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Swarms, Colonies, Flocks, and Schools: Exploring the Ontology of Collective Individuals
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It is likely that upon observing the effortless turning and looping ballet of a flock of pigeons or school of fish you have asked yourself the question, "How do they do it?" As Brian Partridge noted in a *Scientific American* essay from the 80s:

Virginia Batson. *generate, gestate, grow #9*. 2008. Pencil, needle, and glue on paper. 7x7 in.

> [This] question occurs naturally to anyone watching a school of silversides moving slowly over a reef in clear tropical waters. Hundreds of small silver fish glide in unison, more like a single organism than a collection of individuals. The school idles along on a straight course, then wheels suddenly; not a single fish is lost from the group. A barracuda darts from behind an outcropping of coral and the members of the school flash outward in an expanding sphere. The flash expansion dissolves the school in a fraction of a second, yet none of the fish collide. Moments later the scattered individuals collect in small groups; ultimately the school re-forms and continues to feed, lacking perhaps a member or two.[1]

Or consider the ostensibly simple act of a honeybee foraging for nectar as Bert Hölldobler and E.O. Wilson describe it in their 2009 collaboration *Superorganism*:

> Although simple in appearance, the act is a performance of high virtuosity. The forager was guided to this spot by dances of her nestmates that contained symbolic information about the direction, distance, and quality of the nectar source. To reach her destination, she traveled the bee equivalent of hundreds of human

> miles at bee-equivalent supersonic speed. She has arrived at an hour when the flowers are most likely to be richly productive. Now she closely inspects the willing blossoms by touch and smell and extracts the nectar with intricate movements of her legs and proboscis. Then she flies home in a straight line. All this she accomplishes with a brain the size of a grain of sand and with little or no prior experience.[2]

Finally, consider the complex forms of social organization achieved by African driver ants:

> Viewed from afar, the huge raiding column of a driver ant colony seems like a single living entity. It spreads like the pseudopodium of a giant amoeba across 70 meters or so of ground. […] As the column emerges, it first resembles an expanding sheet and then metamorphoses into a treelike formation, with the trunk growing from the nest, the crown an advancing front the width of a small house, and numerous branches connecting the two. The swarm is leaderless. … These predatory feeder columns are rivers of ants coming and going. The frontal swarm, advancing at 20 meters an hour, engulfs all the ground and low vegetation in its path, gathering and killing all the insects and even snakes and other larger animals unable to escape. After a few hours, the direction of the flow is reversed, and the column drains backward into the nest holes.[3]

How indeed are such coordinated efforts possible? How can each of these simple brained and seemingly independent individuals achieve such impressive acts of coordination, communication, and collaboration? Witnessing such performances, it is understandable why in the late nineteenth and early twentieth century some researchers believed that the corporate behavior of flocks of birds, schools of fish, and colonies of ants, bees, and termites involved some undiscovered form of telekinesis.

Organisms and Superorganisms

Contemporary research has instead revealed that swarms of birds, fish, and insects are in fact leaderless systems more akin to a single living organism than a mere collection of individuals.[4] The school, flock, and colony, it turns out, has just as much right to the title "individual" as does the solitary fish, bird, bee, ant, or termite.[5] Indeed, the degree of unity achieved by some societies of social insects – such as army ants, weaver ants, termites, and honeybees – is so great that many sociobiologists characterize them as "superorganisms." As one prominent researcher, Thomas Seeley, notes, "A colony of honey bees, for example, functions as an integrated whole and its members cannot survive on their own, yet individual honey bees are physically independent and closely resemble in physiology and morphology the solitary bees from which they evolved. In a colony of honey bees two levels of biological organization – organism and superorganism – coexist with equal prominence."[6]

The term "superorganism" was coined in 1910 by the sociobiologist William Morton Wheeler, who noted the striking similarities between, on the one hand, caste and division of labor in social insect colonies and, on the other hand, the functioning of cells and organs in individual organisms.[7] Individual members of a colony function in much the same way that individual cells do in the human body. For instance, just as particular cells in the body specialize and collectively perform certain functions within the body, particular ants or bees are members of specific "castes" which perform specific tasks, such as reproduction, defense, and food distribution. This isomorphism between an individual organism and a superorganism is nicely captured in the following table from Hölldobler and Wilson.[8]

Organism	Superorganism
Cells	Colony members
Organs	Castes
Gonads	Reproductive castes
Somatic organs	Worker castes
Immune system	Defensive castes; alarm-defense communication; colony recognition labels
Circulatory system	Food distribution, including regurgitation between nestmates (trophallaxis), distribution of pheromones, and chemical cues
Sensory organs	Combined sensory apparatus of colony members
Nervous system	Communication and interactions among colony members
Skin, skeleton	Nest
Organogenesis: growth and development of the embryo	Sociogenesis: growth and development of the colony

What is all the more amazing is that this intense coordination of behavior is, in fact, self-organizing; there is no leader. By following very simple algorithms or decision rules colonies collectively achieve feats unthinkable by the individuals of which they are comprised, such as finding the shortest path to food, selecting a suitable nest site, defending the nest from invaders, maintaining a narrow range of optimal nest temperature, allocating workers to different tasks, distributing food.[9] "Nothing in the brain of a worker ant represents a blueprint of the social order," Hölldobler and Wilson write. "There is no overseer or 'brain caste' who carries such a master plan in his head. Instead, colony life is the product of self-organization. The superorganism exists in the separate programmed responses of the organisms that compose it. The assembly instructions the organisms follow are the developmental algorithms, which create the castes, together with the behavioral algorithms, which are responsible for moment-to-moment behavior of the caste members."[10] "Thus," Hölldobler and Wilson continue, "a distributed colony intelligence is created greater than the intelligence of any one of the members, sustained by the incessant pooling of information through communication."[11] It is the emergence of a "distributed colony intelligence" or what many researchers call "swarm intelligence" that makes such complex integrated behavior possible.[12] As a collective individual they achieve forms of social organization rivaled only by humans.[13]

These findings introduce many interesting and important metaphysical issues. Understanding how millions of insects can coordinate their behavior so closely that they become a single collective individual introduces fascinating problems regarding individuality, identity, the boundary between the living and non-living, the origin of societies, and perhaps a key to the evolutionary origins of consciousness itself. The philosophical question which seems most immediately pressing is, "How would it be best to *explain*, not just describe, the emergence and maintenance of these forms of order?"

For their part, many scientists continue to use the metaphor of mechanism to describe the order of social insects. For instance, despite the fact that they describe insect societies as "emergent" forms of social order that arise through the collective "decision making" of individual insects, at times Bert Hölldobler and E.O. Wilson describe the colony as "a growth-maximizing machine"[14] composed of "cellular automata"[15] whose operations can be described by the languages of physical and computer sciences.[16] Thomas Seeley is even more explicit in his use of the mechanistic model. "In choosing a nest site," he writes, "building a nest, collecting food, regulating the nest temperature, and deterring predators, a honey bee colony containing a queen resembles a smoothly running machine in which each part contributes to the efficient operation of the whole." Indeed, he goes even further, arguing that, "It should be very revealing, and at most only slightly misleading, to view a honey bee colony as an integrated biological machine that promotes the success of the colony's genes."[17] Seeley's view is representative of both of the dominant trends within modern biology: molecular biology and neo-Darwinism.

As the biologist Scott Turner perceptively notes, the former, molecular biology, has "relentlessly pursued an understanding of life as a mechanism, as a special case of chemistry, physics, and thermodynamics."[18] The latter, neo-Darwinism, has come to focus exclusively on the transmission of genes, as is perhaps best represented by Richard Dawkins' "extended phenotype." An unintended consequence of these two trends, Turner notes, is the gradual disappearance of the very notion of an organism. For molecular biologists, "the organism itself has become, at best, an unwelcome distraction from the fascinating cellular and molecular business at hand," and for the neo-Darwinist "the organism has become essentially an illusion, a wraith obscuring the 'real' biology of the genes, bound together in a conspiracy to promote the genetic interests of its members."[19] Much of Anglo-American philosophy is, for its part, largely in keeping with this account. Despite what I take to be its limited explanatory force, some version of mechanistic physicalism is so widely accepted among a certain segment of philosophers that it scarcely requires defense.

However, as the philosophers Alfred North Whitehead, Charles Sanders Peirce, William James, John Dewey, Henri Bergson, Pierre Teilhard de Chardin, and others so forcefully argued in response to an earlier generation of physicalists, the mechanistic metaphor cannot adequately do justice to the reality of living, evolving, striving, emoting, beings connected in interdependent social relations. Indeed, at times there is strong evidence to suggest that Hölldobler and Wilson perceive the inadequacy of the mechanistic model.

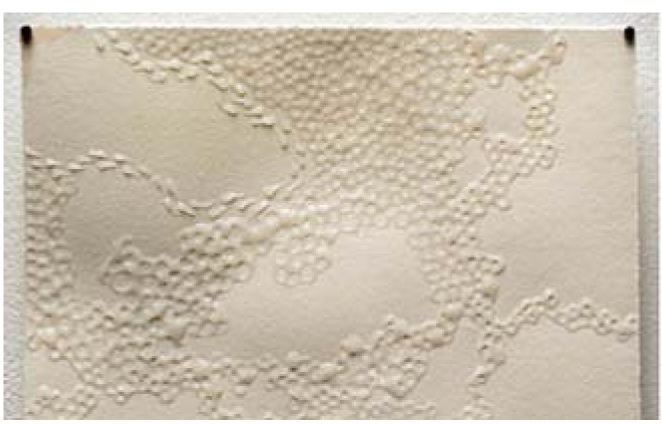
> Watched for only a few hours, a colony of social insects might be

> interpreted as consisting of automata driven with the same uniform set of decision rules. But that is far from the case. Each member of the colony is distinct in some manner or other that affects its behavior. Each has a mind of its own. By mind we do not mean a reflective, self-aware, wide-roaming consciousness of the human kind, but rather a cognitive consciousness built with a relatively complex brain that can store information from all its sensory modalities (taste, smell, touch, sight, and sound) as well as some memory of the events it has experienced during its short life.[20]

Though comparatively simple, an individual insect is not an interchangeable machine part, nor is it "a simple automaton."[21] Even on Hölldobler and Wilson's account, the algorithms upon which individual insects make their decisions are not rigidly deterministic, they are rather "central tendencies."[22]

If we are to adequately capture the beauty and dynamism of these complex societies of individuals, if we are to explain, and not just describe, how these patterns of behavior emerge and are perpetuated, we need a more adequate model of the relationships between individuals. We need, as it were, an explanatory framework for describing how social order can emerge. I will argue that, although not fully adequate, Alfred North Whitehead's "philosophy of organism" provides the most adequate conceptual toolbox for explaining the ontological status of collective individuals and thereby points beyond the current hegemony of reductive molecular biology and neo-Darwinism.

Alfred North Whitehead (1861-1947) developed his "philosophy of organism" in opposition to two historical trends: the longstanding tradition of substance ontology, particularly as it came to be defined in the modern era by Rene Descartes, and the early twentieth century trend toward what Whitehead called "scientific materialism," of which physicalism is the contemporary heir. According to Whitehead's organic view of individuality, there are no discrete individuals (or independent substances) mechanistically determined by absolute laws of nature. Although the mechanistic metaphor has been wildly successful, it ultimately does not do justice to the complex interrelations between individuals. We ought, Whitehead presciently insisted, to abandon the mechanistic metaphor in favor of the metaphor of organism, according to which individuals are determined by internal relations and nested within ever expanding environments. "The only way of mitigating mechanism is by the discovery that it is not mechanism."[23]



On this organic model of individuality, the ontological fabric of the universe contains no true gaps.[24] Thus, the difference between, for instance, a wildflower and a boulder is ultimately found not in an appeal to different ontological kinds, but in the difference in the *degree* of "coordination" achieved by the occasions of which each is composed.[25] "The organic starting point is from the analysis of process as the realization of events disposed in


Virginia Batson. generate, gestate, grow #12. 2008. Pencil, needle, and glue on paper. 7x7 in.

an interlocking community. The event is the unit of things real. The emergent enduring pattern is the stabilization of the emergent achievement so as to become a fact which retains its identity throughout the process."[26]

The macroscopic objects which we experience – e.g., desks, bees, trees, rocks – are what Whitehead calls "nexûs" (the plural form of nexus) of actual occasions which are real, individual and particular "in the same sense" in which their constituent occasions are real, individual, and particular. Actually, to be more precise, entities such as bees and trees are particular types of nexûs which Whitehead refers to as "societies." While all societies are nexûs, not all nexûs are societies. For Whitehead, it is societies and nexûs, not actual occasions, which are the "things" that endure and that have adventures. "The real actual things that endure are all societies. They are not actual occasions. It is the mistake that has thwarted European metaphysics from the time of the Greeks, namely, to confuse societies with the completely real things which are the actual occasions."[27]

On this view, a society is not an "aggregate" of "discrete," "externally related" beings held together in an "extrinsic unity." Rather, a society is a *socially ordered* nexus of *internally* related events that form an *intrinsic* unity. Societies are *not* mere collections, aggregates, or assemblages of entities to which the same class-name applies. This is the difference between a nexus and a society. Whereas a nexus is simply any real fact of togetherness, including extrinsic unities such as aggregate entities, e.g., boulders, a society is a particular type of nexus which enjoys "social order." That is, a society's constituent occasions share a common "defining characteristic" because of the conditions imposed upon them by their *internal* relatednesswith previous members of that self-same society. Hence, contrary to aggregate entities, complex structured societies such as plants and animals are organic entities that, like systematic entities, are characterized by, as the philosopher Frederick Ferré puts it, "strong internal relations between parts that vary with one another and together perform a common function. The entity as a whole is what it is because of the [constitutive] interplay of these parts, and without them would cease to be an entity of that kind."[28]

All macroscopic individuality, on this reading, is a matter of order. If the degree of order is particularly high and the potential for novelty is introduced, then it is a living society. If it is higher still it may be a personal society. Though a colony of weaver ants or honeybees may not have the same degree of intrinsic unity as a plant or animal, for instance, they are nonetheless real forms of togetherness with properties of their own. In this way, the organic model is better able to *explain* the unity of experience which perduring macroscopic individuals possess. A Whiteheadian organic model of individuality not only meets the challenge of providing an adequate account of the experienced unity of macroscopic individuals, but it does so with greater explanatory depth.

With this organic model of individuality in hand, I would like to examine one final illustration of collective individuals, this time from macrotermes colonies or African termites. Take the complex architecture of termite mounds. As Scott Turner notes in his fascinating essay, "A Superorganism's Fuzzy Boundaries," opening a mound reveals "a capacious central chimney from which radiates a complex network of passages, connecting ultimately to an array of thin-walled tunnels that lie under the mound's surface like veins on an arm." Beyond the impressiveness of the construction, what is most surprising, Turner notes, is what you do not see, namely termites. The mound, it turns out, is not built to house the millions of termites that continually maintain it. They live in a large spherical nest under the mound.[29] To understand the mound's purpose requires that we examine termites' dietary habits.

Termites, Turner explains, are unable to digest the bits of grass, bark, dead wood, and dung that they swallow. Instead, each species of termite cultivates a particular species of fungus that can break down the material into a digestable form. However, this digestive arrangement significantly increases the oxygen requirement of the colony, since the fungus requires five times the oxygen of the termites.[30] According to Turner, "This fungus, together with the bacteria and other soil microorganisms, raises the oxygen requirement to the amount needed by a cow. Indeed, ranchers in northern Namibia think of each termite ground mound as the equivalent of one livestock unit: each nest's foraging insects eat about the same quantity of grass as would one head of cattle. A cow buried alive would soon die without access to air, and so it is with a termite colony: without ventilation, it would suffocate."[31]

The mound, therefore, is not a residence or even a defensive structure, it is an external lung. By building the mound up vertically, the natural force of the wind exchanges the air through the network of capillary tunnels.[32] "Thus," Turner concludes, "the regulated environment, maintained by a constructed physiological organ – the mound – furthers the interests of both groups of inhabitants. The termite colony – insects, fungus, mound, and nest – becomes like any other body composed of functionally different parts working in concert and is ultimately capable of reproducing itself. Taken as a whole, the colony is an extended organism."[33] The subterranean nest is like the skin or skeleton of an organism, the fungus serves as its digestive system, the mound the respiratory system, various castes serve as the reproductive, sensory, immune, and nervous systems. Though a complete organic unity itself, a single termite is unintelligible apart from the collective organism of which it is a member. Indeed, as Turner himself notes at the end of his article, "Understanding the system requires thinking about the mound as not really an object but a process."[34] "In the case of termite mounds," he continues, "the termites and fungi certainly qualify as living, but so does the mound, in a sense. After all, it does just what our lungs do for us. The primary difference is in perspective. For a human, what is inside the body is pretty clear, but for the termite colony, 'inside' includes the nest environment."[35]

Recognizing that an entire colony – nest, mound, insect, and fungus – is a single organic individual undermines the longstanding conception of individuals as discrete beings. As Turner puts it, "if the existence of physiological function is not dependent upon a clear partition of an organism from its environment, then there seems to be little reason to regard the organism as an entity discrete from its environment."[36] Whitehead's philosophy of organism provides a rich metaphysical basis for Turner's biological account of the "extended organism." Returning to a holistic, organic model such as that developed by Whitehead provides an avenue for overcoming the reductionism that has come to dominate both science and philosophy throughout the late twentieth and early twenty-first century. In the epilogue to his fascinating study *The Extended Organism*, Turner suggests that, although their explanatory success is indubitable, the main intellectual contributions of molecular biology and neo-Darwinism have already been achieved; their best insights are behind them.

Molecular biology may have a rich future in developing new industrial applications, Turner writes, but “there is also nothing to come from it that will make us think about the world in a fundamentally different way….”[37] Similarly, as the proponents of neo-Darwinism are “engaged in endless rancorous debate over ever more arcane and abstract subjects” the field is becoming “scholastic” and “is now looking a bit frayed and dowdy.”[38] If Turner is right that “the path to biology’s next Golden Age will involve breaching the essentially arbitrary boundary between organisms and the environment, to create a biology that unifies the living and the inanimate worlds,”[39] there is good reason to believe that Whitehead’s philosophy of organism will be an important part of the revolution.

Endnotes

[1] Brian L. Partridge “The Structure and Function of Fish Schools,” *Scientific American* 246.6 (1982): 114.

[2] Bert Hölldobler and E. O. Wilson, *The Superorganism*: *The Beauty, Elegance, and Strangeness of Insect Societies* (New York: Norton, 2009), 4. As a prominent researcher, Thomas Seeley, noted “Within colonies there are various tappings, tuggings, shakings, buzzing, stroking, waggling, crossing of antennae, and puffings and streakings of chemicals, all of which seem to be communication signals. The result is that within a honey bee colony there exists an astonishingly intricate web of information pathways, the full magnitude of which is still only dimly perceived” (Thomas D. Seeley, “The Honey Bee Colony as a Superorganism,” *American Scientist*. 77.6 (1989): 550). See also, “The essential element in the performance is the waggle run, or straight run; it is the middle piece of the figure-eight dance pattern, and it conveys the direction of the target during the outbound flight. Straight up on the vertical surface represents the direction of the sun the follower will see as she leaves the nest. If the target is on a line 400 to the right of the sun, say, the straight run is made 400 to the right of vertical on the comb” (Hölldobler and Wilson 169). “The waggle dance conveys more information than just the direction of the outbound flight. The duration of the waggle run is correlated with the distance of the food site from the hive: farther away the site, the longer each waggle run takes. Circumstantial evidence suggests that the key element in the signal is the duration of the buzzing sound” (171).

[3] Hölldobler and Wilson, xx.

[4] As Iain Couzin argues in his 2007 *Nature* essay “Collective Minds,” “The organising principles employed by ants provide no evidence for leadership; in fact, they demonstrate that leadership is unnecessary to co-ordinate complex group behaviour. We now know that group behaviour may be co-ordinated by relatively simple interactions among the members of the group, a process termed ‘self-organization’” (38).

[5] This is not to say that a flock of birds is as integrated as a colony honey-bees. As I will suggest, integration is a matter of degree.

[6] Seeley, 546-47.

[7] Cf. Hölldobler and Wilson, 85. “William Morton Wheeler, in his famous 1911 essay ‘The Ant-Colony as an

Organism,' brought the concept explicitly into sociobiology. 'The ant-colony is an organism,' he wrote, 'and not merely the analogue of the person.' The colony, Wheeler pointed out, has several diagnostic qualities of this status: (1) it behaves as a unit. (2) It shows some idiosyncrasies in behavior, size, and structure, some of which are peculiar to the species and others of which distinguish individual colonies belonging to the same species. (3) It undergoes a cycle of growth and reproduction that is clearly adaptive. (4) It is differentiated into "germ plasm" (queens and males) and 'soma' (workers)" (Hölldobler and Wilson 10).

[8] Ibid., Figure 5.1, 85.

[9] Peter Miller, "Swarm Theory," *National Geographic* 22.1 (2007): 127-142. As Sakata and Katayama put it in their article on ant colony defense systems, "A colony of social insects, consisting of a large number of individuals, shows highly context-specific and well-organized behavior, similar to a sophisticated organism…. Within each colony, each individual gathers only a small part of the information necessary for decision-making, and makes only a limited response. Sophisticated behavior of an organism often consists of responses of many subunits (e.g. organs and cells). A colony of social insects is an excellent model to observe the mechanism of information processing and decision-making through interactions among subunits with limited skills…" (Hiroshi Sakata and Noboru Katayama, "Ant defence system: A mechanism organizing individual responses into efficient collective behavior," *Ecological Research* 16.3 (2001): 395). For a simple account of such rule following, see Hölldobler and Wilson, 65: "Her decision rules can be stated as follows: (1) Not enough nectar collectors in the field? If yes, and if you also have immediate knowledge of a producing flower patch, perform the waggle dance. (2) Is the flower patch rich or the weather fine or the day early or does the colony need substantially more food? Perform the dance with appropriately greater vivacity and persistence. (3) Not enough active foragers to send into the field? Perform the shaking maneuver. (4) Not enough nectar processors in the hive to handle the nectar inflow? Perform the tremble dance. Hundreds of bees making such decisions more or less simultaneously yield the overall response of the superorganism."

[10] Hölldobler and Wilson, 7.

[11] Ibid., 58-9.

[12] Passino, Seeley, and Visscher give an excellent example of swarm cognition in their study of honeybee nest selection. "The swarm's distributed group memory is distinct from the internal neural-based memory of each individual bee. What is known by the swarm is actually *far more* than the sum of what is known by the individual bees, as the swarm's knowledge includes the information stored in the bees' brains *and the information coded in the locations of the bees and their actions.* No bee can know all the locations and activities for all other bees. But this information is coded at the swarm level and … is explicitly used in decision making" (Kevin M. Passino, Thomas D. Seeley, and P. Kirk Visscher, "Swarm cognition in honey bees," *Behavioral ecology and sociobiology* 63.3 (2008): 407, authors' emphasis).

[13] Cf. "The ants, bees, wasps, and termites are among the most socially advanced nonhuman organisms of which we have knowledge" (Hölldobler and Wilson xviii).

[14] Hölldobler and Wilson, 114.

[15] Ibid., 53.

[16] Ibid., 58.

[17] Seeley, 549.

[18] J. Scott Turner, *The Extended Organism: The Physiology of Animal-Built Structures* (Cambridge, MA: Harvard UP, 2000), 2.

[19] Ibid.

[20] Hölldobler and Wilson, 117. They continue, "Thus, while a brief surveillance of an insect colony may seem to disclose a confusing kaleidoscope of activity, longer periods of observation reveal that patterns are built from many quite individual minds linked by a high degree of organization. That amount of order is central to the colony's survival and reproduction" (119). "To conclude that the central tendencies of role change with aging have a genetic basis is not to imply that it is rigidly determined. Instead, the ensemble of genes that program the sequence of role changes have, like all such hereditary unites, a norm of reaction, the array of possible outcomes in physiology and behavior determined by the interaction of the genes and the particular environment in which the development occurs" (121).

[21] Ibid., 55.

[22] Ibid., 116.

[23] Alfred North Whitehead, *Science and the Modern World*, 76.

[24] Alfred North Whitehead, *Process and Reality*, Corrected Edition, Ed. David Ray Griffin and Donald W. Sherburne (New York: Free Press, 1978), 110.

[25] Cf. "It seems that, in bodies that are obviously living, a coördination has been achieved that raises into prominence some functionings inherent in the ultimate occasions. For lifeless matter these functionings thwart each other, and average out so as to produce a negligible total effect. In the case of living bodies the coördination intervenes, and the average effect of these intimate functionings has to be taken into account" (Alfred North Whitehead, *Adventures of Ideas* (New York: Free Press, 1933)207).

[26] Alfred North Whitehead, *Science and the Modern World* (New York: Free Press, 1925), 152.

[27] Whitehead, *Adventures of Ideas*, 204.

[28] Frederick Ferré, *Being and Value: Toward a Constructive Postmodern Metaphysics* (Albany: State University of New York Press, 1996),337.

[29] Turner, "A Superorganism's Fuzzy Boundaries," 63.

[30] Cf. "The fungi are the major heavy breathers in the nest, consuming oxygen about five times faster than the termites do. Why, then, do termites work so hard to build an earthen lung if the fungi, Termitomyces, actually do the most to make the nest air stuffy? To be sure, the act is not altruistic, because the fungi, by breaking down the termites' food, are performing a critical function. In a sense, the termites are "paid" for their work. But the fungi may be gaining much more than simply having termites supply them with a steady diet of cellulose: Termitomyces, you see, have competitors" (Ibid. 63).

[31] Ibid.

[32] Cf. "The flow of the wind pushes air through the porous soil on the windward side and sucks it out on the leeward side, allowing the nest atmosphere to mix with fresh air from the outside world. This in itself is not surprising; lots of animals build structures that do similar things. What is remarkable is the pattern of ventilation: an in-and-out movement very similar to the way air flows into and out of our own lungs. In fact, what most distinguishes the action of the two 'organs' is that the termites' is powered by the ebb and flow of wind instead of by the contractions of muscle" (Ibid. 65).

[33] Ibid., 66.

[34] Turner, "A Superorganism's Fuzzy Boundaries," 67.

[35] Ibid. For his part, Whitehead is not even sure that we can define where the human organism begins and ends. "We think of ourselves as so intimately entwined in bodily life that a man is a complex unity – body and mind. But the body is part of the external world, continuous with it. In fact, it is just as much part of nature as anything else there – a river, or a mountain, or a cloud. Also, if we are fussily exact, we cannot define where a body begins and where external nature ends" (Whitehead, *Modes of Thought* (New York: Free Press, 1938), 21).

[36] Turner, *Extended Organism*, 25.

[37] Ibid., 214.

[38] Ibid.

[39] Ibid.

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