is also worth saying, is in fact how research proceeds: by starting with healthy humans and then studying their microbiota to discover clues to what makes a human microbiome healthful, that is, a determinant of the health of the human host. Hooks and O'Malley (2017) make this point in their arguments against the usefulness of the idea of microbiome "dysbiosis," the term for a symbiosis gone wrong (a "dysbiotic" gut is one failing to perform certain normal functions). They write, "Many of our 100 long definitions specify that for the altered microbiota to be considered dysbiotic, the changed state would need to have a negative effect on the host" (2017). According to microbiome scientists, it is human welfare that determines what is considered dysbiotic.

4.2. Diverging interests

Let me turn to the second problem. Holobiont theories emphasize seeing microbes and their human host as parts of a single holobiont, but this is at odds with, or at least fits very awkwardly with, the equally necessary seeing of them as separate systems with potentially diverging interests, and not parts of the same system.[22] The holobiont theory, despite the pragmatic appeals, encourages a kind

[21] As a reviewer helpfully pointed out, we might gain some ground regarding issues of persistence and substitutability in biological systems by looking to literature on "self-maintenance" or "organizational closure," as developed in the organizational theory of function literature; see, for the seminal discussion, Mossio et al. (2009), and my discussion below.

[22] I will not embark on a full discussion about what counts as a part of a whole. But there is perhaps an important biological sense in which humans and the microbes that make up their microbiomes are not parts of a common holobiont system. This is in an evolutionary sense. For a detailed analysis of this issue, and related issues about understanding what is "good for" an agent of evolution, see Okasha (2018). The "fitness alignment" approach taken by Bourrat and Griffiths (2018) could be applied here as it is one intelligible way of treating evolutionary interests. Arguments about evolutionary interests cohere well with the reasoning in this section, and support it, but are not required for its conclusions.

of binary thinking opposed to a more nuanced view of our relationship with microbes. Consider a few examples.

First, there is an issue raised by bacteria with both positive and negative effects on human health. A lot of microbes are not strict pathogens (like those that cause tuberculosis or cholera) but are well-behaved under some circumstances and less well-behaved under others. If the human immune system is weakened, or they find themselves in parts of the human body they should not be, or there are no competitor microbes, or there are a lack of bacteriophages (viruses that infect bacteria), one-time beneficial bacteria can lead to human illness.[23]

Consider *Helicobacter pylori*. This is one of the only bacteria that can survive in the human stomach and it colonizes half the world's population of humans. It in fact only lives in human stomachs, no where else on earth! It was long ago confirmed, in part through self-experimentation, that this bacterium can lead to stomach ulcers and stomach cancer in a small subset of people. So, it is sometimes bad. However, recent evidence now suggests that *H. pylori* may play a positive role in inhibiting cancer formation in the lower esophagus and inhibits other esophageal diseases. This has led Martin Blaser, a central figure in this research, to conclude that "in a world of black and white, *H. pylori* is gray." *H. pylori*'s interests only partly align with our own.[24]

Similar issues are raised by the many so-called "opportunistic pathogens." Species that are members of the group *Viridans streptococci*, for example, are persistent colonizers of humans, often favorable to us, but sometimes causing disease. For example, if they escape from the mouth microbiome into the bloodstream, they can cause endocarditis and inflammation of the inner layer of the heart (Blaser 1999). In this case, the bacteria are taking advantage of their new context, but at the expense of the human. The interests of opportunistic pathogens only contingently align with our own.

Finally, a different kind of issue is raised with regard to *Clostridioides difficile* (or *C. diff*) infection in humans. *C. diff* is a bacterium that is common in the guts of healthy people but can become a problem when its population grows too large. Infections are difficult to treat and lead to recurrent bouts of life-threatening diarrhea. *C. diff* population size is kept in check by competition with other resident microbes, and so infections typically occur in people who have taken a strong dose of broad-spectrum antibiotics, often those being treated in a hospital for a different infection. As a side effect of the administered antibiotics, many resident microbes are killed. Without these resident microbes to outcompete (or at least suppress the growth of) *C. diff*, it can gain enough of a footing in the community to grow a large enough population to cause disease. Thus, in healthy people, it seems to be the community of microorganisms in the gut *as a whole* that is providing protection against *C. diff* infection.

The problem with these cases for the holobiont theory is the following. The holobiont theory encourages seeing microbes as parts of a single holobiont, but in the case of *H. pylori* and opportunistic pathogens, it is equally necessary to see them as in an important way *not* parts of a single holobiont. Understanding and preventing these health problems involves seeing microbes as independent systems with diverging interests. That fits awkwardly with seeing them as parts.

[23]Barnes (2023, 27) raises a similar problem specifically for Boorse's naturalistic theory of health. In this paper I am concerned with arguing against holobiont theories, but as Barnes notes, these issues might complicate some of the traditional philosophical theories as well.

[24]The case of *H. pylori* and *C. diff* (described below) are carefully discussed in Lynch, Parke, and O'Malley (2019), where single-species cases like these are compared to cases where disease causality is attributed to the entire microbiome. See also the commentary about this paper—e.g., Lean (2019), Schneider (2020), Skillings (2019)—and Lynch et al.'s response (Lynch, Parke, and O'Malley 2020). I do not consider entire microbiome causality directly here because my point in this section is to offer an argument against the holobiont health option, and the *H. pylori* and *C. diff* examples illustrate the point in a less controversial way.

The *C. diff* example is slightly different. The issue with our traditional treatment of microbes was to see them as *all* bad. The future requires a more nuanced view: of seeing them in a more contextual way, as neither always good nor always bad.[25] However, the holobiont theory seems to encourage us to treat some microbes as parts, such as the resident microorganisms in our guts, and others, *C. diff* as bad intruders. The theory would then encourage a kind of binary thinking that seems to be at odds with opportunistic pathogens and has been a very significant root in the tree of the larger problem. More boundary drawing, even more sophisticated boundary drawing, does not seem like a step in the right direction. Thus, when it comes to usefulness, the pragmatic argument seems to swing in the opposite direction.

I think this has been why many biologists, despite recognizing the importance of microbiomes, are also at pains to emphasize that the holobiont is not made of parts working in harmony with one another. As evolutionary biologist Toby Kiers puts it: "We need to separate important from harmonious. The microbiome is incredibly important but it doesn't mean that it's harmonious" (Yong 2016, 85).

As with the preceding section, I should clarify again what these arguments do and do not warrant. The cells of our own body, for example, sometimes go rogue and when they do, they can cause cancers. That should not warrant the conclusion that our human cells are not parts of our body because they have the capacity to work against our interests when the circumstances are right (or *wrong*, better yet!). That is, the argument does not warrant the (stronger) conclusion that microbes cannot be parts of holobionts or humans. The argument might lead us to question whether our traditional understanding of the human body could use a little nuance if it undermines our capacity to appreciate the fragile, context-sensitive nature of our human parts and their relation to our health. But regardless, the point here is that the holobiont view seems to encourage a simplistic, binary (this-is-a-part-and-this-is-not) manner of thinking that is inappropriate for appreciating the context-sensitive nature of our microbial relations.

4.3. Functional integration

I would like now to turn to the argument that is offered in favor of the holobiont view, the *Argument from Functional Integration*. I do not think this argument is convincing. Above I summarized the argument as follows:

> *Premise 1*: *X* is a system that is highly functionally integrated.
> *Premise 2*: All highly functionally integrated systems are health subjects.
> *Conclusion*: Therefore, *X* is a health subject.

The problem is the controversial premise 2. The argument for holobiont theories depends on a connection between high functional integration and the capacity for health, namely, that to determine whether a system is a health subject we need only show that it is highly functionally integrated. But why think this is so? The long-standing controversy over the coherence of ascribing health to ecosystems, alluded to above, is not merely a debate over whether ecosystems are highly functionally integrated—those on both sides of the debate would seem to agree that they are. The issue, it seems to me and which I will now develop, is that functional integration is a descriptive claim about a system, but in deciding whether an entity is a health subject, we do not need to be convinced that a descriptive claim is apt. We need to be convinced that an evaluative claim is intelligible and warranted.

[25]For a nuanced, helpful, and related discussion of the complexities of defining "pathogen" and "pathogenicity," see Méthot & Alizon (2014).

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It will help to start by thinking about what is required for a normative or naturalist account of health to be applicable. According to normative accounts of health, health is a valuable state.[26] There are different ways to flesh out this claim, in part depending on how one understands the relationship between health and well-being. But, minimally, what's required for a system to be a health subject, then, is for it to make sense to say of that system that certain states of the system are better for it (i.e., are more valuable) than are other states of the system. That there are better and worse states of being, rather than just different ones.

According to a normative account of health, then, proving high functional integration is not necessarily sufficient for determining whether a system is a health subject. Functional integration is a descriptive claim about a system, but health is an evaluative notion: health ascription assumes that certain states of a system can be more valuable than others. What is required, minimally, according to a normative account, is a way of making sense of a system's welfare.[27]And it seems very plausible that not all highly functionally integrated systems have welfare, for example, my smartwatch. So, if we accept a normative account of health, then the argument from functional integration fails because premise 2 is very likely false: not all highly functionally integrated systems are health subjects. At the very least, we need an argument for why we should think that all highly integrated systems (even all highly integrated *living* systems) are subjects of welfare.[28] That is where the burden of proof lies.

We might instead pursue a naturalist account of health. I will here utilize Hausman's well-defended functional efficiency theory (Hausman 2014; 2012). According to Hausman's account, we assess health by assessing the functional efficiency of the parts of a living system, that is, their causal contribution to the goals of the subsystem of which they are a part, or to the survival and reproduction of the whole organism. The comparative functional efficiency of parts can be assessed statistically through comparisons of similar parts in similar systems in a wider population. For example, if my heart is pathological, this is because it fails to provide an adequate causal contribution to blood circulation, where "adequate" means the average functional efficiency of hearts of members of a reference population, say males between 35 and 40. Hausman writes, "regardless of where the line between pathology and health is drawn, systems or organisms with higher levels of functional efficiency are, with regard to the particular part or process, healthier; and systems or organisms with lower levels of functional efficiency are less healthy" (2014, 642).

Naturalistic theories of health, like Hausman's, may be value-free, but they are still evaluative: they evaluate on the basis of whether one person's heart, for example, is "*better* or *worse* than another with respect to the achievement of specific system goals" (2014, 640). Evaluating functional efficiency is not, contra the normative account, a matter of contribution to welfare. It is a matter of how well, statistically speaking, a part contributes to a system- or subsystem-level goal. For a health ascription to be meaningful, then, a system must, minimally, be decomposable into parts, demonstrate goal-directed behavior, and be amenable (in principle) to the kind of functional efficiency statistical analysis that Hausman describes. Health subjects are, minimally, a subset of goal-directed systems (perhaps those directed toward the ultimate goals of survival and reproduction).[29] And so, here too, we need a more detailed story in lieu of premise 2: are all functionally integrated systems goal-directed in the right kind of way? The issue, to repeat, is that functional integration is a descriptive claim about a system, but in deciding whether an entity is a health subject, we need to be convinced that an

[26]For a summary of such positions, see Ereshefsky (2009).

[27]This maps well onto the discussions of ecosystem health, as described above, where those in favour of the idea argue this by explaining what it means for an ecosystem to be a subject of welfare, to have a "good of their own."

[28]For a discussion of the subjects of welfare, including biological examples, see Lin (2018).

[29]Odenbaugh's (2010) argument that ecosystems do not evolve by natural selection, and so do not have the goals of survival and reproduction, and so cannot be described as healthy in naturalist terms, is relevant here, and might put further pressure on ascribing health to holobionts or ecosystems. Self-maintenance might offer an alternative to "survival and reproduction" and some have argued that ecosystems can exhibit the right kind of self-maintenance to ground goals relevant for functional ascription (Nunes-Neto, Moreno, and El-Hani 2014). For a critique of the latter approach, see (Dussault and Bouchard 2017).

evaluative claim is intelligible and warranted. As Ereshefsky (2009, 225) writes, "state descriptions make no claims about whether a physiological or psychological state is functional or dysfunctional."

A less well-developed, but promising naturalistic account, the systemic organizational theory of malfunction, can be used to draw a similar conclusion (Saborido et al. 2016). According to this theory, the function of a part of an organism is the part's contribution to the realization of the systemic organization that generates and maintains the organism and thus also its parts (including the very part under consideration). A malfunction occurs when a structure is "unable to display the range of functional processes that the other functional traits of the system presuppose, and therefore the system is acting within a narrower range of viability than the range of viability that the system's organization presupposes" (Saborido et al. 2016, 111). Malfunction is not defined through statistical comparison, as in Hausman's theory, but through self-comparison: malfunction occurs when a part fails to contribute to self-maintenance in the way it previously did.[30]

With regard to the overall task of this section of the article, two points are worth emphasizing. The first is that because malfunction (and thus, health and disease) are here defined through temporal comparison of the functioning of a system, health, and disease are once again more than simply claims about functional integration—they are, rather, about comparisons of functional integration through time. Secondly, and more significantly, the application of this account is conditional on the system exhibiting organizational differentiation. As Mossio et al. (2009) write in a seminal article,

> Organizational differentiation implies not only that different material components are recruited and constrained to contribute to self-maintenance but, in addition, also that the system itself generates distinct structures contributing in a different way to self-maintenance. In other words, material components become candidates for functional attributions *only if they have been generated, and are maintained, within and by the organization of the system.* (2009, 826, my emphasis).

Thus, organizational differentiation goes beyond mere "material complexity" (i.e., having a variety of interconnected internal components). But as a result, this kind of organization seems to be exactly what is most contestable in discussions about the human–microbe relationship (i.e., that microbes have been generated and are maintained within the organization of the system), and thus, it seems unlikely that humans and their microbes would qualify as a system with high organizational differentiation. In fact, and though it does not prove it, I believe that the previous section of the article (§4.2) summarizing the context-sensitivity of the relationship defined by conflicting interests supports this conclusion.

Reflecting, as we have been doing, on how normative and naturalist accounts of health would delineate the set of health subjects given the prerequisite qualities required for their respective applications might point to two different ways to improve the argument from functional integration. We could, instead of premise 2, treat the defining feature as possessing welfare or goal-directedness.[31] Either might provide a more convincing argument. One problem, though, is that we may end up where we ended in §4.1. If it is welfare that matters, then this is human welfare, and if it is goal-directedness that matters, then it is the goals of the human organism. The argument, then, might not support the holobiont option, if that option means to treat health in wholistic or nonanthropocentric terms.

[30] In this sense, this theory of health and disease takes Canguilhem's theory of the normal and the pathological as its precursor (Saborido et al. 2016).

[31] I leave organizational differentiation out here because, as stately above, I do not think the human-microbe system exhibits this property to a high degree. If this could be shown, then this may be the most promising option for a naturalistic theory of holobiont health.

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5. So, What Is Left?

So, succinctly, the three problems with holobiont theories are that: (i) to avoid absurdity, the holobiont theory must give up what made it novel and attractive, (ii) the pragmatic argument may actually swing in the other direction, and (iii) the argument from functional integration is unconvincing. If I am right that holobiont theories are unacceptable for these reasons, then we are left with a choice between the traditional and the relational. I will conclude with a few words about this choice.

Relational theories, as I am calling them, would state that microbes are features of our environment, but that the activities of some microbes, those that closely interact with human development and physiology, are in fact constitutive of our human health. The bearer of health and disease states is, as traditional wisdom would have it, the human; but human health is constituted by more than the internal functioning of human parts.

There are a few reasons in favor of accepting a relational theory over both traditional and holobiont theories. (i) It would avoid the problems caused by attempting to specify which microbes are parts of the holobiont and which are not. In contrast, it says that, because of our long-standing evolutionary relationship with microbes, some of their activities, those that are good or bad *for us*, are in part constitutive of the health of the human organism. (ii) It would avoid the need to invoke ideas about overall holobiont capacities, functional profiles, or welfare, because it is in fact human welfare that matters for medicine, thus avoiding the *human substitution* reductio. (iii) It would encourage (or at least in contrast to the holobiont theory, would not *discourage*) recognizing that microbes and humans have only contingently aligned interests. (iv) It would avoid drawing the *argument from functional integration*: it makes no claim that functional integration is sufficient for an entity to be considered a health subject.[32] (v) In contrast with traditional theories, it would encourage us to attend to what has been ignored to our peril, that is, that humans have such a dependency on microbes that attacking them wholesale has and will lead to as many problems as it solves. (vi) And, also in contrast with traditional theories, this view has the advantage of better flagging that the environment is not merely a static background, but is created and structured through dynamic interactions between the host and its microbes; these relations and interactions are constitutive of our health, not merely background against which we assess our health.

The relational theory also hangs together well with alternatives to the human holobiont conception found in the theoretical biology literature. For example, Foster et al. (2017) argued that the human–microbe relationship should be characterized not as an emergent organism, but as an "ecosystem on a leash": "When host species interact with a diverse but beneficial microbiota, as occurs in mammals, evolutionary theory predicts that the microbial functions will centre on persistence in the microbiome ecosystem, while the host will attempt to control the microbiota, hence the 'leash'" (2017, 48).[33] "Unlike a rainforest or river ecosystem," they write "the microbiome is not only driven from the bottom up by species interactions, but the host is under strong natural selection to shape the microbiota from the top down and foster a community that is beneficial" (2017, 47) Using this characterization of the human–microbe relationship, they ascribe health to the human host, and thus, the benefits they refer to (such as improved nutrition, pathogen resistance, immune system function, and mental health) are beneficial *because* they benefit the host. They intend this characterization to highlight the dependency that is likely to evolve in such a situation. So, what Foster et al. appear to be describing is an option between the idea that microbial species are

[32] Of course, from a relational perspective, the degree of functional integration may be helpful in deciding which environmental activities are constitutive of health and disease, but the health subject is still the human, traditionally-conceived.

[33] They contrast the "ecosystem on a leash" with three other types of host-microbial interaction: host control (when the host has control over which microbes it hosts), symbiont control (when the symbiont controls the host), and open ecosystem (when a host carries a microbiota but neither has mechanisms controlling the specific composition or interactions of the other).

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merely a part of the environment and the idea that they are a part of us, and, consequently, the relational theory is apt.

Accepting a relational theory would entail rejecting *health neutralism*, as I have concluded already. Health, according to the relational theory, is a matter of the functioning of at least some parts of the environment. And because recent work in the philosophy of medicine treats disease as fundamentally a "bodily property," this would also entail treating health as more than the absence of disease (Fuller 2018). It remains, for example, at least a theoretical possibility that one's internal functioning operates normally (so one is not diseased, per se), but that one fails to be fully healthy if crucial activities provided by the microbial environment are missing.

Should all this convince us to move from a traditional theory of health to a relational one? That move would be premature, and, like the holobiont theories, there are important challenges for any relational theory to overcome, either by showing that they are not in fact problems or by "biting the bullet" in the name of greater overall theoretical virtue. Let me briefly outline three.

One challenge arises from potentially counterintuitive cases that follow from a rejection of health neutralism. From a relational perspective, it is at least a possibility that an unhealthy and a healthy individual could have *identical* internal functioning if the former, but not the latter, was in an environment lacking in important microbial processes and products. How unintuitive and damaging is that? I am not sure. A related challenge can be formulated as a slippery slope: humans have evolved to use more than just microbial products, of course; for example, we are dependent on oxygen produced by "macrobial" organisms, like trees. Does this entail that the photosynthetic processes of trees are constitutive of human health? Once we have opened the gates to such thinking, where does it stop? And a final challenge relates to the goals and practices of medicine. Stegenga (2018, 14) considered whether all positive theories of health—theories, like the relational theory, that treat health as more than the absence of disease—would saddle medicine with extra responsibilities more pertinent to society at large than the medical domain. If the aim of medicine is to cure disease and bring about health, and health is constituted by an individual's relations to their environment, then does medicine have a responsibility to attend to structural social and environmental issues that are now considered constitutive of health states?

I do not have the space here to develop or contend with these objections. But they do not appear insurmountable. Against the first, we might say so long to our intuitions: microbiome science shows that a truer understanding of humans situates their health within their ecological relations. Against the first and second, these problems are not uniquely damaging. They are problems for all *nonneutral* theories of health because such theories require decisions to be made about the scope of what is constitutive of health beyond the functioning of internal parts, and this includes the World Health Organization's theory of health as "complete physical, mental and social well-being" and capacity theories in which health involves the capacity to engage in certain activities.[34] And against the third, we might quibble over whether an argument based on medicine's current goals and practices is convincing. If it turns out that this is how we should think about health, then perhaps medicine itself should change.

These are inadequate responses that need further development. If the reader understands why the development of these objections and responses is important and will be philosophically fruitful, then the goal of this paper was successful. My conclusion is that when we are discussing the challenge posed by microbiome science, we should be debating the merits of traditional and relational theories, rather than holobiont theories.

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[34]The WHO constitution can be found here: https://www.who.int/about/governance/constitution. For capacity theories of health, see Carel (2007) and Canguilhem (2008). An interesting development of Canguilhem's theory can be found in Sholl (2016), and in particular Sholl's attempt to operationalize Canguilhem's theory is relevant to these criticisms.

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