Intimate Ecologies: Symbioses in the Nineteenth Century

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Typical Forms

In 2012 an interdisciplinary group of scholars—the biologist Scott Gilbert, the historian of biology Jan Sapp, and the philosopher Alfred Tauber—published a piece in the *Quarterly Review of Biology* arguing for the importance of symbiosis to contemporary biology. They argued that dominant biological understandings of individuality (marked as anatomical, embryological, physiological, immunological, genetic, and evolutionary) have been undermined by the discovery of "not only . . . a microbial world of much deeper diversity than previously imagined, but also a world of complex and intermingled *relationships*—not only among microbes, but also between microscopic and macroscopic life."[1] Symbiosis, they argued, "is becoming a core principle of contemporary biology, and it is replacing an essentialist conception of 'individuality' with a conception congruent with the larger systems approach now pushing the life sciences in diverse directions. These findings lead us into directions that transcend the self/nonself, subject/object dichotomies that have characterized Western thought."[2]

In recent years, work like that of Gilbert, Sapp, and Tauber has brought symbiosis to the forefront of interdisciplinary conversations about the limits of bounded individuality, drawing attention to connection and interdependence in all life and lending small-scale intimacies a sort of novelty in academic circles.[3] But symbiosis is not, of course, a new concept, and neither is the idea that small-scale intimacies force us to question conventional approaches to individuality. The concept of symbiosis originated in the nineteenth century precisely as a way of understanding complex biological relationships in which it was often difficult to distinguish where one organism ended and another began; from

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the start, symbionts troubled biological conventions, prompting questions about the nature of biological individuality, dependence and interdependence, kingdom and species, and the relationship between parts and wholes as well as acting as models for human social life. Not only that, but symbiosis grew out of nineteenth-century understandings of biological parasitism, which had been attuned to the ambiguity of small-scale multispecies intimacies since the 1850s. Indeed, prior to the invention of symbiosis, the Victorians tended to call all long-standing, boundary-defining intimacies between organisms "parasitisms," whether they were of help or harm to the organisms involved. We might even say that parasitism acted as modern symbiosis *avant la lettre*, a catch-all term encompassing a range of more or less asymmetrical relationships as notable for their complexity and interdependence as for their draining and destruction.

This essay outlines the emergence of symbiosis, tracing its roots to nineteenth-century understandings of parasitism and theories of compound individuality. Focusing on the work of the Swiss botanist Simon Schwendener and the Belgian zoologist Pierre-Joseph Van Beneden, I show how symbiosis emerged as an umbrella category specifically to facilitate differentiation between small-scale intimacies that hurt (especially parasitisms) and those that do not (mutualisms, commensalisms). From there, I consider how open forms of relation—forms like parasitism, mutualism, and commensalism, which help us conceptualize not boundedness but a necessary intimacy—shaped understandings of social as well as biological systems. To this end, I examine the work of the biologist and urban planner Patrick Geddes, whose early writings on "reciprocal accommodation" and so-called "animal chlorophyll" presaged his later studies of the evolution of "social forms" in areas like Greater London.[4] Like the other essays in this constellation, then, I am concerned with the Victorians' "more open, less integrated models for how assemblages operate," as Deanna Kreisel and Devin Griffiths put it in their introduction to this special issue.[5] But what occupies me above all is the process through which intimacies observed under the microscope become, in George Henry Lewes's formulation, "typical forms" that help us conceive of social and biological systems as open, while also introducing new limitations in their own right.[6] Specifically, I show that the emergence of symbiosis—and through it, other, specifically cooperative forms of multispecies intimacy such as mutualism—helped close off previously existing possibilities for reciprocation and mutual aid presented by older, similarly open *parasitic* forms, thus paving the

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way for views of parasitism as simple, unidirectional, and straightforwardly problematic by century's end. This Victorian-era shift in understandings of parasitism, I suggest, made possible contemporary theory's relative lack of interest in the imaginative possibilities of parasitic forms.

Underlying this essay is a critique of recent eco-theoretical approaches to asymmetrical relations *within* symbiosis—parasitism in particular. Though scholars like Gilbert, Sapp, and Tauber are careful to remind readers that symbiosis is an umbrella term encompassing parasitism, mutualism, and everything in between, parasitic examples are few and far between even in the best contemporary interdisciplinary work dealing with symbiosis. Donna Haraway's *Staying with the Trouble,* for instance, stresses that "symbiosis is not a synonym for 'mutually beneficial,'" but her descriptions of model relationships—Lynn Margulis's *Mixotricha paradoxa* as well as coral reefs, lichen, a "choanoflagellate-bacteria model for the invention of animal multicellularity," and "a squid-bacteria model for the elaboration of developmental symbioses"—are never explicitly parasitic; when they are characterized by asymmetry at all, it tends to be diffused across complex assemblages.[7] There is value in such ambiguity, not least that it highlights the difficulty of distinguishing between parasitisms, mutualisms, and commensalisms as well as between creatures. But insofar as it makes it easy for readers to associate symbiosis with largely symmetrical exchange, it also misses an opportunity to reveal the potential of parasitic forms in the face of the very crises that most concern contemporary ecocritics. For as I suggest in my conclusion, parasitism may be one of our most powerful tools for thinking outside of organic ecology, with its totalizing effects and limiting entanglements. In helping us imagine extreme shifts in the power dynamics that lie at the core of our current socio-ecological moment, it suggests that ecologies are open and messy, rife with relationships that are painful and asymmetrical, but also full of possibility.

1. Biological Individuality

At the start of the Victorian period, before anyone was using the term "symbiosis," researchers across Europe were troubled by questions of biological individuality and bodily autonomy. Confronted with a wide array of parasites and organisms like medusae, tapeworms, and earthworms—who lived and moved together like one organism but could also be divided into different organisms separately able to perform life functions—researchers were asking questions about "compound" life forms,

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regeneration and reproduction, and dependence and interdependence.[8] What, they asked, made a biological individual? Could there be ways of understanding individuality that were not strictly morphological? How could one tell if an organism was part of another organism or a whole organism itself? Could it be both? Of particular interest at this moment were figures like polyps and salps: creatures that could produce offspring that seemed completely unlike their parents but who would, in turn, produce offspring like the original parent generation in the next or some future generation. By the 1840s, Japetus Steenstrup at the University of Copenhagen had come up with an explanation: in his estimation, naturalists were observing an "alternation of generations," in which unlike generations of offspring were meant "to prepare the way for the later, succeeding generations of animals destined to attain a higher degree of perfection."[9]

Steenstrup's explanation seemed to provoke as many questions as it answered with regard to biological individuality: especially among those whose work was rooted in vertebrate life-forms, the alternation of generations and its undermining of morphological understandings of individuality led to confusion.[10] In the wake of this confusion, researchers across Europe worked to make sense of the sexual practices of invertebrates. In England, scientists developed a particular interest in the subject of biological individuality in the 1850s, examining a wide range of invertebrates for clues about compound individuality and growing increasingly fascinated with the intimate, seemingly necessary relationships formed between tiny creatures in marine environments. One of the most notable was Richard Owen, whose *On Parthenogenesis* (1849) aimed to account for regeneration as well as the alternation of generations; Owen argued that when organisms reproduce sexually, they form a "germ-mass" whose "spermatic force," if not fully consumed in the organism's development, is used for asexual reproduction and regeneration.[11] Herbert Spencer's 1852 essay "Theory of Population" took up Owen's interest in compound organisms as well as his argument for classifying organisms according to whether their nervous systems were centralized or decentralized. According to Spencer, creatures like mollusks had nerve centers all over their bodies; others, like articulates, had a ganglion for each bodily segment; still others had one nerve center centralizing the entire nervous system (this was the case for the higher—and so less divisible—organisms). Spencer saw nerves as a means of communicating between more or less independent systems; he also saw something like "spermatic force" working differently for different animals. In a complex organism,

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germ mass was used to develop increasingly complex parts, whereas in the simplest of organisms it was used for phenomena like regeneration.

While Spencer was writing on compound organisms, Thomas Henry Huxley was studying ascidians, marine invertebrates that sometimes live alone and sometimes live in aggregate colonies.[12] He started to correspond with Spencer about their mutual interest in creatures that could exist as individuals or as aggregates. While Spencer was fascinated by what he saw as aggregates of individual organisms, however, Huxley argued that the same bodies were individuals composed of zoöids—surprisingly independent and organizationally complete, but "pseudo-individual," forms.[13] These differences in understanding were rooted in both the ambiguity of biological individuality and the creatures the writers chose as their prime examples of individuality *in general*: if Spencer opted for segmented creatures like annelids or crustaceans, Huxley relied on organisms with centralized nervous systems.

While Spencer and Huxley were disagreeing about zoöids and pseudo-individuality, the Swiss botanist Simon Schwendener was developing his controversial "dual hypothesis" of lichen association, which suggested that lichens were also compound in nature. Schwendener described lichen as "colonies" comprised of "hundreds and thousands of individuals," only one of which

> acts as master, while the others, in perpetual captivity, provide nourishment for themselves and their master. This master is a fungus of the order Ascomycetes, a parasite which is accustomed to live upon the work of others; its slaves are green algals, which it has sought out or indeed caught hold of, and forced into its service. It surrounds them, as a spider does its prey, with a fibrous net of narrow meshes, which is gradually converted into an impenetrable covering. While, however, the spider sucks its prey and leaves it lying dead, the fungus incites the Algae taken in its web to more rapid activity, nay, to more vigourous increase.[14]

Schwendener's assessment of the dual nature of lichen troubled lichenists insofar as it contravened systems of classification in which lichen represented a specific class of plant; it also troubled those who imagined that the proposed relationship between algae and fungus could exist on more friendly terms than those of master and slave. And it would have an important effect on studies of parasitism, which at this point were proliferating, particularly in popular natural historical circles. For after centuries of being used by literary writers to describe a distinctly human character type—a sponger, a flatterer, or a hypocrite—in the eighteenth century the term "parasite" had started rapidly entering new fields of

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discourse and expanding its meaning accordingly. Botany, which was fast forming as an amateur pursuit but also a professional discipline, came first. The initial recorded use of the term in a botanical context dates to the entry for parasites in the first edition of Ephraim Chambers's *Cyclopædia* (1728): "a Kind of diminutive Plants, growing on Trees, and so called from their Manner of living and feeding, which is altogether on others."[15] From here, the term invaded other scientific fields as they emerged and professionalized: the *Oxford English Dictionary* suggests that the first reference to a nonhuman animal parasite was made by William Kirby and William Spence in the fourth volume of their *Introduction to Entomology,* which was published in 1826. In the human context, meanwhile, the term began to enter economic discourse with the consolidation of capitalism across Europe and the colonies in the eighteenth century. At this point, it became possible to imagine parasitic humans as spongers of money rather than mere meals from their patrons and even as social parasites, those figures who drained an entire social body rather than just wealthy individuals.[16]

As a result of these expansions in meaning, by the middle of the nineteenth century the "parasite" had taken shape as an especially protean concept, describing a wide array of figures who benefited from a range of asymmetrical relations. According to Anne-Julia Zwierlein, the Victorians in particular experienced a "craze for parasites," as writers from George Eliot to Arthur Conan Doyle grew fascinated by both social and biological threads of parasitic meaning.[17] Interest in nonhuman parasitism was especially strong among those who studied insects and marine invertebrates, particularly as popular writers and naturalists like Philip Henry Gosse began to write about the densely packed, often parasitic relationships to be found in tide pools and under rocks. Gosse's *A Naturalist's Rambles on the Devonshire Coast* (1853) suggests that tiny, often parasitic creatures could be God's chosen examples for the incredible beauty and economy of space to be found in nature. His many examples of organisms crowded together in dense webs of interdependent relationships inspired figures like Charles Kingsley and George Henry Lewes to treat parasites not as simply destructive but as potentially beneficial to a larger environment—as necessary players in intimate ecologies found all along the English coast.[18] In *Glaucus* (1856), for instance, Charles Kingsley contemplates the organisms growing on the legs of a hardworking spider crab:

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> On that leg grows, amid another copse of the grey polypes, a delicate straw-coloured Sertularia, branch on branch of tiny double combs, each tooth of the comb being a tube containing a living flower; on another leg another Sertularia, coarser, but still beautiful; and round it again has trained itself, parasitic on the parasite, plant upon plant of glass ivy, bearing crystal bells, each of which, too, protrudes its living flower; on another leg is a fresh species, like a little heather-bush of whitest ivory, and every needle leaf a polype cell—let us stop before the imagination grows dizzy with the contemplation of those myriads of beautiful atomies. And what is their use? Each living flower, each polype mouth is feeding fast, sweeping into itself, by the perpetual currents caused by the delicate fringes upon its rays (so minute these last, that their motion only betrays their presence), each tiniest atom of decaying matter in the surrounding water, to convert it, by some wondrous alchemy, into fresh cells and buds, and either build up a fresh branch in their thousand-tenanted tree, or form an egg-cell, from whence when ripe may issue, not a fixed zoophyte, but a free swimming animal.[19]

In suggesting that parasites might do good not only for themselves but for their environment, Kingsley takes Gosse's work on the beauty and complexity of parasitic relations a step further. Though later in *Glaucus* he acknowledges that his assumption—that zoophytes work to purify their marine environments—"has yet been verified," he stresses that "the infusorial animalcules do so, reversing the functions of animal life, and instead of evolving carbonic acid gas, as other animals do, evolve pure oxygen."[20]

Others were less interested in whether parasites do good to those around them than they were in what parasites revealed about life and relationality in general. In *The Origin of Species* (1859), for instance, Charles Darwin uses parasites to demonstrate several important qualities of the natural world. First, they exemplify what Darwin calls the "dependency of one organic being on another": he talks about the dependence of mistletoe on the apple tree, of "the humblest parasite which clings to the hairs of a quadruped or feathers of a bird," and of the cuckoo on birds of other species, among others.[21] This dependence is asymmetrical—when he talks about the mistletoe and the apple tree, for instance, he makes it clear how the mistletoe benefits from the tree but does not say anything about the tree benefiting from the mistletoe—but it is also *mutual*. The apple tree may not receive direct benefits from its parasite, but it relies equally on other creatures for functions crucial to its continued existence and propagation.

Second, and closely related, parasites are figures for what Darwin famously called the "web of complex relations" that binds organisms

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together (73). Natural selection works for each species through "its infinitely complex relations to other organic beings and to external nature," and "the structure of every organic being is related, in the most essential yet often hidden manner, to that of all other organic beings, with which it comes into competition for food or residence, or from which it has to escape, or on which it preys. This is obvious in the structure of the teeth and talons of the tiger; and in that of the legs and claws of the parasite which clings to the hair on the tiger's body" (61, 77). In this context, the parasite tends to be important in its capacity to exemplify the *scale* of such complexity, much as it is for Gosse—even the tiniest, most insignificant-seeming creatures form integral parts of the larger web.

Third, Darwin presents parasites as surprising figures for complex instincts. Concerned that some instincts are so complex that readers will find it difficult to believe they are rooted in natural selection, Darwin spends an entire chapter of the *Origin* showing that complex insect instincts don't stand in the way of his theory; he wants to show that they cannot, for instance, be "acquired by habit in one generation, and then transmitted by inheritance to succeeding generations" (209). Much of this evidence concerns the instincts of domestic and trained animals—the rabbit, the dog, the pigeon. But when he moves on to consider "instincts in a state of nature," parasites like the cuckoo and the parasitic bee, as well as the more ambiguous case of the slave-making ant, take center stage. Darwin's use of parasites in this section presents what may be an unusual conception of parasitic life—we tend to think of parasites, after all, as mostly passive, nonsentient creatures. But it is consistent with Darwin's use of parasitic examples throughout the text: parasites, in his view, are exemplary of all creatures who struggle to exist in changing, competitive environments.

In each of these approaches, Darwin resists earlier attempts to tie parasitism to negative social and ethical valuations, which makes his final point about parasitism more striking. At the close of his chapter on instinct, he offers one last bit of support for parasites as evidence for natural selection. "It may not be a logical deduction," he writes, "but to my imagination it is far more satisfactory to look at such instincts as the young cuckoo ejecting its foster-brothers,—ants making slaves,—the larvae of ichneumonidæ feeding within the live bodies of caterpillars,—not as specially endowed or created instincts, but as small consequences of one general law, leading to the advancement of all organic beings, namely, multiply, vary, let the strongest live and the

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weakest die" (243–44). It is a jarring moment, as Darwin switches gears, presenting natural selection as a more appealing explanation for parasitism, not due to its beauty or complexity, but due to its instinctual cruelty.[22] This, then, is the final way in which parasites work in the *Origin*: as evidence of the darker side of intimate ecologies. Here the parasite is evidence of natural selection, but also evidence against design, and against any too-Pollyannaish view of the world, which is filled with "misery." Alongside Darwin's occasional exuberance about parasitic life and his claims that parasites are beautiful and impressive, he stresses here that when we look closely at parasitic activity, it seems not only competitive and marked by struggle but also, at least sometimes, gratuitous—this characterization taps into long-standing negative valuations of the parasite as a problem even as it implicates parasitism in a consolidating evolutionary narrative.

Here, then, we have a parasitism that is both perilous and full of promise. But when experimental botanists all over Europe—particularly at Schwendener's institute of experimental biology at the University of Berlin and at the German botanist Anton de Bary's institute at Strassburg—took up work on the "dual hypothesis," they tended to ignore such complex parasitisms, choosing instead to accept Schwendener's assessment of parasitism as a unidirectional relationship that fell somewhere between master/slave and predator/prey. And so in the last few decades of the century, those who felt that Schwendener did not properly describe the fungus-alga relationship started trying to develop new terminology to describe multispecies intimacies that did not necessarily cause harm.

Of the new alternatives to Schwendener's "dual hypothesis" in the 1870s, the most notable were Albert Bernhard Frank's *symbiotismus* (symbiosis) and Pierre-Joseph Van Beneden's mutualism. Frank first used symbiosis to describe "all the cases where two different species live on or in one another." Unlike parasitism, which considered "the role which the two individuals play," Frank was occupied with "mere coexistence," and so for him, symbiosis encompassed a wide range of intimate relations, including parasitism.[23] Van Beneden's paper "A Word on the Social Life of Lower Animals" (1873), meanwhile, similarly carved out space for intimate relationships that cannot properly be called parasitic but was more specifically interested in relationships that do not cause harm. In Van Beneden's essay, food is of the utmost importance: he stresses that every creature is food to another, everyone disappears into someone else's mouth. But in the midst of all this devouring, the

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creatures that most interest him are gentle, accommodating eaters. As he writes, "every day we discover those who had passed for parasites yet who do not in any way live at the expense of their host." Though such creatures "cannot live without help," they do not harm their host: they merely "claim from their neighbors a place at the table for partaking of the day's meal."[24]

In using the image of a shared meal, Van Beneden illustrates creaturely harmlessness by means of an image that had been traditionally used to illustrate parasitism proper. For as J. Hillis Miller notes in "The Critic as Host," the ancient Greek parasite was originally a religious figure and then "a fellow guest, someone sharing the food with you, there with you beside the grain," before it was introduced into ancient Greek comedy and lost its positive connotations.[25] The associations between parasitism and meal sharing, however, never disappeared. From the fourth century BCE to Molière's play *Tartuffe* (1664), to be a parasite was to be a meal cadger, someone who manipulated his way into your home to take a seat at your table. But for Van Beneden, meal cadging is not a problem: it is a natural result of excess.

Thus Van Beneden reconstructs the standard image of the parasite as dinner guest but with an important difference: he suggests that the creatures which interest him do not cause harm and even engage in "mutual aid," paying for their meals "in kind."[26] Unlike "true parasites" such as the leech or the flea, creatures like the plover "offer services that we might consider medical," while the red-billed oxpecker "performs a surgical operation every time he uses his knife to open a larva-containing tumor in the middle of a buffalo's back."[27] He explains that parasites are those creatures who "feed themselves at the expense of a neighbor, either by installing themselves voluntarily in his organs, or by abandoning him after each meal."[28] Those who would not count as parasitic, meanwhile, range from the crustacean who "settles into the service of an ascidian" in return for some "good bits" of food; the "benevolent animal [who] renders a service to his neighbor, either by maintaining the cleanliness of its teeth, or by removing the detritus that encumber certain organs";[29] and the list goes on.

By the 1870s, studies of cooperative intimacies were proliferating throughout Europe, as research on a wide range of organisms including planarians, crustaceans, sea anemones, and protozoa provided fodder for questions about not only compound individuality but also species and kingdom. One avenue for such research was the study of so-called animal chlorophyll. As early as the 1850s, it had become apparent that some

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simple marine organisms moved around like animals but nourished themselves like plants. The idea that there could be two different types of chlorophyll—one for plants and one for animals—fascinated researchers from Richard Owen and T. H. Huxley to Ernst Haeckel: what would it mean for two-kingdom systems of classification if animals could produce their own food through chlorophyll? And if chlorophyll was not endogenous to these organisms, then was a wide range of lower animal life engaging in symbiotic relations with plants? What would it mean for plants to live not just *on* but *in* their animal intimates?

In the 1850s and 1860s, evolutionists had suggested that "chlorophyll-containing organisms" like protozoa, planarian worms, and sea anemones might be "examples of the not-quite-animal-not-quite-plant ancestors of all living things."[30] Many, moreover, suggested that they comprised a third kingdom, variously named the Protozoa (Richard Owen), Protoctista (John Hogg), Primilia (Thomas B. Wilson and John Cassin), and Protista (Ernst Haeckel). By the 1880s, however, scientists like Patrick Geddes in Edinburgh, Géza Entz at Klausenberg, L. Cienkowski in Russia, and Karl Brandt in Berlin were calling third-kingdom hypotheses into question, suggesting that chlorophyll was not endogenous to these animals: not only could many of them be found without chlorophyll, but scientists could remove their chlorophyll without doing them any harm.[31] To Geddes, it seemed more likely that what was called "animal chlorophyll" was in fact plant chlorophyll and that the intimate ecologies under question involved symbiosis between plants and animals. In a paper published in *Nature* as "Further Researches on Animals Containing Chlorophyll," Geddes recounts his studies of *Convoluta schultzii* (a "grass-green planarian") at Roscoff, France, in 1878, and *Bonellia viridis* and the green crustacean *Idotea viridis* in Naples during spring 1879; he suggests that when the substance under question is chlorophyll at all, it is in fact plant-based and symbiotic.

The subject that most interested Geddes was one that had been studied before—it was "the long-outstanding enigma of the nature and functions of the 'yellow cells' of Radiolarians, as Huxley first called those of *Thallassicolla*." These yellow cells were once thought to be associated with reproduction and were more recently tied to nutrition by Haeckel. But Geddes alludes to a shift in understanding of these creatures beginning in 1871, when Cienkowski claimed that the cells, which exist in most Radiolarians, were in fact "parasitic algae": indeed, Cienkowski "showed that they were capable not only of surviving the death of the Radiolarian, but even of multiplying, and of passing through

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an encysted and an amoeboid state."[32] Brandt confirmed Cienkowski's finding when he discovered that these cells can "survive for no less than two months after the death of the Radiolarian."[33] Though other scientists may have disagreed about the nature of such creatures, much evidence seems, he says, to support the idea that they were taking part in a multispecies relationship—and to support similar findings among other groups of creatures.

But Geddes and others were interested in further theorizing the relationship between these green and yellow algae and their animal counterparts. And so Geddes probed "the physiological relationship of the plants and animal thus so curiously and intimately associated."[34] What, he wants to know, is the nature of this relationship? What do these organisms offer one another? His answer is as follows:

> Every one knows that all the colourless cells of a plant share the starch formed by the green cells; and it seems impossible to doubt that the endoderm cell or the Radiolarian, which actually incloses the vegetable cell, must similarly profit by its labours. In other words, when the vegetable cell dissolves its own starch, some must needs pass out by osmose into the surrounding animal cell; nor must it be forgotten that the latter possesses abundance of amylolytic ferment. Then, too, the *Philozoon* is subservient in another way to the nutritive function of the animal, for after its short life it dies and is digested; the yellow bodies supposed by various observers to be developing cells being nothing but dead algae in progress of solution and disappearance. Again, the animal cell is constantly producing carbonic acid and nitrogenous waste, but these are the first necessities of life to our alga, which removes them, so performing an intracellular renal function, and of course reaping an abundant reward, as its rapid rate of multiplication shows.[35]

Here, both the philozoon (Geddes's term for the yellow cells in Radiolaria) and the cells of the radiolarian itself benefit from their intimacy; Geddes calls this relationship "reciprocal accommodation."[36] He suggests, moreover, that "for a vegetable cell no more ideal existence can be imagined than that within the body of an animal cell of sufficient active vitality to manure it with carbonic acid and nitrogen waste, yet of sufficient transparency to allow the free entrance of the necessary light."[37] The same is true for an animal cell: "there can be no more ideal existence than to contain a vegetable cell, constantly removing its waste products, supplying it with oxygen and starch, and being digestible after death." This, for Geddes, proves not just something about reciprocal accommodation or symbiosis between plant and animal cells but about relationships between plants and animals in general: "in short," he writes,

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"we have here the relation of the animal and the vegetable world reduced to the simplest and closest conceivable form."[38] It wasn't long before these studies with radiolaria would help Geddes conceive of an even wider range of relationships, including those between humans, as marked by something like reciprocal accommodation.

2. The Rise of Symbiosis

Around the time Geddes was publishing his reports on reciprocal accommodation in *Nature,* he was also starting to develop an interest in slum improvement and town planning in Edinburgh, an interest that would continue to grow after he left Edinburgh for a position at University College Dundee in 1888. There, as chair of botany, Geddes wrote extensively on city planning (from what he called an "ecological" perspective) and eventually published his best-known work, *Cities in Evolution* (1915). This book evidences a very different focus than Geddes's early work on animal chlorophyll, and yet it reveals that over the course of his career, Geddes treats reciprocal accommodation as underlying all relations, from the tiniest, most intimate ecologies to the largest metropolis.

In *Cities in Evolution*, Geddes compares London to a great and growing polyp. As he writes:

> This octopus of London, polypus rather, is something curious exceedingly, a vast irregular growth without previous parallel in the world of life—perhaps likest to the spreadings of a great coral reef. Like this, it has a stony skeleton, and living polypes—call it, then, a "man reef" if you will. Onward it grows, thinly at first, the pale tints spreading further and faster than the others, but the deeper tints of thicker population at every point steadily following on. Within lies a dark and crowded area; of which, however, the daily pulsating centre calls on us to seek some fresh comparison to higher than coralline life.[39]

Geddes's "man reef" is a compound individual. It grows and functions as one and many at the same time, to the point that one must distinguish between "the real aspect of Greater London" and a "Historic London" marked by centuries-old county lines that "were once traced so painfully and are still so strictly maintained" (26); from the perspective of a city planner or Londoner, he argues, such historical boundaries have little purpose, and already the historic names of "innumerable constituent villages and minor boroughs" have been "swallowed up, apparently forever, like those microscopic plants, those tiny plants and animals, which a big spreading amoeba so easily includes, so resistlessly devours" (26, 27).

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True to Geddes's work on symbiosis and compound organisms, however, being "swallowed up," even if forever, does not mean disappearing. Instead, and somewhat counterintuitively, to be "devoured" means to be "included" or incorporated—and thereby to benefit. Geddes describes not a giant, predatory amoeba but "a vast new unity" and "a house-province, spreading over, absorbing, a great part of south-east England" (27). The unity moves quickly:

> Instead of the old lines of division we have new lines of union: the very word "lines" nowadays most readily suggesting the railways, which are the throbbing arteries, the roaring pulses of the intensely living whole; or, again, suggesting the telegraph wires running beside them, so many nerves, each carrying impulses of idea and action either way. It is interesting, it is necessary even, to make an historic survey of London—an embryology, as it were—of this colossal whole. We should, of course, look first into its two historic cities; we should count in its many boroughs as they grew up before being absorbed; we should take note of, however easily we forget, its innumerable absorbed old villages and hamlets, its ever new and ever spreading dormitory areas. . . . We see, we recognise these many corporate or at least associated units of the body politic, all growing more and more fully into one vast agglomerate, and this with its own larger corporate government, its County Council. Yet even this is already far outgrown; but in time, if the growth process continues, as in every way obviously under present conditions it must, this governing body must overtake the spreading growth, and bring all that is really functional London into its province, with economy and advantage to the vast majority of all concerned. (27–28)

Geddes's radiolarian was marked by a progressive symbiotic circuit, one in which the animal cell offered the vegetable cell carbonic acid and nitrogen waste in exchange for oxygen, starch, and waste removal. The relationship between the radiolarian and chlorophyll was "ideal" and beneficial to both creatures. In Geddes's London, however, symbiosis works on a larger scale, a longer time frame, and to even greater advantage. Geddes imagines the "units of the body politic" as continually growing and coming together, which in turn facilitates a scaled-up version of the reciprocal accommodation Geddes wrote about in his article in *Nature* in the 1880s. This is presented as a process of *development:* the passage is full of contrasts between the new London, signaled by unifying railways and telegraph wires, and the old London, signaled by separate and now-absorbed "old villages and hamlets." The former is roaring, pulsing, enveloping, ever spreading; the latter, meanwhile, is divided, outgrown, forgotten—an artifact. And though Geddes suggests that the old city is worth studying, it is worth studying only in relation to the city's present, as part of an embryology or study of origins. The "Town

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aggregates" combine, then, not just to survive or even to grow but to *evolve*, becoming increasingly functional and bringing "economy and advantage to the vast majority of all concerned."

Geddes's tendency to apply evolutionary language to symbiotic activity is perhaps what makes his writing most resonate with contemporary work on symbiosis, particularly approaches inspired by the evolutionary biologist Lynn Margulis (such as the work by Gilbert, Sapp, Tauber, and Haraway mentioned above). Margulis is known as a theorizer of symbiogenesis, which treats symbiosis as a primary driver of evolution. As Haraway puts it, "the core of Margulis's view of life was that new *kinds* of cells, tissues, organs, and species evolve primarily through the long-lasting intimacy of strangers. The fusion of genomes in symbioses, followed by natural selection—with a very modest role for mutation as a motor of system level change—leads to increasingly complex levels of good-enough quasi-individuality to get through the day, or the aeon."[40] Like Margulis, Geddes in his later work treats symbiosis as a driver of change and of increased complexity; the "intimacy of strangers" creates space for what Geddes calls "new forms" and Margulis calls "holobionts." But in both cases, these strangers are not bounded individuals; they start out as open forms because *there are no closed forms*. Life, on the smallest and largest scales, is symbiotic. Thus London, for Geddes, is a "new form of population-grouping," a dynamic urban form that merits a new name (it is a "Conurbation") and produces its own distinct and cooperative "social forms" ("co-operation" and "amicable conference among all the representatives, rustic and urban, of the various cities and county-regions concerned") (34, 34, 43, 43).

But if Margulis was not the first to imagine that the intimate ecologies she viewed through a (compound) microscope could tell her something about relationships in general, neither, of course, was Geddes. In treating symbiotic forms as foundational to all relationships, Geddes was reaching back to his roots in Victorian science. For as Bernard Lightman has shown, small and microscopic organisms "contained tremendous significance for those Victorians seeking to determine the ultimate meaning of nature," whether that meaning was religious or secular, benevolent or malevolent.[41] Under a microscope's lens, a drop of water from the Thames might become a microcosm of the larger world; it could teach the viewer about general laws that governed social as well as biological systems. It could also lay bare what George Henry Lewes called life's "typical forms": forms that repeat across the natural world

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and take shape with the tiniest of organisms.[42] In his natural history text *Sea-Side Studies* (1858), Lewes recounts:

> The typical forms *took possession* of me. They were ever present in my waking thoughts; they filled my dreams with fantastic images; they came in troops as I lay awake during meditative morning hours; they teazed me as I turned restlessly from side to side at night; they made all things converge towards them. If I tried a little relaxation of literature . . . a phrase like "throbbing heart" would detach my thoughts from the subject of the book, and hurry them away to the stage of the Microscope, where the heart of some embryo was pulsating. I could not look at anything intently, but the chance was that some play of light would transform itself into the image of a mullusc or a polype.[43]

Once we learn to recognize forms that repeat across the natural world, Lewes suggests, we cannot help but see them everywhere we look—even when we're not looking for them at all. Spending enough time at a microscope familiarizes the observer with forms like the mollusk, the embryo, and the polyp that repeat themselves across the natural world—and that repetition raised questions about part and whole relations, development and reproduction, and, of course, compound organisms.[44] But the challenge to bounded individuality here is double: it is there in the compound forms that Lewes seems to see everywhere, but it is also there in the associative nature of the exercise itself. It is because Lewes spends so much time at a microscope, in other words, that "anything" he looks at long enough will open out into something else. This isn't a mere trick of his eyes; it is the open ecological worldview promoted by the study of nature. And it is what allows him elsewhere to imagine life in general as at once boundless and extraordinarily dense and contingent in its relations.

For writers like Lewes, one of the greatest pleasures of microscopic observation was encounters like this, where the naturalist encounters an "astonishing . . . variety of form" suggesting open ecologies populated by interdependent organisms and repeating forms.[45] In a similar vein, in *Drops of Water* (1851), Agnes Catlow describes tiny organisms shaped as "tops, trumpets, pincushions with pins in ready for use, telescopes, balls, leaves, sticks, threads, bells, hollow spheres, &c; there are also others like different kinds of fruit, flowers, fish, eels, and serpents; others, again, are egg-shaped, round, square, three-cornered, oval, spiral, spindle-shaped, star-shaped; besides some representing funnels, cylinders, flasks, and many having an apparatus which perfectly resembles a rapidly-turning wheel" (23–24). She suggests that the forms we see

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daily have tiny, microscopic counterparts, though she is particularly fascinated by anything of "compound form" (xvi). In her preface, long before she runs through this list of typical forms, she has her readers imagine that they can be transported through the lens of her microscope: "my readers," she says, "must fancy themselves spirits, capable of living in a medium different from our atmosphere, and so pass with me through a wonderful brazen tunnel, with crystal doors at the entrance" (x). Once they have reached the drop of water on the other side of her lens, they encounter all sorts of fascinating creatures: a plant whose "myriad" cells appear to form "numberless yards of green figured ribbon, in a state of entanglement," or a living globe containing replicas of itself: "other smaller globes, formed exactly like the larger one, being already full of little individuals ready to enter on active life" (xii, xii, xv). Neither of these creatures is "*one* being alone, but is formed of hundreds of minute beings, all enjoying life, and grouped together in this curious manner for mutual support" (xiii–xiv). The globes, especially, are infinitely recursive; when the original form ruptures, the globes inside exit and form their own recursive clusters. Clustering and rupturing, division inward and expansion outward: these are images of life's proliferation and interdependence. And to Catlow, they offer us a glimpse of the intimacy and beauty of organisms on the most basic level, a formula that she scales up to convey a natural order in which "the wonderful power of the Creator is as clearly manifested in the formation of the smallest animalcule, as in that of the largest living being" (2).[46]

3. From Parasitism to Symbiosis

Like Catlow and Lewes, Geddes and Margulis treated small-scale interdependencies as guides to all relationships, not just those found under a microscope; if symbiosis helped them conceive of open systems, however, it was by no means impossible to think of such systems prior to the term's emergence. We should remember this even if it runs counter to our sense of the Victorians as attached to a relatively uncomplicated organicism. Like mutualism and reciprocal accommodation after it, parasitism emphasized the difficulty of distinguishing between creatures that form intimate relations, and it undermined straightforward approaches to subject/object, individual/community, organism/environment, and giving/taking binaries. What set symbiosis apart from parasitism, then, was not that parasitism could never accommodate mutual benefit but that

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symbiosis was set up to accommodate harmony and symmetry in ways that parasitism would not; it was less messy, and it offered more hopeful visions of social change.

Perhaps a more surprising outcome of the invention of symbiosis than its ability to give imaginative form to complex, open ecologies, then, was that it helped limit the meaning of parasitism as a straightforward, unidirectional relationship between two organisms. As much as this sounds like a given today, it was not in the Victorian period, where straightforward taking without giving was just one possible version of parasitism. For others, to be a parasite was to participate in an asymmetrical but also deeply ambiguous relationship to one's intimates. And much as it would for philosophers like Michel Serres a century later, for many of these writers the parasitic relationship, marked as it was by ambiguity, dependence, and asymmetry, became foundational: it became the baseline relationship form.

Indeed, in the Victorian period, the parasite became a figure for the complexity and ambiguity not just of parasitic relationships but of relationships among all organisms. Writers were fascinated (and sometimes terrified) by the idea that parasites could disrupt the boundaries of seemingly any body, and certainly that they could hurt. But taken as forms typical to natural life, parasites helped the Victorians model and think through the smaller (if diffusive) asymmetries of interpersonal communication, political practice, and economic and natural life. And abstracted outward, parasites helped them imagine the surprisingly complex and often painful interdependencies that seemed increasingly to define social and biological systems. As forms of symbiosis outside of parasitism exploded, however, writers and scientists moved away from more complex understandings of parasitism, and the possibility of benefit within parasitism was largely foreclosed. By the turn of the century, it became difficult to see the parasite as anything but a pest, while from Geddes to Peter Kropotkin and beyond, the assumption that mutual aid was natural or foundational bolstered communitarian projects as well as radical politics.[47]

The split of parasitism into "true parasitism" and nonparasitisms, all under the umbrella of symbiosis, reminds us how forms multiply and shift. But it also reminds us what can be lost when some forms are absorbed into others. When parasitism was absorbed into symbiosis, an important way of giving form to radical openness was foreclosed. My sense is that the time is ripe now for new reworkings of parasitism, or even a new explosion of parasitic forms similar to the nineteenth-century

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explosion in symbiotic forms I explore above, or to the current explosion of interest in symbiosis, holobionts, and the work of Lynn Margulis among such eco-theorists as Haraway, Anna Tsing, and the contributors to the recent edited collection *Arts of Living on a Damaged Planet.*[48] If symbiosis represents for many contemporary scholars a way out of bounded individualism and anthropocentric hubris, or a way of living on a smaller scale with more contingency, my sense is that parasitism offers this and then some, without leaving as much room for harmony, symmetry, or painlessness. Accordingly, I'm most interested in approaches to parasitism that stress the parasite as small and unseen but *insidious*—an approach taken most recently by artists like Janna Graham and 16 Beaver, a "para-artistic" space in New York City, among others. This is a parasitism of disruption and redirection at least as much as it is one of ambiguity and complexity—and it seems particularly useful in the face of the extreme asymmetries that mark our present moment.

Notes

1. Gilbert, Sapp, and Tauber, "A Symbiotic Way of Life," 326, authors' emphasis.
2. Ibid.
3. Such findings have also led some scientists to take up the evolutionary biologist Lynn Margulis's term "holobiont," which, unlike traditional conceptions of the individual, describes "the multicellular eukaryote plus its colonies of persistent symbionts," as Gilbert, Sapp, and Tauber put it ("A Symbiotic Way of Life," 326).
4. Geddes, "Researches on Animals Containing Chlorophyll," 362; Geddes, *Cities in Evolution*, 44.
5. Griffiths and Kreisel, "Introduction: Open Ecologies," x.
6. Lewes, *Sea-Side Studies*, 34.
7. Haraway, *Staying with the Trouble,* 60, 64, 64.
8. Daniel Harris has written on the importance of compound organisms in Victorian literature: in his essay "Politics for the Polyps," he argues for the importance of compound organisms to the novels of Charles Kingsley in particular.
9. Steenstrup, *On the Alternation of Generations*, 2.
10. See Farley, *Gametes and Spores,* especially 75.
11. Owen, *On Parthenogenesis,* 5, 19.

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12. For more on the Huxley/Spencer debates regarding biological individuality and on Spencer's interest in both Steenstrup and Owen, see Elwick, "Herbert Spencer."
13. Huxley, *Scientific Memoirs*, 1:52.
14. Quoted in Crombie's critique of Schwendener, "On the Algo-Lichen Hypothesis," 261.
15. Chambers, *Cyclopædia,* 2:351.
16. Perhaps the best example of the introduction of parasitic terminology into economic discourse can be found in the work of Marx and Engels, who use the term to describe, among others, the economic parasitism of landlordism and capitalism (see, for example, "The Communist Manifesto" and *Capital*, vol. 3). For an excellent example of social parasitism, see Olive Schreiner's characterization of nearly all women as parasites in *Woman and Labour.*
17. Zwierlein, "From Parasitology to Parapsychology," 158.
18. See Samyn, "George Eliot."
19. Kingsley, *Glaucus,* 169–70.
20. Ibid., 171.
21. Darwin, *On the Origin of Species*, 75. All subsequent references to this edition are noted parenthetically in the text.
22. Similar concerns would be repeated in Darwin's letter to Asa Gray the following year, in 1860.
23. Quoted in Sapp, *Evolution by Association*, 6. For more on the history of symbiosis in general, see this text.
24. Van Beneden, "Un Mot," 785, translation mine. (Original passage in full: «il y en a un certain nombre qui, sans être parasites, ne sauraient vivre sans secours, et qui réclament de leurs voisins, tantôt un simple gite pour pêcher à côté d'eux, tantôt une place à la même table pour partager les plats du jour: on en découvre journellement qui passaient pour des parasites et qui cependant ne vivent en aucune manière aux dépens de leur hôte.»)
25. Miller, "The Critic as Host," 442.
26. Van Beneden, "Un Mot." (Original passage in full: «Il y a des secours mutuels chez plusieurs d'entre eux, des services se payent même par de bons procédés ou en nature.»)
27. Ibid, 785, 790, 790. (Original: «les parasites véritables»; «rend des services, que l'on pourrait comparer à des services médicaux»; «le *Pique-Boeuf*» fait «une opération chirurgicale chaque fois qu'il ouvre, avec son bistouri à lui, la tumeur qui renferme une larve au milieu du dos du Buffle.»)

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28. Ibid., 785. (Original: «Ceux qui méritent le nom de parasites se nourrissent aux dépens d'un voisin, soit en se colloquant volontairement dans ses organes, soit en l'abandonnant à terme, après chaque repas, comme le fait la Sangsue ou la Puce.»)
29. Ibid., 784. (Original: «Qu'un crustacé Copépode s'installe dans l'office d'une Ascidie et lui dérobe au passage quelques bons morceaux, on ne peut dire qu'il est parasite. Qu'un animal bienveillant rende un service à son voisin, soit en entretenant la propreté de son râtelier, soit en enlevant des détritus qui encombrent certains organes, on ne peut dire qu'il est parasite.»)
30. Sapp, *Evolution by Association,* 10.
31. See Sapp, *Evolution by Association,* chap. 1 ("Symbiosis: Evolution in Action"), 3–14.
32. Geddes, "Further Researches," 303.
33. Ibid.
34. Ibid., 304.
35. Ibid.
36. Geddes, "Researches on Animals Containing Chlorophyll," 362.
37. Geddes, "Further Researches," 304.
38. Ibid.
39. Geddes, *Cities in Evolution*, 26. All subsequent references to this edition are noted parenthetically in the text.
40. Haraway, *Staying with the Trouble,* 60.
41. Lightman, "The Microscopic World," 48.
42. Lewes, *Sea-Side Studies,* 34.
43. Ibid., 34–35.
44. One of Lewes's preferred "typical forms" at this time was the "cluster," a compound form structured by multispecies intimacies. Lewes's clusters—whether he saw them in water from a tide pool or as sets of houses on a hill—were largely parasitic, comprised of extraordinarily complex asymmetrical relationships. See Samyn, "George Eliot."
45. Catlow, *Drops of Water,* 23. All subsequent references to this edition are noted parenthetically in the text.
46. Ibid., 2. Of course, not all representations of life under the microscope imagined anything so beautiful or unified. If Catlow's recursive and ever-expanding communitarian globes correspond to a vision of nature as unified and beautiful, other scholars have drawn attention to representations of drops of water from the Thames that harbor

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much more negative views of life at the smallest of scales. See, for example, Morus, "More the Aspect."

47. See Sapp, *Evolution by Association*.
48. See, for example, Haraway, *Staying with the Trouble*; Tsing, *Mushroom*; and Tsing et al., *Arts of Living*.

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