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Review

THE ANTHROPOCENE REVIEW

The Anthropocene Review
2023, Vol. 10(2) 434–454
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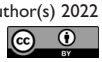
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Is our planet doubly alive? Gaia, globalization, and the Anthropocene's planetary superorganisms

Boris Shoshitaishvili

Abstract

The theory of the superorganism—that there exist composite forms of life organized at scales above the multicellular organism—has been part of scientific discourse and speculation since the late 1800s. Over the last century theories of the superorganism have grown in scope from designating the local insect colony as emergently alive to positing a global entity enveloping the entire planetary surface. The planetary version of superorganism theory has developed in two different forms, the ecological form of Gaia theory and the sociological form of globalized humankind, with the possible implication that the surface of our single planet is now occupied by two distinct planetary superorganisms. In this article, I summarize the parallel histories of this speculative biological-planetary concept, propose a theory about the relationship of the two coexisting planetary superorganisms, and reflect on how this theory recasts the global environmental challenges of the Anthropocene. I conclude with a note about simplistic or totalizing superorganism assertions.

Keywords

Anthropocene, Gaia theory, globalization, organicism, superorganism

> . . .superorganism claims have also been used to convey the idea that some insect colonies represent a distinct level of organization above metazoan multicellularity. Formulated this way, superorganismality becomes shorthand for a macro-evolutionary hypothesis that such colonies may represent an entirely distinct type of life. Reaching superorganism status then becomes analogous to other major transitions, such as the convergent evolution of obligate multicellularity, as in animals, plants, some fungi, and some algae. (Boomsma and Gawne, 2018)

University of California Berkeley, USA

Corresponding author:
Boris Shoshitaishvili, University of California Berkeley, 232 Kroeber Hall, Berkeley, CA 94720, USA.
Email: borisshosh@gmail.com

First Gaia gave birth to a child equal to herself,
Starry Ouranos, that he might envelop her completely (*Theogony*, ll.126–127)

Introduction

According to James Lovelock and Lynn Margulis's Gaia theory, life has not only differentiated into numerous species across deep time but also interacted with the physical processes of the Earth to create a single semi-stable and self-regulating, that is homeostatic, planetary entity. (Lovelock and Margulis, 1974) This entity possesses a "geophysiology" which "regulate[s] its 'body' chemistry and temperature" (Bjornerud, 1997; Lovelock, 1989) like an organism. On this basis, it has been argued that Gaia is the planet's "largest living entity," equivalent to "'Life' with a capital L" (Lenton et al., 2020). Gaia's planetary scale and holistic character lend the theory a mystique unusual for concepts in the natural sciences, amplified by the adoption of the theoretical entity's name from the language of ancient Greek religious poetry. These associations have also made the concept popular outside the academy (Latour and Porter, 2017).

In parallel with Gaia, an alternate theory of a planet-sized superorganism emerged in the 20th century and also crossed the academic-broader public divide: the theory that human society, in the process of becoming globally interconnected by means of technology, is forming a single coherent living entity—a "Metaman," as one futurist called this second hypothetical Earth-spanning entity in the 1990s (Stock, 1993).

These two theories of planetary-scale organismic entities, ecological (Gaia) and sociological (human globalization), have rarely been considered side-by-side despite conceptual similarities. A number of scientists and scholars endorse or critique Gaia theory (Doolittle, 2020; Latour and Porter, 2017; Lenton et al., 2020; Pigliucci, 2014; Ruse, 2013; Schneider et al., 2004). A separate smaller group of thinkers have focused on the human planetary superorganism idea, with interest growing in the last decade, especially in the context of the Anthropocene and the mass effects of globalization (Hagens, 2020; Vince, 2020; Wilson, 2020). This review aims to link the two theories together. I first contextualize them in the historical development of the superorganism concept, make an argument about the relationship of the two proposed global entities, and finally use the vision of two related planetary superorganisms to reframe the predicament of the Anthropocene epoch.

In Part 1, I outline the development of the two planetary theories from the more general concept of the superorganism originally used to designate eusocial insect colonies, ecological communities, and human social groups on local and national scales. I highlight how organicist theories of the superorganism shifted into more abstract systems-based descriptions as the scale of envisioned superorganismic entities expanded from local to planetary.[1]

In Part 2, I consider the 21st century return of organicist versions of the superorganism concept across multiple scales, with particular focus on the planetary. I engage a core critique biologists have directed at Gaia theory: the apparent absence of a Gaian reproductive lineage. I argue that this critique makes space for a new theory about how the ecological and sociological forms of the planetary superorganism may relate to each other: as parent-offspring.

In the conclusion, I suggest that exploring the conceptual puzzle of how two planetary superorganisms could coexist when there is only one Earth for both to be "planetary" on presents a new perspective on a key question of the Anthropocene epoch: how to envision an ongoing interaction between globally interconnecting human societies and Earth's more-than-human biosphere without minimizing the presence of either.

Part 1: An overview of the superorganism concept's history

Superorganism in biology

In biology, the term superorganism has been in use for more than a century in the study of eusocial insect colonies "in which some individuals reduce their own lifetime reproductive potential to raise the offspring of others" (Nowak et al., 2010). Other than the queen and a subset of males, members of many insect colonies are fully or partially sterile. This fact perplexed Darwin (1859) when he was developing the theory of evolution by natural selection. How could the "struggle for existence" lead to organisms sacrificing their own individual reproductive capacity for the sake of others? He referred to this apparent challenge to his theory as "one special difficulty" and argued that it could be explained by a sort of family-level selection process. He considered the entire insect colony as the reproductive unit of selection, instead of the individuals within it, and speculated that the different infertile body types were analogous to tissues in a multicellular organism.

In 1911 W. M. Wheeler argued that ant colonies should be treated as "superorganisms" because of the distinctive morphologies and division of labor among insect castes (Wheeler, 1911), and also because individual ants in a colony are offspring of a single queen and share genetic material with the rest of the colony. This way of thinking about insect colonies was revisited periodically throughout the 20th century (e.g. Emerson, 1939), and the analogy was provided with genetic support in the 1960s when William Hamilton connected the unusual haplodiploid genetics of hymenoptera (ants and bees) with their tendency for reproductive "altruism." Like somatic cells in a multicellular body sterile colony members in hymenoptera and (diplodiploid) termites are more genetically similar than are individuals in non-colonial species (Hamilton, 1964a, 1964b). The idea of the colony as a superorganism was specifically revived in a 1989 paper by Wilson and Sober (1989) and became the theme of a book on eusocial insects by Hölldobler and Wilson (2009).

More recently, added emphasis has been placed on the insect colony exhibiting a kind of "swarm intelligence" or "hive mind," with castes and members responding in highly concerted ways to stimulus and threat. Therefore, the colony appears not only to reproduce but also to interact with its environment as a collective entity of differentiated morphologies and functions, its multitude of individuals working synergistically (Turner, 2016).

There is debate over the precise point in a lineage at which the colony of a particular insect species qualifies as a superorganism, but the general description of at least some insect colonies as superorganisms is less controversial than the other applications of the concept explored below. The use of the term superorganism for the insect colony is not a radical expansion of biology's traditional scope: While it represents a shift in scale from the multicellular organism to a hypothetical higher-order form of life, the absolute size of any particular insect colony is relatively small and its members all belong to a single species and even single family.

Superorganism in ecology

The expansion of the ecological superorganism concept from local to planetary. The superorganism concept emerged in ecology at around the same time. Frederic Clements and other early 20th-century ecologists understood entire ecological communities, such as the American prairie, as constituting higher-order living organisms passing through predictable stages of development:

> "The unit of vegetation, the climax formation, is an organic entity. As an organism, the formation arises, grows, matures, and dies. . . The life-history of a formation is a complex but definite process, comparable

> in its chief features with the life-history of an individual plant. The climax formation is the adult organism, the fully developed community, of which all initial and medial stages are but stages of development.
>
> Succession is the process of the reproduction of a formation, and this reproductive process can no more fail to terminate in the adult form in vegetation than it can in the case of the individual plant." (Clements, 1916: 124)

According to this view, populations of completely different species in an ecological community become interrelated with each other to such a degree that together they form a higher-order organism possessing a physiology as well as ontogeny, that is a coherent biological entity moving through a predictable set of developmental stages (Kirchhoff, 2020).

This ecological concept of superorganism represents a more radical expansion than seeing the insect colony as a superorganism. When used for the insect colony as a unit, the superorganism concept scaled up organismic integration from the familiar level of the multicellular individual (e.g. an ant) to the less familiar level of the collective entity (e.g. an entire ant colony). Nevertheless, in insect biology, it remained limited to a single family unit in a single species since the many individuals of any eusocial insect colony share the same parent(s). Clements's ecological organicism, on the other hand, went further. He proposed that significant portions of the Earth's surface characterized by complex interactions of many different species (ecological communities) could each be conceived as unified biological superorganisms. The whole multi-species prairie is a superorganism rather than the smaller single-species, single-family anthill inside it.

In addition to expanding the superorganism concept in physical size as well as number of species and genetic diversity among constituent members, ecological organicism implicitly shifted the evolutionary origins of the superorganism category of life further back in evolutionary time. Extrapolating the views of ecological organicists, the earliest appearance of any ecological community can also be understood as the first appearance of the superorganism as a new level of life. The ecological superorganism becomes nearly as ancient as the multicellular organism, as old as the first ecological community. This shift creates another contrast with insect biology where only a few eusocial species (ants, bees, termites, etc.) are said to have evolved into superorganism configurations at specific junctures in evolutionary history.

In the second half of the 20th century, the ecological superorganism idea developed a planetary corollary. Gaia theory recast the superorganism concept even more profoundly than earlier conceptual differences between the insect colony and ecological community. Gaia resembles the idea of an ecological community as a superorganism but on the scale of the planet itself—an ecological community broadened to include not only all species of the biosphere but also many of Earth's physical and chemical processes. While there are no direct links between ecological organicist theorists such as Clements and Lovelock and Margulis, the initial ecological expansion of the superorganism concept in space, number of species, and time by Clements and others can be seen as the precursor for the Gaia vision of a planetary superorganism.[2]

While ecological organicism and Gaia theory differ in conceptions of the number and size of the superorganism, both theories present an emergent biological category in which many different species (or all species) act as a composite living unity—as a fundamental form of life that is, in both cases, nearly coeval in evolutionary history with the multicellular organism. On the global level of Gaia, however, only one gargantuan and ancient superorganism is posited, which originated with the biosphere's early entwinement in Earth processes through millions of differentiating and interacting species.

From living superorganism to ecosystem and Earth system. A more subtle way in which 20th century ecology served as the forerunner to Gaia theory was its general movement from biological (super) organicism into systems-oriented description. Tansley (1935), an ecologist and contemporary of Clements who for decades had critiqued Clements's assertion that an ecological community should be seen as a genuine biological superorganism passing through ontogenetic stages, successfully reoriented ecological theory around the idea of the "ecosystem":

> the more fundamental conception is, as it seems to me, the whole system (in the sense of physics), including not only the organism-complex, but also the whole complex of physical factors forming what we call the environment of the biomes – the habitat factors in the widest sense. Though the organisms may claim our primary interest, when we are trying to think fundamentally we cannot separate them from their special environment,
>
> with which they form one physical system. . . These *ecosystems*, as we shall call them, are of the most various kinds and sizes (Tansley, 1935)

The centering of "system" instead of "organism" not only allowed Tansley to highlight the multiplicity of physical processes involved in the formation of an ecological community but also helped him resist Clements's ontogenetic understanding of ecological transformation. (van der Valk, 2014) The climax community, rather than resulting from an ontogenetic process through which the superorganism "matures," represented for Tansley "the highest stage of integration and the nearest approach to perfect dynamic equilibrium that can be attained in a system developed under the given conditions and with the available components" (Tansley, 1935: 300). The next generation of ecologists such as Lindeman (1942) and Odum (1953) advanced Tansley's "ecosystem" concept further through attention to, and quantification of, energy transfer and mineral or nutrient cycling. Meanwhile, the biological superorganicist conception of the ecological community receded.

A comparable systems-thinking response to the directly biological frame of the superorganism can be found in the shift of (much) Gaia theory into Earth System Science.

Lovelock and Margulis's original formulation of the Gaia hypothesis often emphasized that Gaia was a single biological entity of planetary scale, a living superorganism. Like ecological organicisim, though with more focus on the living planet's homeostatic dynamics and (geo)physiology (Lovelock and Margulis, 1974) in contrast to Clements's ontogenetic description of the climax formation's "maturation" and stages of development, Gaia theory privileged biological concepts.

From early on, however, Lovelock also employed some of the control systems language of feedback and cybernetics to explain the emergence and activity of the planetary superorganism (Latour and Porter, 2017; Lovelock, 1988; Ruse, 2013). Because such systems thinking was present in Lovelock's work from the start, there was less need and room in Gaia theory for a Tansley-like figure who would introduce systems thinking in opposition to a predominantly organicist frame (Marshall, 2002).

The subsequent development of Earth System Science amplified this kernel in Gaia theory, resulting in a replacement of organicist emphasis with a greater systems perspective. This shift resembles the movement from Clements's ecological community to Tansley's ecosystem. ESS expanded the systems theory elements already present in Gaia theory while downplaying or avoiding its vision of a genuinely new kind of planetary living being. In the following decades, ESS, rather than the more biological Gaia theory, found greater institutional acceptance in the natural sciences as well as international research bodies (Lenton et al., 2020). Lovelock and Margulis,

meanwhile, continued to stress in books and essays on Gaia more biological conceptions of the planetary superorganism.

Superorganism in sociology

The expansion of the human superorganism concept into geopolitical impact. Even as insect biology and ecology gravitated to the superorganism concept, superorganicist thought also pervaded sociology's initial development as a discipline. The theory of human society as a new form of superorganism appeared with variations in the works of many of sociology's early thinkers, including Émile Durkheim, Alfred Espinas, Jacques Novicow, Friedrich Ratzel, Albert Schaeffle, Herbert Spencer, Paul von Lilienfeld, Lester Ward, and René Worms. The concept of the social superorganism helped establish the concept of "society" as a "concrete entity that was part of the natural, physical world" and hence as a subject appropriate for study by the latest self-proclaimed scientific discipline of sociology, essentially adding a biological aspect to Auguste Comte's foundational positivistic vision of the discipline (Barberis, 2003; Bauer, 2014).

The embrace of modern cell theory in the early-to-mid 1800s provided important background for developing this concept of human society as superorganism, and there was persistent exchange between the life and social sciences in the century that followed (Latour and Porter, 2017). In modern cell theory, an individual animal or plant was reconceived as a unity made up of much smaller interconnected and interdependent living units (cells). This transformed concept of the individual organism supported the organicist sociologists in taking a similar perspective on society as a whole: Human beings were analogized to the cells of a body, smaller definable units that interlinked to form the new higher-order organic unity of society (D'Hombres and Mehdaoui, 2012).

This perceived analogy between multicellular organisms and societies helped sociologists ground the emergence of society in evolutionary theory, suggesting a kind of scientific logic to the prehistoric origins of human sociality. Just as early life made a major evolutionary transition when single-celled organisms joined to form the new living entity of the multicellular organism, human societies represented a more recent evolutionary transition in which a new kind of organism emerged, a superorganism made up of many interdependent conscious language-using individuals.

Unlike the superorganism interpretation of the insect colony or the ecological community, the human social superorganism concept immediately carried a strong sociopolitical valence. Society being viewed holistically and in biological terms as a living entity resonated with the body politic metaphor, according to which the overarching sociopolitical unit was understood as a living body, often with the ruler or ruling elite analogized with the head, heart, or mind (Latour et al., 2020). This metaphor had been in common use at least as early as the first millennium BCE and, in addition to its role as an explanatory framework, was employed by those in power to legitimate sociopolitical hierarchies. (Huang, 2007)

However, the 20th-century superorganism conception of society differed significantly from the body politic metaphor, and the differences make the superorganism more fraught than its predecessor. The body politic metaphor draws analogies primarily to the body's organs and limbs, constituent parts of a living whole that are each irreplaceable. But the social superorganism concept, in its connection to modern cell theory, privileged a more granular level of constituency. While organicist sociologists continued to compare social functions and classes to organs and limbs, many went further and analogized individual human beings in society to the cells of a body. This granular analogy was especially misleading when applied to the human world since the multicellular organism regularly replaces its cells, unlike its organs and limbs, without harm to the whole. The inherent value of any single cell in the entire organism was easier to minimize. Therefore, by the

extension of the cell analogy, it became easier for those thinking in terms of the theory of the social superorganism to minimize the inherent value of any individual human being.

The close association of the social superorganism with contemporary population and evolutionary biology distinguished the concept from the body politic in another and equally problematic way. The metaphor of the body politic hardly envisioned anything beyond the boundaries of the specific society to which it was applied. In other words, the body politic tended to focus on the physiology of a single body politic. The superorganism concept, by contrast, expanded this focus to see each social superorganism as an entity acting in an external environment and competing with other superorganisms. Like the multicellular organism, the social superorganism could be interpreted as participating in natural selection dynamics, understood primarily in narrow 19th century terms of the "survival of the fittest." These analogies to competition and natural selection for new organicist theories of society supported additional politically volatile conclusions: If a particular sociopolitical entity (e.g. a nation-state) invaded or destroyed another, the political decision could now be rationalized and justified in pseudo-biological terms.

While these biological analogies appear superficial or specious on careful consideration, the superorganism concept lent them the weight of scientific authority. Bio-organicist sociologists were eager to secure for sociology the legitimacy of the natural sciences and often exaggerated similarities or downplayed differences, failing to consider the possible ramifications if society and politics became more widely seen in this new light.[3]

The dangers became clear in the 1920s to 1940s with the rise of totalitarian movements, especially Nazi Germany and the Soviet Union. Many of their proponents and theorists conceptualized these unprecedented and destructive societies in pseudo-scientific terms echoing the superorganism language of sociologists from decades earlier. The concept of the superorganism appeared numerous times in the writings and speeches of Adolf Hitler (applied to Nazi Germany) and Joseph Stalin (applied to the Communist Party), as well as in an infamous article by sociologist Gini (1927) arguing in support of Mussolini that the social superorganism idea establishes the "scientific basis of fascism."

The role of social organicism as part of the pseudo-scientific architecture of totalitarianism has been studied (Cassata, 2008; Harrington, 2009; Latour et al., 2020; van Ree, 1993), but this history can also be set alongside the transformation in scale of the superorganism concept in ecology described in the previous section. The ecological superorganism concept expanded from the local form of the climax formation to the planetary scale in Gaia theory. Somewhat analogously but catastrophically, the human social superorganism concept grew from local and general descriptions of society into an element of the expansionist totalitarian visions.

The expansion of the social superorganism concept from geopolitically significant to global. One of the first global yet not explicitly authoritarian descriptions of the human superorganism is found in the post-war writing of the paleontologist and Catholic priest Pierre Teilhard de Chardin. Teilhard's ideas about global humanity presented in *The Human Phenomenon (1955)* and *The Future of Man (1959)* mark the concept's expansion in the organicist sociological tradition into a planetary form most directly analogous to the ecological superorganism's expansion in Gaia theory.

Following the World Wars, Teilhard was early in recognizing the processes of post-industrial globalization, interpreting them specifically as the formation of a new planetary social superorganism. Unlike the superorganism ideas of totalitarian governments in the 1930s and 1940s, his conceptual expansion did not include specific ideas about the political form a global human superorganism should adopt. Rather, in Teilhard's often mystical and theological contemplations, human beings were forming almost unwittingly the various organs of a new kind of integrated

planetary living being as individuals and societies interacted along proliferating lines of trade and communication through technology.

Teilhard's theory rested on a series of specific analogies: Worldwide industrial technology was forming the musculoskeletal system of this human superorganism; intergenerational culture was its inheritance system; the telecommunication and research capacities of human beings were forming the equivalent of a planetary nervous system. Finally, in describing this super-nervous system, Teilhard likened the billions of human individuals interrelating across the planet to the billions of neurons connected in the brain. Like the organicist sociologists, this vision drew both on the ancient body politic metaphor focused on the body's irreplaceable organs and limbs as well as on the newer superorganism framework that problematically compared individual human beings with replaceable cells.[4] The latter analogy led even Teilhard's non-authoritarian theory to downplay the inherent value of individuals, prompting reductive reasoning similar to totalitarian political leaders and their supporters: in his later writings, Teilhard contemplated radical eugenics as a means for attaining the planetary superorganismic "body of humanity" with "faith in that other higher personality" (Slattery, 2017; Teilhard, 1971)

From human superorganism to living systems theory. Shock at the atrocities committed by totalitarian states and the eventual disavowal of eugenics policies through most of the world led to decades-long suspicion of interpreting any scale of human society in scientific terms as a superorganism, and Teilhard's postwar planetary views never found acceptance in mainstream academic thought in the following decades.

Perhaps as significantly as the widespread suspicion of its sociopolitical consequences, superorganismic conceptions of society were eclipsed by the rise of systems thinking. This shift parallels the replacement of organicism by systems thinking in ecology in the later 20th century.

Not only did superorganicism fade from mainstream sociology, but theorists who looked to organismal biology for understanding human society began to express their conclusions in abstracted systems terms instead. A clear example is the later work of the sociologist Niklas Luhmann, who applied in sociology the theory of autopoiesis ("self-generation") developed by biologists Humberto Maturana and Francisco Varela for studying the origin of life:

> [I]f we abstract from life and define autopoiesis as a general form of systembuilding using self-referential closure, we would have to admit that there are nonliving autopoietic systems, different modes of autopoietic reproduction, and general principles of autopoietic organization which materialize as life, but also in other modes of circularity and self-reproduction. In other words, if we find nonliving autopoietic systems in our world, then and only then will we need a truly general theory of autopoiesis which carefully avoids references which hold true only for living systems. (Luhmann, 1986: 172)

This approach allowed Luhmann to emphasize shared organizational principles in both domains, the living organism and human society, without conflating them. Identifying both social systems and psychological systems as autopoietic yet nonliving became the basis for a transdisciplinary theory of autopoiesis whose overarching principles could be applied separately to living (organismal) or nonliving (social and psychological) entities. Thus, Luhmann highlighted the common features of human society and the biological organism while avoiding the theoretical leap made by earlier organicist sociologists who had represented one domain (human society) as a special case of the other (organismal biology) (Seidi, 2004).

Even James G. Miller, the late 20th century psychologist who made the same leap as the pre-war organicist sociologists by arguing that unified entities from the single cell to international human society were all living organisms, expressed himself in more abstract systems terminology. In his

monumental book Living Systems (Miller, 1978), he developed an elaborate systems schema over more than 1000 pages. Though his analyses of different subsystems and various cross-subsystem interactions can be thought-provoking, they resulted in a system-heavy view of living entities resembling Luhmann more than the biological emphasis of the early organicists or Teilhard.

Moreover, in the 1980s a new conceptual framework "globalization" — developed to describe the interconnectivity of human societies on a planetary scale. Globalization paradigms highlighted the accelerating interconnections and global movements of individuals, processes, and networks affecting different aspects of human life (economic, political, cultural, informational, environmental, etc.) (Beck, 2000; James and Steger, 2014; Ritzer, 2008). Instead of interpreting these processes as proof of a new singular giant living entity gradually emerging, globalization thinkers have limited themselves to describing the processes themselves and, at most, seeking to outline broadly directions and challenges for this latest form of human civilization. While globalization discourse is not explicitly systems-based like Luhmann or Miller, it also largely avoids the conceptual language of biology when theorizing planetary-scale processes.

Part 2: The 21st century return of the superorganism

In the last 20 years, the superorganism concept has reappeared in frameworks that are more biological than systems-based.

This return of the biological superorganism is part of the recentering of the basic concept of organism in biology. In the decades following the mid-20th century's Modern Evolutionary Synthesis, biologists shifted attention away from the organism to focus on levels of scale beneath (genes) or above (populations) it. Recently, for multiple reasons including

(a) the realization that the Modern Synthesis does not provide a fully satisfactory understanding of evolution;
(b) the growing awareness of the limits of reductionism in molecular biology; and
(c) the renewed interest in the nature of life as a genuine scientific problem (Nicholson, 2014)

biologists are shifting some of their attention from populations and genes to reconsider the organism as a key concept. Study of the organismal level is significant to recent developments in fields including origin of life research (Deacon, 2012) and organism-environment interactionist theories such as niche construction (Odling-Smee et al., 2003), as well as to the overarching perspectives of the Extended Evolutionary Synthesis (Laland et al., 2015).

The non-planetary superorganism in the 21st century

Alongside the organism, the superorganism is becoming a renewed focal point in multiple scientific domains at scales smaller than its planetary version.

In medicine and human physiology, the growing realization of the importance of the microbiome has prompted scientists to describe the human individual as a superorganism consisting of a symbiosis of human cells with relatively greater numbers of bacteria and eukaryotes (as well as viruses). While debate about the nature of the human microbiome continues—including basic questions about the relative ratio of human to non-human cells in the average individual or about a theoretical "core" microbiome shared in common by most human beings (Gilbert et al., 2018)—the concept's popularity has led some scientists to announce a "superorganism revolution" (Dorit, 2014). This new conception recasts the human being as more than a union of human cells (more

than an organism). The individual body is seen instead as a superorganismic composite entity of cells of many differently species and genomes (Kramer and Bressan, 2015).

As the *-biome* part of the word suggests, the concept of the human microbiome depends on an analogy to ecology. The word *biome* originated in the ecological superorganicism of the early 20th century described above. Frederic Clements introduced the word in a presentation as a synonym for the biological community: an "organic unit" that "produces a succession of biomes, comparable in practically all essentials to the succession of plant communities"—the kind of succession which, according to Clements' theory, was best understood as a superorganism's progress through a series of developmental phases (Clements, 1916). Given this ecological history alongside the renewed centrality of the organism in the 21st century, it is not surprising that the microbiome has come to be used as a shorthand for understanding the human individual as a micro-ecological superorganism joining human cells with non-human cells. Recent formulations of the microbiome exemplify how new organicist conceptions are offsetting the systems-heavy theories of the late 20th century by repurposing organicist language from a 100 years prior.

Biologists have also begun presenting superorganicist interpretations of higher scales of life, ranging from the eusocial colonies of insects and mole rats to human social groups (Aunger, 2017; Boomsma and Gawne, 2018; Coplan et al., 2017; Gardner and Grafen, 2009; O'Shea-Wheller et al., 2015; Wilson, 2007, 2020; Wilson et al., 2008).

David Sloan Wilson's body of work is noteworthy among these retheorizations of social and eusocial superorganisms. He has developed a theory of superorganism evolution under the specific conditions of "multilevel selection"—a reconceptualization of group selection theory in which multiple levels of functional organization are dynamically interacting, from the level of the individual organism striving to survive and reproduce to the small group and, in principle, to the group of groups. Among biologists, Wilson (2007) has also strongly advocated extending renewed superorganism conceptions from eusocial insect colonies to human collectives, including the religious community and the nation-state.

Unlike the predominant systems approaches of the second half of the 20th century, both the vision of the human individual as a microbiome-integrating superorganism as well as Wilson's theory of superorganisms and higher-order units of selection emerging through multilevel selection depart from the cybernetics/systems theory language of complexity, feedback loops, and control systems. Instead, more traditional concepts from biology—adaptation, function, and evolutionary selection—again become central in superorganism theory.

Gaia and planetary humanity as superorganisms within multilevel selection theory

While these biology-oriented theories of the superorganism now find wider scientific circulation, there is resistance to extending them to the planetary level in either ecological (Gaia) or sociological (human civilizational) form.

Some of this resistance has come from Wilson himself. According to multilevel selection theory, only significant competition occurring at a higher level of scale allows initially loose associations on that level to cohere into true organic unities by countering the presence of competition at lower constitutive levels. For example, sustained competition between various small groups of humans constrains competition between individuals within each group to make certain small human groups cohere and function as superorganisms possessing strong group identities.

The logic that competition at higher levels can counter fragmentation at lower competitive levels complicates any theory that a planetary superorganism could exist, since its emergence would depend first on significant competition between multiple loose planetary associations or proto-superorganisms. Consider the ecological example of Gaia as planetary superorganism: To satisfy the

theoretical requirements of multilevel selection, ongoing competition would need to take place among many different nascent planetary biosphere-geosphere homeostatic unities. Only a proto-Earth-biosphere (Gaia) competing interplanetarily with other biospheres (e.g. a Mars-biosphere and a Venus-biosphere) would in the course of geologic time result in one or more of these planets suppressing lower-level competitions of myriad species to develop stable global physiologies, that is to make the planet function as a single superorganism. This hypothetical scenario finds no support in current scientific knowledge of a solar system in which only one planet possesses a biosphere, that is a solar system with no evidence of interplanetary competition in the past or present.

However, the same multilevel selection perspective leads Wilson to a different conclusion for the prospect of a human sociological planetary superorganism. In this case, Wilson has proposed the kernel of a theory based on the human symbolic capacity to vividly imagine and simulate multiple scenarios for the potential course of planetary civilization. Each possible scenario for humankind becoming interconnected on a planetary scale is seen as a kind of higher-order entity in theory, and each of these theoretical entities is in competition with other visions for being realized. Wilson speculates that the human capacity for symbolic thought and especially human simulation capacity could become potent enough for this ideational competition between planetary visions (rather than between actual planet-biospheres) to offset competition among and between lower-level human social bodies such as nation-states, religions, and corporations. This multilevel dynamic may finally lead to a differentiated but interconnected and coherent planetary civilization, that is a human planetary superorganism. (Honick and Wilson, 2020)

Whether one accepts Wilson's speculative arguments and the multilevel selection theory underlying them, his split perspective—"no" for the ecological version of Gaia; "possibly" for the sociological version of a human global civilization—serve as useful illustrations of how current biological (rather than systems) theorists are variously developing and deploying the planetary superorganism concept.

Gaian reproduction(s)

Even before Wilson's multilevel selectionist appraisal of the planetary superorganism idea in its two forms, biologists had a more basic reason for rejecting Gaia theory's description of the Earth and its biosphere as a living planetary superorganism. For many biologists, living beings are understood to exist necessarily (and only) in reproductive lineages, that is living beings are the products of reproduction, or have the capacity to reproduce, or both.[5] This feature of lineage-participation is key to the evolutionary process which gives rise to organisms adapted to external environments and possessing elaborately homeostatic physiologies (Ruse, 2013). The absence of an obvious reproductive lineage for Gaia led biologists such as Richard Dawkins to discount the theory of a planetary living being out of hand:

> Homeostatic adaptations in individual bodies evolve because individuals with improved homeostatic apparatus pass on their genes more effectively than individuals with inferior homeostatic apparatuses. For the analogy to apply strictly, there would have to have been a set of rival Gaias, presumably on different planets. Biospheres which did not develop efficient homeostatic regulation of their planetary atmospheres tended to go extinct. The Universe would have to be full of dead planets whose homeostatic regulation systems
>
> had failed, with, dotted around, a handful of successful, well-regulated planets of which Earth is one. . . **we would have to postulate some kind of reproduction, whereby successful planets spawned copies of their life forms on new planets**. (Dawkins, 2016: 236, emphasis added)

Dawkins's critique is a simpler version of Wilson's multilevel selectionist critique. Both emphasize the absence of evolutionary selection dynamics that could explain how a fine-tuned Gaian physiology could arise. Wilson underscores how different levels of selection would have to be present for higher-scale competition between worlds to outweigh lower-level competition between species on each world, resulting over time in a major evolutionary transition. Dawkins leaps to treating his hypothetical rival Gaias as a priori unities with varyingly successful geophysiologies, largely avoiding the question of how constitutive parts on lower levels which are themselves living (e.g. single- and multicellular organisms, and species) would end up interdependent in the new unity of a planetary superorganism in the first place.

Yet Dawkins's critique, while less elaborate than Wilson's in terms of selection dynamics, is particularly valuable for making explicit that natural selection from any perspective (multilevel or otherwise) presupposes reproduction, that is participation in a lineage. His argument is that if Gaia as planetary superorganism does not belong to a reproductive lineage, then it cannot have arisen through evolution and selection. And if it does not take part in evolution and selection, then it falls outside evolution by natural selection, the overarching theory embracing all living beings at all scales in contemporary biology. In other words, reproduction/lineage-participation is not an optional criterion among other criteria that Gaia might fail but still be designated a living entity. Instead, lineage-participation is the core trait by which entities are seen to be biologically alive in the predominant framework of the contemporary life sciences.

One response to this critique has been to assert that lineage-participation is not so fundamental a feature of life as biologists claim. Pro-Gaia scientists and thinkers argue that Gaia's planetary scale should be recognized as an emergent level which brings with it new emergent criteria for what it means to be alive; in other words, that the criteria of life are themselves scale-dependent (Bjornerud, 1997; Lenton et al., 2020). This argument by emergence can be paired with another more specific pro-Gaia argument emphasizing homeostasis rather than lineage-participation/reproduction/evolutionary selection as the fundamental feature of a living being (Ruse, 2013). Another in this family of arguments proposes that evolution can operate not only through differential reproduction but also through differential persistence (Doolittle, 2017, 2019).

A different kind of response has acknowledged the Dawkins and Wilson critique but proposed that Gaia does (or soon will) participate in a lineage. According to this argument, Gaia will have reproduced when Earth seeds another planet with a biosphere (Cazzolla Gatti, 2017, 2018; Marshall, 2002; Sagan, 2016; Sagan and Margulis, 1989). The act of seeding (of Gaian reproduction) could occur by humans terraforming non-living planets during space exploration (intentionally or unintentionally). Or, less likely, simpler forms of Earth life such as bacteria could be carried to another planet by non-technological, non-human-facilitated means (e.g. on an asteroid).[6] In both cases, a new planetary superorganism's geophysiology could then arise through the speciation by natural selection of that initial seeding community. The myriad new species on the destination planet would integrate over time with that planet's physical and geochemical processes, as happened on Earth, to form a "descendant Gaia."

A more comprehensive version of the same theory might suggest that Earth's Gaia itself emerged as the product of just such an act of planetary reproduction, that our own microorganism ancestors were seeded by simple life transported from another biospherical planet, from an "ancestor Gaia," either with or without the help of exoplanetary technology. This would mean that Earth's Gaia is a planetary superorganism positioned in the middle or end (rather than the beginning) of a planetary lineage.[7]

Planetary humanity as the product of Gaian reproduction

Understanding Gaian reproduction only as the seeding of another planet overlooks an alternate possibility. If Gaia's designation as a planetary superorganism is based on the recognition that a multitude of differentiated physical processes, species, and organisms over time integrated into global homeostasis, one can first ask if there exists on Earth a comparable collective and composite entity: one which derives from Gaia but has developed its own form of profuse differentiation followed by planet-scale interrelationships and homeostasis. If there is another Gaialike organization on Earth besides Gaia, then we could make the argument that Gaian reproduction has occurred without invoking other planets.

As sociological thinkers beginning at least with Teilhard have suggested, globalized humanity may be exhibiting superorganismic qualities and integrations on an increasingly planetary scale. Humankind is differentiated not into numerous species and physical processes (like Gaia) but into a myriad of cultures, languages, religions, economic systems, technologies, and ways of living and interacting with each other and the more-than-human world. These diverse modes can be said to integrate with varying degrees of success into higher-level "physiology"-like organizations—certainly on local scales such as communities and cities as well as on the meso-level scale of nation-states and religions, but also, arguably, on a planetary scale in an initial dynamic coherence that approximates a global physiology, that is globalization. This human global physiology could, at least theoretically, be one that maintains its coherence through time. Just as Gaia possesses differentiated cycles and systems (e.g. heat, chemical, gaseous, ecosystemic, population-level biological) that interlock and maintain global homeostasis in the face of changing conditions (e.g. the gradual intensification of heat from the sun), globalized humanity develops comparably global, differentiated, and interrelated feedback cycles and systems of its own. Resource distribution through governmental and intergovernmental bodies, circulation of goods and services through global trade and finance, and knowledge gathering and exchange through intercultural relationships (not to mention the waves of affect, narrative, and metaphor traveling between cultures) could conceivably allow a planetary humanity to develop its own versions of homeostasis in response to global perturbations.

How effective a physiology and homeostasis planetary humanity can develop is of course the pressing question, especially in relation to the collective impact of humankind on the Earth System in the Anthropocene. It is increasingly clear that worldwide crises have been initiated and exacerbated by the same globalization processes associated with these superorganismic qualities. Anthropogenic climate change, swiftly spreading pandemics, staggering species loss, resource depletion, and other crises have been intensified by the headlong tilt into greater globalization known as the Great Acceleration (Shoshitaishvili, 2021; Steffen et al., 2015). And these human-driven challenges to human stability and sustainability have shown themselves to also be Gaia's challenges. For humanity to achieve planetary homeostasis rather than spiral further into short-lived runaway globalization now appears critical if Gaia is to preserve some form of its ancient homeostasis. In this sense, the crises of two theoretical planetary superorganisms overlap in the Anthropocene.

What this vision sketches is that planetary humanity may be the first (known) superorganismic offspring of Gaia that exists on a comparable global scale. Unlike other single living species, humankind has not only become global but differentiated itself into an immense cultural and technological diversity that now interrelates through globalization to present at least the theoretical prospect of planetary homeostasis (alongside the threat of precipitous planetary collapse). Moreover, human technologies entangle human activities profoundly and globally with the many physical processes of the planet, an analogy to Gaia's entanglement of the biosphere's activities

with Earth's physical processes. Therefore, in spite of crucial differences such as human reliance on symbolic culture and technology and the destabilizing speed with which humankind is becoming interconnected on a planetary scale, globalized humanity may well be the most Gaialike collective entity in view, besides Gaia itself.

This way of understanding Gaian reproduction leads back to the conceptual puzzle posed at the start of this article: How can two planetary superorganisms, ecological and sociological, coexist on the same planet? When seen through the lens of lineage and reproduction, the puzzle is not only conceptual but environmental, Anthropocenic, and even in some sense "familial" on a planetary scale. In the course of planetary development, Gaia, the ecological superorganism, produced global interconnected humanity. Humankind can be seen as its first planetary "child," whose arrival brings instability to the parent entity with which the single Earth is shared. Recognizing Gaia as belonging to the speculative meta-biological category of planetary superorganism—as a planetary being participating in a planetary reproductive lineage—may also mean confronting our own planetary identity as its destabilizing offshoot.

Part 3: Relevance for the Anthropocene

What does this perspective offer contemporary discussions of the Anthropocene, the concept of the planetary, and Gaia?

Adding specificity to "humankind" in the Anthropocene

First, it provides a more specific conception of the collective "humankind" implied in the Anthropocene. The Anthropocene as an epoch relies on the conception of humankind as a collective, cumulative, and out-of-control geophysical force. This framing is based on the physics concept of "force," which emphasizes impact while hinting at the possibility of equal and opposite geophysical reactions. But this framing reveals little about the rationale for treating humankind as a collective entity (*anthropos*) coherent enough to be said to exert force in the first place. Couldn't a person avoid Anthropocene conclusions and debates by continuing to see humanity as a completely unstructured multitude of billions of individual and trillions of motivations and forces, none of which on its own qualifies as being "geophysical" in scale?

Theorizing humankind's superorganismic traits on a planetary scale—the complex diversifications and interrelations of technological, cultural, and economic globalization processes—complements the Anthropocene framing with an account of what humankind is developing into, of what kind of meta-organization or meta-entity or hypersubject can be said to exert planetary force (even a destructive form of such force). The theoretical biological ideas of differentiation, interdependency, and functional integration into organism-like coherence provide an initial basis for conceptualizing humankind as a planet-scale composite entity that disrupts planetary processes while displaying at least the potential to reorient toward new forms of planetary homeostasis. In other words, the idea of humankind as a vastly diversifying but also increasingly interrelating planetary phenomenon—a humankind expressing initial planetary superorganismic features comparable to Gaia's—posits a background theory for scientific descriptions of monumental human influence on the Earth System and biosphere in the Anthropocene.

Navigating between Anthropocentrism and Gaiacentrism

At the same time, the comparison of human planetary being to Gaia confronts us with the fact that even as an Earth-encompassing interlinked collective phenomenon we are precisely neither central

nor alone. Rather, when theorizing superorganismic humankind on the planetary scale, we appear next to a comparable planetary entity, Gaia, a composite unity which is both like and unlike our own. In this way, investigating the concept of superorganismic planetary humanity *alongside* superorganismic Gaia may help check versions of Anthropocene theory that scholars worry could fuel anthropocentrism (Haraway, 2016; Sideris, 2017).

The proposal is to hold both theoretical mega-entities in view as soon as either is invoked. Recognizing the superorganismic features in planetary humankind is only the beginning of the process. If Gaia's superorganismic features are ignored or excluded in the process (as they have been in sociological versions of planetary superorganism theory from Teilhard to Stock), the result will indeed be a narrow anthropocentrism artificially limited to only one of two coexisting planetary superorganismic configurations. The sociological planetary vision in these cases becomes a misguided celebration (or, less often, condemnation) of humankind which fails to recognize its parallel ancient (parent) entity—a theoretical oversight that contributes to continued harm in their planetary interactions.

Gaia theorists face a similar challenge. While locating the biosphere's and Earth System's superorganismic features in Gaia, they often position humankind as a component of Gaia: as Gaia's cancer or Gaia's growing nervous system (Lovelock, 2000; Lovelock and Epton, 1975). Yet this neglects the realization that humanity's globalization is giving rise to the very kinds of features—the complexity of cultural and technological differentiations and integrations that give the entire global human system at least the possibility of responding to external perturbations and internal imbalances—whose biogeochemical analogs made Gaia distinguishable as a superorganismic entity in the first place. If we fail to properly recognize and theorize these superorganismic aspects of human planetary identity next to Gaia's, we may foreclose a full understanding of human collective agencies and vulnerabilities in the Anthropocene. We may lament Gaia's disruption without fully recognizing the complex parallel significance of interrelating cultures and technologies on multiple scales, including the planetary.

Elements of the perspective shift proposed here exist in contemporary ideas such as Gaia 2.0, the "Symbiocene," (Albrecht, 2016) and Vladimir Vernadsky's "coevolution of the noosphere and biosphere." To focus on the most recent: Timothy Lenton and Bruno Latour have outlined broad principles human beings can adopt and adapt from Gaia ("autotrophy," "heterarchy," "networks") in order to self-regulate our global activities. This process of learning from Gaia could contribute to a Gaia 2.0 that incorporates into planetary feedback loops a technology- and symbol-using humanity. Kim (2021) recently built on this idea, outlining how international environmental law could be reframed around the concept of a "ruptured Anthropocene" to facilitate the integration of self-aware human activity into Gaia 2.0. These theories could be interpreted as descriptions of how relationships could form between comparable entities (in this case, between hypercomplex and hyperdiverse planetary entities): Lenton and Latour's humankind "learning" from Gaia as part of a newly realized "relation between free agents"; Kim's humankind "negotiating with" and "taming" Gaia.[8]

I would add to their efforts a shift in emphasis. For Gaia to become "Gaia 2.0" should not mean theories of Gaia successfully subsuming humanity into itself. Instead, it could mean conceiving a vision of Gaia *and* a vision of humankind as two partially distinct collectivities of agencies exhibiting superorganismic features and coming to exist in sustainable relationship with each other. In other words, based on the historical outline and conceptual arguments above, "Gaia 2.0" presupposes a globalizing "humankind 2.0." In fact, the "2.0," rather than stably fixed to either planetary entity on its own, would better designate an ongoing situation where both become recognizable as interlinked and interdependent composite entities (parent-child) that are now challenged to reestablish their connections with each other.

To some extent, this conclusion runs counter to arguments that distinctions between "nature" and "culture" or between "humanity" and the "natural world" or between "geological time" and "human historical time" have collapsed in the Anthropocene. (Biermann, 2021; Folke et al., 2020; Lenton and Latour, 2018; Lövbrand et al., 2020) A simple dichotomy may have collapsed, but the Anthropocene may represent precisely the geohistorical framework in which we have good reason to think about the differentiation of one planetary phenomenon from the other. Instead of the separate and transcendental categories of "culture" versus "nature," we can explore the possibility that a "noodiverse"[9] planetary superorganismic entity is emerging from, and encountering, its "biodiverse" parent entity. "Facing Gaia," in Bruno Latour's phrase adapted from Lovelock, would therefore also always entail Gaia facing a planetary "humankind" developing and exhibiting a comparable complexity of its own. This vision of interactive duality between "Gaia" and "globalizing humankind" has the advantage of precision in the specific scale and core features to which it applies—that is the planetary scale and superorganismic features. It would hopefully offer a more productive basis for discussions of planetary identities, agencies, and governance models in the Anthropocene than the rigid binary of "nature" and "culture."

Sociopolitical dangers of asserting the superorganism concept simplistically

In addition to providing a framework for understanding collective human and more-than-human activities in the Anthropocene, more rigorous investigation of the superorganismic aspects of the planetary are necessary to offset the sociopolitical pitfalls riddling superficial uses of the concept. The dangers were most obvious in the historical relationship of the superorganism concept to 20th century totalitarian and eugenics movements, summarized in Part 1 above. But even recent treatments have occasionally asserted the human superorganism as a totalizing kind of description and strayed into alarming territory: brainstorming eugenics measures such as releasing a virus to sterilize human beings as a method of checking overpopulation for the sake of the global human superorganism's health (Stock, 1993) or equating human beings who diverge from and disrupt laws and social norms with "social parasites" whose punishment/injury/death could be justified as a legitimate "immune" response by the human superorganism. The errors here are that thinkers are tempted to see the "superorganism" as an answer rather than a question, as a more straightforward category than it really is—as though, aside from greater scale, the superorganism is nearly the same as the multicellular organism. This kind of error can lead theorists to understand human beings and human communities too simplistically through our current understanding of cells and groups of cells. This results in comparisons, asserted in scientific language, of human beings to cancers and parasites or to constituent parts whose reproduction can be controlled for the good of the whole.

Gaia theory faces analogous challenges. As mentioned above, its superorganismic aspects can lead to analogies of humankind as a whole to a planetary cancer (Lovelock, 2000). There are also fears that Gaia theory could be twisted into pseudo-intellectual support for forms of "ecofascism" or totalitarian movements in the future (Latour et al., 2020; Marshall, 2002).

Some thinkers have already sounded the alarm and proposed we forego the terms "organism" or "superorganism" for Gaia (Lenton and Latour, 2018). And contemporary sociology already mostly avoids the term for human groups. This article has also frequently relied on qualified phrases such as "superorganismic entity" and "superorganismic features" to try and prevent misinterpretations that a planetary superorganismic entity *is* a multicellular organism just on a planetary scale. The more significant effort, in this regard, is the overall argument: Seeing Gaia and humankind as two interacting planetary superorganismic entities should make it harder to stumble into an overly simplistic or totalizing vision of either one.

But avoiding the concept of the planetary superorganism wholesale may not be possible or desirable. Scholars, scientists, and journalists are thinking and writing in planetary superorganicist terms increasingly as megatrends such as globalization, Earth System disruption, and the pandemic continue to unfold (Hagens, 2020; Vince, 2020; Wilson, 2020). Therefore, there need to be direct engagement with the concept's history and more attempts to theorize it with care for its limitations. I hope this review helps more thinkers across disciplines enter this space.[10]

Acknowledging its dangers and limitations, the planetary superorganism, when seen as potentially plural, may be the concept best suited for a particular function: It brings home the impression that on the planetary scale of the Anthropocene we may be troubled participants in the Earth becoming doubly alive.

Acknowledgement

I'm very thankful to David Christenson, Francisco Cruces, Terrence Deacon, Tammo Feldmann, Michael Jacob, Adiv Johnson, Ben Kacyra, Brian Pines, Parham Pourdavood, David Ronfeldt, Jaida Samudra, Max Shokhirev, Rick Steele, Brian Swimme, Clément Vidal, and the members of the Teleodynamics Research Group for valuable insights and suggestions. I'm also grateful to the two anonymous reviewers whose suggestions and critiques significantly improved the manuscript.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Funding for this research was provided by the Human Energy Project, a nonprofit initiative of the Kacyra Family Foundation.

ORCID iD

Boris Shoshitaishvili https://orcid.org/0000-0002-8566-2948

Notes

1. Part 1 is a selective overview of early theories of the *superorganism* idea that gives context to the following discussions in Part 2 and Part 3, not a detailed analysis of *organicist thought* more generally. I encourage readers interested in organicism—that is the mindset and approaches privileging holism and analogies to living beings, often contrasted with mechanistic theories in the life sciences—to consult Haraway (1976), Marshall (2002), and Ruse (2013).
2. Lovelock (1988) did later note the importance of theoretical ecology for Gaia Theory. See also Egerton (2019).
3. Some organicists like Herbert Spencer did highlight differences, yet overall it was the similarities and the prospect of scientific credibility that the social superorganism concept could give sociology that remained central in their thinking and writing.
4. The human planetary superorganism was Teilhard's understanding of the broader concept of the "noosphere," the planetary thinking layer emerging with human beings out of Earth's biosphere. The "noosphere" was contemporaneously articulated in non-organicist terms by the Russian geochemist Vladimir Vernadsky as a new stage of Earth's geological and biological evolution, but Teilhard described it specifically as a planetary superorganism created by the convergence of human beings and human societies from around the world (Vernadsky, 1945).
5. Even organisms who are sterile (e.g. worker bees) or simply do not reproduce in their lifetimes are nevertheless part of a lineage by being the products of reproduction.

6. If the probability of pre-technological interplanetary seeding turns out not to be vanishingly small, then it may have already occurred. At some point in the long history of life on this planet (the last 3.8 billion years), Earth's Gaia may have seeded another planet with a biosphere—for example if some of our microorganisms traveled on an asteroid to a new planetary home where their speciation led to the formation of a new biosphere fitted to that planet. In theory, Earth's Gaia may have already reproduced without human beings having realized it.
7. Interestingly, in the version where Earth's Gaia is the first Gaia, the puzzle of its status as a living entity, as a planetary superorganism, becomes analogous to the question of life's ultimate origin on the smallest scale of the first cell-like microorganism(s). If life as a whole depends on reproduction yet the origin of life was also the origin of reproduction and lineage (and evolution), then the very first life form(s) could not have themselves evolved but must have "emerged." Abiogenesis, the study of the origin of life from non-life, has multiple theories of how this emergence before reproduction might have occurred. Analogously, if Earth's Gaia is the first planetary superorganism, then its arising may be the precondition for, rather than product of, planetary reproduction. Gaia may have emerged in a manner similar to the first proto-cell(s), and it may become the origin of a differentiating lineage of planetary superorganisms just as the first cell(s) was the origin of a differentiating lineage of species on Earth.
8. "Taming" made somewhat less problematic when Kim relates the term to "taming complexity" and to St. Exupéry's *Le Petit Prince*, where it means "establishing ties" and "becoming responsible forever for what you have tamed."
9. Or "homodiverse," to follow Latour and Porter's (2017) important call for "homodiversity."
10. The Anthropocene also prompts us to evaluate parallel frameworks for planetary identity, such as the "-spheres" paradigm of the "geosphere," "biosphere," and "noosphere" (Moiseev, 1993; Oldfield and Shaw, 2006; Rispoli and Grinevald, 2018; Shoshitaishvili, 2021). It would not be surprising if multiple frameworks are required for thinking carefully about the interactions, forces, collectivities, and entities now diversifying and interrelating on the planetary scale. Relating such frameworks to each other is another task to be undertaken.

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