

Sympoiesis

Symbiogenesis and the Lively Arts of Staying with the Trouble

Symbiogenesis

Sympoiesis is a simple word; it means “making-with.” Nothing makes itself; nothing is really autopoietic or self-organizing. In the words of the Inupiat computer “world game,” earthlings are *never alone*.¹ That is the radical implication of sympoiesis. *Sympoiesis* is a word proper to complex, dynamic, responsive, situated, historical systems. It is a word for worlding-with, in company. Sympoiesis enfolds autopoiesis and generatively unfurls and extends it.

The vivid four-by-six-foot painting called *Endosymbiosis* hangs in the hallway joining the Departments of Geosciences and Biology at UMass Amherst, near the Life and Earth Café, surely a spatial clue to how critters become-with each other.² Perhaps as sensual molecular curiosity and definitely as insatiable hunger, irresistible attraction toward enfold-ing each other is the vital motor of living and dying on earth. Critters interpenetrate one another, loop around and through one another, eat each another, get indigestion, and partially digest and partially assimilate one another, and thereby establish sympoietic arrangements that are otherwise known as cells, organisms, and ecological assemblages.



3.1. *Endosymbiosis: Homage to Lynn Margulis*, Shoshanah Dubiner, 2012.
www.cybermuse.com.

Another word for these sympoietic entities is *holobionts*, or, etymologically, “entire beings” or “safe and sound beings.”³

That is decidedly not the same thing as One and Individual. Rather, in polytemporal, polyspatial knottings, holobionts hold together contingently and dynamically, engaging other holobionts in complex patternings. Critters do not precede their relatings; they make each other through semiotic material involution, out of the beings of previous such entanglements. Lynn Margulis knew a great deal about “the intimacy of strangers,” a phrase she proposed to describe the most fundamental practices of critters becoming-with each other at every node of intra-action in earth history. I propose *holoents* as a general term to replace “units” or “beings.”

Like Margulis, I use *holobiont* to mean symbiotic assemblages, at whatever scale of space or time, which are more like knots of diverse intra-active relatings in dynamic complex systems, than like the entities of a biology made up of preexisting bounded units (genes, cells, organisms, etc.) in interactions that can only be conceived as competitive or cooperative. Like hers, my use of *holobiont* does not designate host + symbionts because all of the players are symbionts to each other, in diverse kinds of relationalities and with varying degrees of openness to attachments and assemblages with other holobionts. *Symbiosis* is not a synonym for “mutually beneficial.” The array of names needed to designate the heterogeneous webbed patterns and processes of situated and dynamic dilemmas and advantages for the symbionts/holobionts is only beginning to surface as biologists let go of the dictates of possessive individualism and zero-sum games as the template for explanation.

An adept in the study of microbes, cell biology, chemistry, geology, and paleogeography, as well as a lover of languages, arts, stories, systems theories, and alarmingly generative critters, including human beings, Margulis was a radical evolutionary theorist. Her first and most intense loves were the bacteria and archaea of Terra and all their bumptious doings. 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. Margulis called this basic and mortal life-making process symbiogenesis.

Bacteria and archaea did it first. My sense is that in her heart of hearts

Margulis felt that bacteria and archaea did it all, and there wasn't much left for so-called higher-order biological entities to do or invent. Eventually, however, by fusing with each other in stabilized, ongoing ways, archaea and bacteria invented the modern complex cell, with its nucleus full of ropy chromosomes made of DNA and proteins, and diverse other sorts of extranuclear organelles, from undulating whips and spinning blades for locomotion to specialized vesicles and tubules for a zillion functions that work better kept a bit separate from each other.⁴ Because she was a founder of Gaia theory with James Lovelock and a student of interlocked and multileveled systemic processes of nonreductionist organization and maintenance that make earth itself and earth's living beings unique, Margulis called these processes autopoietic.⁵ Perhaps she would have chosen the term *sympoietic*, but the word and concept had not yet surfaced.⁶ As long as autopoiesis does not mean self-sufficient "self making," autopoiesis and sympoiesis, foregrounding and backgrounding different aspects of systemic complexity, are in generative friction, or generative enfolding, rather than opposition.

In 1998, a Canadian environmental studies graduate student named M. Beth Dempster suggested the term *sympoiesis* for "collectively-producing systems that do not have self-defined spatial or temporal boundaries. Information and control are distributed among components. The systems are evolutionary and have the potential for surprising change." By contrast, autopoietic systems are "self-producing" autonomous units "with self defined spatial or temporal boundaries that tend to be centrally controlled, homeostatic, and predictable."⁷ Symbiosis makes trouble for autopoiesis, and symbiogenesis is an even bigger troublemaker for self-organizing individual units. The more ubiquitous symbiogenesis seems to be in living beings' dynamic organizing processes, the more looped, braided, outreaching, involuted, and sympoietic is terran worlding.

Mixotricha paradoxa is everyone's favorite critter for explaining complex "individuality," symbiogenesis, and symbiosis. Margulis described this critter that is/are made up of at least five different taxonomic *kinds* of cells with their genomes this way:

Under low magnification, *M. paradoxa* looks like a single-celled swimming ciliate. With the electron microscope, however, it is seen to consist of five distinct kinds of creatures. Externally, it is most obviously the kind of one-celled organism that is classified as a protist. But in-

side each nucleated cell, where one would expect to find mitochondria, are many spherical bacteria. On the surface, where cilia should be, are some 250,000 hairlike *Treponema spirochetes* (resembling the type that causes syphilis), as well as a contingent of large rod bacteria that is also 250,000 strong. In addition, we have redescribed 200 spirochetes of a larger type and named them *Canaleparolina darwiniensis*.⁸

Leaving out viruses, each *M. paradoxa* is not one, not five, not several hundred thousand, but a poster critter for holobionts. This holobiont lives in the gut of an Australian termite, *Mastotermes darwiniensis*, which has its own SF stories to tell about ones and manys, or holoents. Termite symbioses, including their doings with people, not to mention mushrooms, are the stuff of legends—and cuisine. Check out the holobionomes of *Macrotermes natalensis* and its cultivated fungus *Termitomyces*, recently in the science news.⁹ *M. paradoxa* and their ilk have been my companions in writing and thinking for decades.

Since Darwin's *On the Origin of Species* in 1859, biological evolutionary theory has become more and more essential to our ability to think, feel, and act well; and the interlinked Darwinian sciences that came together roughly between the 1930s and 1950s into "the Modern Synthesis" or "New Synthesis" remain astonishing. How could one be a serious person and not honor such works as Theodosius Dobzhansky's *Genetics and the Origin of Species* (1937), Ernst Mayr's *Systematics and the Origin of Species* (1942), George Gaylord Simpson's *Tempo and Mode in Evolution* (1944), and even Richard Dawkins's later sociobiological formulations within the Modern Synthesis, *The Selfish Gene* (1976)? However, bounded units (code fragments, genes, cells, organisms, populations, species, ecosystems) and relations described mathematically in competition equations are virtually the only actors and story formats of the Modern Synthesis. Evolutionary momentum, always verging on modernist notions of progress, is a constant theme, although teleology in the strict sense is not. Even as these sciences lay the groundwork for scientific conceptualization of the Anthropocene, they are undone in the very thinking of Anthropocene systems that require enfolded autopoietic and sympoietic analysis.

Rooted in units and relations, especially competitive relations, the sciences of the Modern Synthesis, for example, population genetics, have a hard time with four key biological domains: embryology and de-

velopment, symbiosis and collaborative entanglements of holobionts and holobiomes, the vast worldings of microbes, and exuberant critter biobehavioral inter- and intra-actions.¹⁰ Approaches tuned to “multi-species becoming-with” better sustain us in staying with the trouble on terra. An emerging “New New Synthesis”—an extended synthesis—in transdisciplinary biologies and arts proposes string figures tying together human and nonhuman ecologies, evolution, development, history, affects, performances, technologies, and more.

Indebted first to Margulis, I can only sketch a few aspects of the “Extended Evolutionary Synthesis” unfolding in the early twenty-first century.¹¹ Forming part of her cosmopolitan heritage, formulations of symbiogenesis predate Margulis in the early twentieth-century work of the Russian Konstantin Mereschkowsky and others.¹² However, Margulis, her successors, and her colleagues bring together symbiogenetic imaginations and materialities with all of the powerful cyborg tools of the late twentieth-century molecular and ultrastructural biological revolutions, including electron microscopes, nucleic acid sequencers, immunoassay techniques, immense and comparative genomic and proteomic databases, and more. The strength of the Extended Synthesis is precisely in the intellectual, cultural, and technical convergence that makes it possible to develop new model systems, concrete experimental practices, research collaborations, and both verbal and mathematical explanatory instruments. Such a convergence was materially impossible before the 1970s and after.

A model is a work object; a model is not the same *kind* of thing as a metaphor or analogy. A model is worked, and it does work. A model is like a miniature cosmos, in which a biologically curious Alice in Wonderland can have tea with the Red Queen and ask how this world works, even as she is worked by the complex-enough, simple-enough world. Models in biological research are stabilized systems that can be shared among colleagues to investigate questions experimentally and theoretically. Traditionally, biology has had a small set of hard-working living models, each shaped in knots and layers of practice to be apt for some kinds of questions and not others. Listing seven basic model systems of developmental biology (namely, fruit flies *Drosophila melanogaster*; a nematode, *Caenorhabditis elegans*; the mouse *Mus musculus*; a frog, *Xenopus laevis*; the zebrafish *Danio rerio*; the chicken *Gallus gallus*; and the mustard *Arabidopsis thaliana*), Scott Gilbert wrote,

The recognition that one's organism is a model system provides a platform upon which one can apply for funds, and it assures one of a community of like-minded researchers who have identified problems that the community thinks are important. There has been much lobbying for the status of a model system and the fear is that if your organism is not a recognized model, you will be relegated to the backwaters of research. Thus, "model organisms" have become the center for both scientific and political discussions in contemporary developmental biology.¹³

Excellent for studying how parts (genes, cells, tissues, etc.) of well-defined entities fit together into cooperating and/or competing units, all seven of these individuated systems fail the researcher studying webbed inter- and intra-actions of symbiosis and sympoiesis, in heterogeneous temporalities and spatialities. Holobionts require models tuned to an expandable number of quasi-collective/quasi-individual partners in constitutive relatings; these relationalities *are* the objects of study. The partners do not precede the relatings. Such models are emerging for the transformative processes of EcologicalEvolutionaryDevelopmental biology.

Margulis gave us dynamic multipartnered entities like *Mixotricha paradoxa* to study the evolutionary invention of complex cells from the intra- and interactions of bacteria and archaea. I will briefly introduce two more models, each proposed and elaborated in the laboratory to study a transformation of organizational patterning in the living world: (1) a choanoflagellate-bacteria model for the invention of animal multicellularity, and (2) a squid-bacteria model for the elaboration of developmental symbioses between and among critters necessary to each other's becoming. A third symbiogenetic model for the formation of complex ecosystems immediately suggests itself in the holobiomes of coral reefs, and I will approach this model through science art worldings rather than the experimental laboratory.

Although multicellular plants appeared on earth half a million years earlier, because of its robustness and sympoietic richness, I focus on a proposed model system for the emergence of animal multicellularity. Every living thing has emerged and persevered (or not) bathed and swaddled in bacteria and archaea. Truly nothing is sterile; and that reality is a terrific danger, basic fact of life, and critter-making opportunity. Using molecular and comparative genomic approaches and proposing infectious—symbiogenetic—processes, Nicole King's laboratory at the

University of California, Berkeley, works to reconstruct possible origins and development of animal multicellularity.¹⁴ These scientists show that interspecies—really, interkingdom—meetings and enfoldings can produce entities that hold together, develop, communicate, and form layered tissues like animals do.

As Alegado and King put it,

Comparisons among modern animals and their closest living relatives, the choanoflagellates, suggest that the first animals used flagellated collar cells to capture bacterial prey. The cell biology of prey capture, such as cell adhesion between predator and prey, involves mechanisms that may have been co-opted to mediate intercellular interactions during the evolution of animal multicellularity. Moreover, a history of bacterivory may have influenced the evolution of animal genomes by driving the evolution of genetic pathways for immunity and facilitating lateral gene transfer. Understanding the interactions between bacteria and the progenitors of animals may help to explain the myriad ways in which bacteria shape the biology of modern animals, including ourselves.¹⁵

In Marilyn Strathern's sense, partial connections abound. Getting hungry, eating, and partially digesting, partially assimilating, and partially transforming: these are the actions of companion species.

King's ambitious program is crafting a stabilized and genomically well-characterized model system of cultures of choanoflagellates (*Salpingoeca rosetta*) and bacteria from the genus *Algoriphagus* to investigate critical aspects of the formation of multicellular animals. Choanoflagellates can live as either single cells or multicellular colonies; what determines the transitions? The close evolutionary relationship between choanoflagellates and animals lends strength to the model.¹⁶ The symbiogenetic theory of origins of multicellularity is contested; there are attractive alternate explanations. What distinguishes King's lab is its production of a model system that is experimentally tractable, transferable in principle to other sites, and generative of testable questions at the heart of being animal. To be animal is to become-with bacteria (and, no doubt, viruses and many other sorts of critters; a basic aspect of sympoiesis is its expandable set of players). No wonder the best science writers bring Nicole King's lab into my dinner conversations on a regular basis.¹⁷

Next, I hold out a tasty model system for studying developmental

symbioses. The question here is not how animals hold themselves together at all, but rather, how they craft developmental patternings that take them through time in astonishing morphogeneses. My favorite model is the diminutive Hawaiian bobtail squid, *Euprymna scolopes*, and its bacterial symbionts, *Vibrio fischeri*, which are essential for the squid's constructing its ventral pouch that houses luminescing bacteria, so that the hunting squid can look like a starry sky to its prey below on dark nights, or appear not to cast a shadow on moonlit nights. The squid-bacterial symbiosis has proven remarkably generative for many kinds of studies, "from ecology and evolution of a symbiotic system to the underlying molecular mechanisms of partner interactions that lead to establishment, development, and long-term-persistence of the alliance."¹⁸

Unless the juvenile squid are infected in the right spot, at the right time, by the right bacteria, they do not develop their own structures for housing bacteria when they are hunting adults. The bacteria are fully part of the squid's developmental biology. In addition, the bacteria produce signals that regulate the adult squids' circadian rhythms. The squid regulate bacterial numbers, exclude unwanted associates, and provide inviting surfaces for setting up vibrio homes. Herself trained in marine invertebrate field biology, biochemistry, and biophysics, McFall-Ngai began work on the naturally occurring squid-bacteria holobiont in 1988, when she started to collaborate with Edward (Ned) Ruby, a microbiologist also interested in symbiosis. Remembering that other vibrio bacteria are responsible for the pathogenic communication that is cholera, I was not surprised to learn what multitalented communicators these sorts of bacteria are. As McFall-Ngai put it, "The Vibrionaceae are a group of bacteria whose members often have broad physiological scope and multiple ecological niches."¹⁹ Material semiotics is exuberantly chemical; the roots of language across taxa, with all its understandings and misunderstandings, lie in such attachments.

The sympoietic collaborations of squid and bacteria are matched by the sympoietic string figures across disciplines and methodologies, including genome sequencing, myriad imaging technologies, functional genomics, and field biology, which make symbiogenesis such a powerful framework for twenty-first-century biology. Working on pea aphid symbiosis with *Buchnera*, Nancy Moran emphasizes this point: "The primary reason that symbiosis research is suddenly active, after decades at the margins of mainstream biology, is that DNA technology and genomics give us enormous new ability to discover symbiont diversity, and more

significantly, to reveal how microbial metabolic capabilities contribute to the functioning of hosts and biological communities.”²⁰ I would add the necessity of asking how the multicellular partners in the symbioses affect the microbial symbionts. “Host-symbiont” seems an odd locution for what is happening; at whatever size, all the partners making up holobionts are symbionts to each other.

Two transformative papers embody for me the profound scientific changes afoot.²¹ Subtitling their paper “We Have Never Been Individuals,” Gilbert, Sapp, and Tauber argue for holobionts and a symbiotic view of life by summarizing the evidence against bounded units from anatomy, physiology, genetics, evolution, immunology, and development. In “Animals in a Bacterial World: A New Imperative for the Life Sciences,” the twenty-six coauthors present the growing knowledge of a vast range of animal-bacterial interactions at both ecosystem and intimate symbiosis scales. They argue that this evidence should profoundly alter approaches to five questions: “how have bacteria facilitated the origin and evolution of animals; how do animals and bacteria affect each other’s genomes; how does normal animal development depend on bacterial partners; how is homeostasis maintained between animals and their symbionts; and how can ecological approaches deepen our understanding of the multiple levels of animal-bacterial interaction.”²²

Stories about worried colleagues at conferences, uncomprehending reviewers unused to so much evidential and disciplinary boundary crossing in one paper, or initially enthusiastic editors getting cold feet surround these papers. Such stories normally surround risky and generative syntheses and propositions. The critics are a crucial part of the holobiome of making science, and I am not a disinterested observer.²³ Nonetheless, I think it matters that both of these papers were published in prominent places at a critical inflection point in the curve of research on, and explanation of, complex biological systems in the urgent times called the Anthropocene, when the arts for living on a damaged planet demand sympoietic thinking and action.

Interlacing Sciences and Arts with Involutionary Momentum

I am committed to art science worldings as sympoietic practices for living on a damaged planet. Carla Hustak and Natasha Myers gave all of us a beautiful paper titled “Involutionary Momentum” that is a hinge for me between symbiogenesis and the science art worldings I present in the

third section of this chapter. These authors reread Darwin's own sensuous writing about his exquisite attention to absurdly sexual orchids and their pollinating insects; Hustak and Myers also themselves attend to the many enfoldings and communications among bees, wasps, orchids, and scientists. The authors suggest that "involution" powers the "evolution" of living and dying on earth. Rolling inward enables rolling outward; the shape of life's motion traces a hyperbolic space, swooping and fluting like the folds of a frilled lettuce, coral reef, or bit of crocheting. Like the biologists of the previous section, Hustak and Myers argue that a zero-sum game based on competing methodological individualists is a caricature of the sensuous, juicy, chemical, biological, material-semiotic, and science-making world. Counting "articulate plants and other loquacious organisms" among their number, living critters love the floridly repetitive mathematics of the pushes and pulls of hyperbolic geometry, not the accountant's hell of a zero-sum game.²⁴

Rather, the orchid and its bee-pollinators are mutually constituted through a reciprocal capture from which neither plant nor insect can be disentangled . . . It is in encounters among orchids, insects, and scientists that we find openings for an ecology of interspecies intimacies and subtle propositions. What is at stake in this involutory approach is a theory of ecological relationality that takes seriously organisms' practices, their inventions, and experiments crafting interspecies lives and worlds. This is an ecology inspired by a feminist ethic of "response-ability" . . . in which questions of species difference are always conjugated with attentions to affect, entanglement, and rupture; an affective ecology in which creativity and curiosity characterize the experimental forms of life of all kinds of practitioners, not only the humans.²⁵

Orchids are famous for their flowers looking like the genitals of the female insects of the particular species needed to pollinate them. The right sort of males seeking females of their own kind are drawn to the color, shape, and alluring insectlike pheromones of a particular species of orchid. These interactions have been explained (away) in neo-Darwinian orthodoxy as nothing but biological deception and exploitation of the insect by the flower—in other words, an excellent example of the selfish gene in action. Hustak and Myers instead read aslant neo-Darwinism, even in this hard case of strong asymmetry of "costs and benefits," to find other necessary models for a science of plant ecology. The stories

of mutation, adaptation, and natural selection are not silenced; but they are not turned up so loud as to deafen scientists, as if the evidence demanded it, when increasingly something more complex is audible in research across fields. “This requires reading with our senses attuned to stories told in otherwise muted registers. Working athwart the reductive, mechanistic, and adaptationist logics that ground the ecological sciences, we offer a reading that amplifies accounts of the creative, improvisational, and fleeting practices through which plants and insects *involve* themselves in one another’s lives.”²⁶


But what happens when a partner involved critically in the life of another disappears from the earth? What happens when holobionts break apart? What happens when entire holobiomes crumble into the rubble of broken symbionts? This kind of question has to be asked in the urgencies of the Anthropocene and Capitalocene if we are to nurture arts for living on a damaged planet. In his science fiction novel *The Speaker for the Dead* Orson Scott Card explored how a young boy who had excelled in exterminationist technoscience in a cross-species war with an insectoid hive species later in life took up responsibility for the dead, for collecting up the stories for those left behind when a being, or a way of being, dies. The man had to do what the boy, immersed only in cyber-realities and deadly virtual war, was never allowed to do; the man had to visit, to live with, to face the dead and the living in all of their materialities. The task of the Speaker for the Dead is to bring the dead into the present, so as to make more response-able living and dying possible in times yet to come. My hinge to science art worldings turns on the ongoing performance of memory by an orchid for its extinct bee.

In xkcd’s cartoon “Bee Orchid,” we know a vanished insect once existed because a living flower still looks like the erotic organs of the avid female bee hungry for copulation. But the cartoon does something very special; it does *not* mistake lures for identity; it does *not* say the flower is exactly like the extinct insect’s genitals. Instead, the flower collects up the presence of the bee aslant, in desire and mortality. The shape of the flower is “an idea of what the female bee looked like to the male bee . . . as interpreted by a plant . . . the only memory of the bee is a painting by a dying flower.”²⁷ Once embraced by living buzzing bees, the flower is a speaker for the dead. A stick figure promises to remember the bee flower when it comes time. The practice of the arts of memory enfold all terran critters. That must be part of any possibility for resurgence!


THERE ARE THESE ORCHIDS WHOSE FLOWERS LOOK LIKE FEMALE BEES. WHEN MALES TRY TO MATE WITH THEM, THEY TRANSFER POLLEN.



THIS ORCHID — *OPHRYA APIFERA* — MAKES FLOWERS, BUT NO BEES LAND ON THEM BECAUSE THE BEE IT MIMICS WENT EXTINCT LONG AGO.

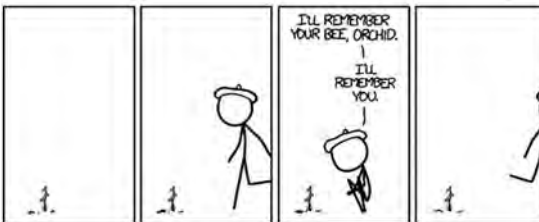



WITHOUT ITS PARTNER, THE ORCHID HAS RESORTED TO SELF-POLLINATING, A LAST-DITCH GENETIC STRATEGY THAT ONLY DELAYS THE INEVITABLE. NOTHING OF THE BEE REMAINS, BUT WE KNOW IT EXISTED FROM THE SHAPE OF THE FLOWER.



IT'S AN IDEA OF WHAT THE FEMALE BEE LOOKED LIKE TO THE MALE BEE... ...AS INTERPRETED BY A PLANT.

WOW, SO...



I'LL REMEMBER YOUR BEE, ORCHID.

I'LL REMEMBER YOU.

3.2. "Bee Orchid." © xkcd.com (Randall Munroe).

Science Art Worldings for Staying with the Trouble

I end this chapter with four engaged science art activist worldings committed to partial healing, modest rehabilitation, and still possible resurgence in the hard times of the imperial Anthropocene and Capitalocene. I think of these worldings as stinger-endowed, unfurling, grasping tentacles of the ink-spurting, disguise-artist, hunting critters of an ongoing past, present, and future called the Chthulucene.²⁸ Speaking resurgence to despair, the Chthulucene is the timespace of the symchthonic ones, the symbiogenetic and sympoietic earthly ones, those now submerged and squashed in the tunnels, caves, remnants, edges, and crevices of damaged waters, airs, and lands. The chthonic ones are those indigenous to the earth in myriad languages and stories; and decolonial indigenous peoples and projects are central to my stories of alliance.

Each of the science art worldings cultivates robust response-ability for powerful and threatened places and beings. Each is a model system for sympoietic, multiplayer, multispecies thinking and action located in a particularly sensitive place: (1) the Great Barrier Reef and all the world's coral reefs, with the Crochet Coral Reef project, initiated and coordinated by the Institute for Figuring in Los Angeles; (2) the island Republic of Madagascar, with the Malagasy-English children's natural history book series called the Ako Project, made possible by multinational friendships among scientists and artists; (3) the circumpolar northern lands of the Inupiat in Alaska, site of the *Never Alone* computer game project, centered in story-making practices among the Inupiat²⁹ and brought into being by the sympoiesis of E-Line Media and the Cook Inlet Tribal Council; and, my most developed case, (4) Black Mesa and the Navajo and Hopi lands enmeshed in Arizona, site of many-threaded coalitional work including Black Mesa Indigenous Support, Black Mesa Trust (Hopi), the scientists and indigenous herding people committed to Navajo-Churro sheep, Black Mesa Weavers for Life and Land, the mostly Diné activists of the Black Mesa Water Coalition, and the people and sheep of Diné be'iiná / The Navajo Lifeway.³⁰

Each of these projects is a case of noninnocent, risky, committed "becoming involved in one another's lives."³¹ Making-with and tangled-with the tentacular ones, which are gripping and stinging for an ongoing generative Chthulucene, each is a SF string figure of multispecies becoming-with. These science art worldings are holobiomes, or holoents, in which scientists, artists, ordinary members of communities, and nonhuman

beings become enfolded in each other's projects, in each other's lives; they come to need each other in diverse, passionate, corporeal, meaningful ways. Each is an animating project in deadly times. They are sym-poietic, symbiogenetic, and symanimagenic.

Four Critical Zones

Bathed in hot and acid oceans that are becoming more acidic and hotter by the decade, coral holobiomes everywhere are threatened. Coral reefs have the highest biodiversity of any kind of marine ecosystem. The symbiosis of cnidarian polyps, photosynthesizing dinoflagellates called zoo-anthellae living in the coral tissue, and a horde of microbes and viruses make up the keystone of the coral holobiome, which is home to multitudes of other critters. Hundreds of millions of human beings, many of them very poor, depend directly on healthy coral ecosystems for their livelihoods.³² Such sentences hugely understate coral interdependence with human and nonhuman critters. Recognition of dying coral reef ecosystems in warming and acidifying seas was at the heart of advancing the very term *Anthropocene* in 2000. Coral, along with lichens, are also the earliest instances of symbiosis recognized by biologists; these are the critters that taught biologists to understand the parochialism of their own ideas of individuals and collectives. These critters taught people like me that we are all lichens, all coral. In addition, deepwater reefs in some locations seem to be able to function as refugia for replenishing damaged corals in shallower waters.³³ Coral reefs are the forests of the sea, like Anna Tsing's forest refugia of the land. Besides all of this, coral reef worlds are achingly beautiful. I cannot imagine it is only human people who know this beauty in their flesh.

A large island nation off the east coast of Africa, the Republic of Madagascar is home to complex, layered tapestries of historically situated peoples and other critters, including lemurs, close relatives of monkeys and apes. Nine out of ten kinds of Madagascar's nonhuman critters, including all species of lemurs, live nowhere else on earth. The rate of extinction and destruction of the many kinds of Madagascar's forests and watersheds vital for rural people (the large majority of Madagascar's human citizens), urban and town residents, and myriad nonhumans is almost beyond imagination, except that it is well advanced—but not uncontested locally and translocally. Evidence from photography indicates that 40 to 50 percent of the forests of Madagascar that were still

thriving in 1950 are gone now, along with their critters, including their people, who for centuries harvested (and cultivated) woodland bounty for their lives. Forest well-being is one of the most urgent priorities for flourishing—indeed, survival—all over the earth. The contestations must matter; it's not a choice, it's a necessity.³⁴

The circumpolar North bears the brunt of the Anthropocene and Capitalocene. The Arctic is warming at almost twice the rate of the global average. Sea ice, glaciers, and permafrost melt; people, animals, microbes, and plants can no longer rely on the seasons, nor indeed on the temporally punctuated solid or liquid forms of matter crucial to their perceptions and ways of getting on in life. Eating each other properly requires meeting each other properly, and that requires good-enough synchronicity. Synchronicity is exactly one of the system properties flipping out all over earth. Change on earth is not the problem; rates and distributions of change are very much the problem. In addition, consumption-obsessed imperial circumpolar nations vie with each other in increasingly militarized seas to claim and extract the huge reserves of carbonized fossils encased in the far North, promising a further release of greenhouse gases on a scale that simply cannot be allowed to happen. A geophysical, geopolitical storm of unprecedented proportions is changing practices of living and dying across the North. The coalitions of peoples and critters facing this storm are critical to the possibilities of earth's powers of resurgence.

Located on the four-thousand-square-mile Colorado Plateau, Black Mesa, or Big Mountain, is ancestral land for both Hopi and Diné peoples. Black Mesa is also a contemporary place needed by both Navajo and Hopi families for income, food, water, sociality, and ceremony. The Black Mesa coalfield, once a huge Pleistocene lake, is the largest coal deposit in the United States. Beginning in 1968, this colonizing capitalist extractive nation hosted the largest strip-mining operation in North America, run by the Peabody Western Coal Company, part of Peabody Energy, the world's largest private-sector coal company. For forty years, coal from the Black Mesa strip mine was pulverized, mixed with immense quantities of pristine water from the irreplaceable Navajo aquifer, and carried in a giant slurry pipeline (owned by Southern Pacific) 273 miles to the heavily polluting coal-fired Mohave Generating Station in Nevada, built by the Bechtel Corporation. This plant provided energy for the blooming toxic cities in the desert Southwest, including Los Angeles. People living on Black Mesa to this day have neither assured clean water nor

reliable electricity, and many of their wells failed as the Navajo aquifer was depleted. Sheep that drink from sulfate-rich toxic waste ponds die, and groundwater is polluted.

First the slurry pipe, then the Black Mesa mine, and finally the Mo-have Generating Station were closed down in 2005 through the concerted work of both indigenous and settler environmentalists.³⁵ Attempting to combine operations with its nearby Kayenta site under a single renewal permit running to 2026, Peabody currently has plans to reopen and expand the Black Mesa mine, targeting still more land needed by sheep and people, not to mention other critters. The expanded operation would wash coal with water from the Coconino Aquifer.

Coal from the Kayenta strip mine is shipped ninety-seven miles to the Navajo Generating Station (NGS) on the Arizona-Utah border, near Glen Canyon Dam; the NGS is the largest power-generating plant in the U.S. West.³⁶ The irony of the power station's name should escape no one, since half of Navajo homes do not have electricity and the Navajo Nation does not own the plant. Even setting aside the long-term well-being of people, other critters, land, and water, without a serious share in the profits made from coal and affordable energy for local residents, dependence on coal-related jobs keeps the Navajo Nation, as well as the Hopi, in a vise grip. Unemployment in the Navajo Nation runs around 45 percent, and both Hopi and Diné are among the poorest citizens of the United States. When built by Bechtel in the 1970s on land leased from the Navajo Nation, this plant was the second-largest utility in the United States. The largest owner of the Navajo Generating Station is the federal government's Bureau of Reclamation in the Department of the Interior; the Bureau of Indian Affairs, also in the Department of the Interior, is charged with protecting Native lands and resources. Coyote is well and truly in the sheep corral in that arrangement. In 2010 Peabody's Kayenta mine was listed among the most dangerous in the United States and targeted for increased scrutiny by the federal Mine Safety and Health Administration.³⁷ This plant powers the pumping stations that transfer the waters of the Colorado River through a 336-mile-long aqueduct to the always fast-growing cities of Tucson and Phoenix. Amid ongoing struggles over both the plant's effect on air quality and access to water in the desert, in 2014 the NGS obtained a permit to continue operation as a conventional coal-fired plant until December 2044.³⁸

Hopi ancestors dug coal for their fires out of seams in Black Mesa's sandstone for centuries. Despite a destructive meme to the contrary—a

very useful meme for the fossil fuel extraction industry—Diné and Hopi agriculturalists and herders lived adjacent to and among each other in mixed amity and competition until the advent of industrial-scale coal mining on Black Mesa, which engineered intense conflict conveniently misread as timeless tribal feuds. In 1966, transnational corporations obtained leases signed by both tribal councils, without discussion or consent by the great majority of tribal members or collective bodies (kivas, chapters). The terms of bargaining for these leases were both inherently asymmetrical and enabled by ethically compromised legal processes, epitomized by a lawyer and bishop of the Mormon church named John Boyden, who, without the Hopi's knowledge, worked simultaneously for Peabody and selected Hopi leaders. Thousands of Navajo lived on Black Mesa, including some of the most traditional among the Diné. The Navajo tribal council initially refused to work with Boyden, so he cultivated Hopi whose leaders were bitterly factionalized between so-called traditionalists and progressives, beginning at a time when the Hopi had no overall governing council. Boyden worked effectively over a long period to craft legislation to clear the land of Navajo sheep people and to shift legal control to the Hopi, who did not live on the land that would be strip-mined. Traditional Hopi fiercely opposed Boyden, but to no avail. Well connected in Washington, Boyden was crucial to crafting the legal, political, and economic strategy to exploit Black Mesa's coal bounty. A Freedom of Information Act suit filed by the Native American Rights Fund ascertained that out of funds held in a federal trust for the Hopi, over thirty years Boyden was paid \$2.7 million for his "pro bono" services to the tribe.³⁹

In 1974, the U.S. Congress passed a bill introduced by Arizona senator John McCain, a man with close personal and family ties to mining and energy industries, called the Navajo-Hopi Land Settlement Act. The act has resulted in the forced removal of up to fifteen thousand Diné without serious provision of anywhere for people and animals to go, even if ties to specific places were irrelevant. But both sheep and people know and care a great deal where they come from, where they are, and where they go.⁴⁰ In 1980 the federal government purchased a uranium-contaminated site near Chambers, Arizona, as new lands for the evicted Diné. In 1996, McCain, then chairman of the Senate Committee on Indian Affairs, authored a second forced relocation act. The Navajo turned to the United Nations High Commission for Human Rights. The struggle continues, with extraordinary efforts by young activists to heal the

coal-scarred wounds dividing Hopi and Navajo. In 2005, 75 percent of overall annual Hopi income and 40 percent of Navajo income derived ultimately from Black Mesa mining operations. The struggle is dauntingly complex.⁴¹

The stories I will tell about Black Mesa are about resurgence in the face of genocide and extermination, about sheep and weaving, about art science activist worldings, about coalitions in struggle for what the Navajo call *hózhó*—balance, harmony, beauty, right relations of land and people—in this troubled world on the Colorado Plateau.

And so these are four critical zones of the tussle between the Anthropocene and Capitalocene, on the one hand, and the Chthulucene, on the other: coral forests of the oceans, diverse tropical forests of an island nation and ecosystem, rapidly melting arctic lands and seas, and coal seams and aquifers of indigenous lands linked in a global chain of ongoing colonial anthropogenic devastation. It is time to turn to sympoietic worldings, to vital models crafted in SF patterns in each zone, where ordinary stories, ordinary becoming “involved in each other’s lives,” propose ways to stay with the trouble in order to nurture well-being on a damaged planet. Symchthonic stories are not the tales of heroes; they are the tales of the ongoing.

Resurgence in Four Parts

THE CROCHET CORAL REEF

In 1997, Daina Taimina, a Latvian mathematician at Cornell University, “finally worked out how to make a physical model of hyperbolic space that allows us to feel, and to tacitly explore the properties of this unique geometry. The method she used was crochet.”⁴² With this tie between math and fiber arts in mind, in 2005, after reading an article on coral bleaching, Christine Wertheim, a crafter and poet, suggested to her twin sister Margaret, a mathematician and artist, “We should crochet a coral reef.”⁴³ We can fight for the coral reefs that way, implied this odd imperative. The sisters were watching an episode of *Xena Warrior Princess*, and Xena’s and her sidekick Gabrielle’s fabulous fighting action—or maybe just the incomparable Lucy Lawless and Renee O’Connor—inspired them.⁴⁴ The consequences have been utterly out of proportion to what the twin sisters in Los Angeles imagined that first night. So far, about eight thousand people, mostly women, in twenty-seven countries—



3.3. Beaded jellyfish made by Vonda N. McIntyre for the Crochet Coral Reef. From the collection of the Institute for Figuring (IFF). Photograph © IFF.

from Ireland, Latvia, the United Arab Emirates, Australia, the United States, the UK, Croatia, and more—have come together to crochet in wool, cotton, plastic bags, discarded reel-to-reel tape, vinyl jelly yarn, Saran wrap, and just about anything else that can be induced to loop and whirl in the codes of crocheting.

The code is so simple: crocheted models of hyperbolic planes achieve their ruffled forms by progressively increasing the number of stitches in each row. The emergent vitalities of this wooly experimental life-form take diverse corporeal shape as crafters increase the numbers from row to row irregularly, oddly, whimsically, or strictly to see what forms they could make—not just any forms, but crenulated beings that take life as marine critters of the vulnerable reefs.⁴⁵ “Every woolen form has its fibrous DNA.”⁴⁶ But wool is hardly the only material. Plastic bottle anemone trees with trash tendrils and anemones made from *New York Times* blue plastic wrappers find their reef habitats. Making fabulated, rarely mimetic, but achingly evocative models of coral reef ecosystems, or maybe of just a few critters, the Crochet Coral Reef has morphed into what is probably the world’s largest collaborative art project.

The involutory momentum of the crochet coral reef powers the sympoietic knotting of mathematics, marine biology, environmental activism, ecological consciousness raising, women’s handicrafts, fiber arts, museum display, and community art practices. A kind of hyperbolic embodied knowledge, the crochet reef lives enfolded in the materialities of global warming and toxic pollution; and the makers of the reef practice multispecies becoming-with to cultivate the capacity to respond, response-ability.⁴⁷ The crochet reef is the fruit of “algorithmic code, improvisational creativity, and community engagement.”⁴⁸ The reef works not by mimicry, but by open-ended, exploratory process. “Iterate, deviate, elaborate” are the principles of the process.⁴⁹ DNA could not have said it better.

The Crochet Coral Reef has a core set of reefs made for exhibitions, like the first ones at the Warhol Museum in Pittsburgh and the Chicago Cultural Center, both in 2007, to the Coral Forest exhibited in Abu Dhabi in 2014 and beyond. The morphing assemblages are kept at the Los Angeles Institute for Figuring (IFF), and they fill the Wertheims’ home. The IFF is the Wertheims’ nonprofit organization in LA, founded in 2003 and dedicated to “the aesthetic dimensions of mathematics, science, and engineering.”⁵⁰ The core concept is material play, and the IFF proposes and enacts not think tanks or work tanks, but play tanks,

which I understand as arts for living on a damaged planet. The IFF and the Crochet Coral Reef are art-science-activist worldings, bringing people together to do string figures with math, sciences, and arts in order to make active attachments that might matter to resurgence in the Anthropocene and Capitalocene—that is, to make string figures tangled in the Chthulucene. There are incarnations of a “biodiverse reef,” “toxic reef,” “bleached reef,” “coral forest,” “plastic midden,” “white spire garden,” “bleached bone reef,” “beaded coral garden,” “coral forest medusa,” and more, along with the many satellite reefs made by collectives of crafters that come together all over the world to mount local exhibits. Crafters make fabulated healthy reefs, but my sense is that most of the reefs show the stigmata of plastic trash, bleaching, and toxic pollution. Crocheting with this trash feels to me like the looping of love and rage.

The skills and sensibilities of Margaret and Christine Wertheim, who were born in Brisbane near the Great Barrier Reef, are fundamental, along with the skills and concerns of the thousands of reef crafters. With degrees in mathematics and physics, Margaret Wertheim is a science writer, curator, and artist. She has written extensively on the cultural history of theoretical physics. Her 2009 TED talk “The Beautiful Math of Coral” has been watched by over a million people.⁵¹ With two books written in feminine feminist materialist poetics, Christine Wertheim is a poet, performer, artist, critic, curator, crafter, and teacher. She aptly describes her work as “infesting fertile zones between cunning linguistics, psychoanalysis, poetry and gender studies.”⁵² Clearly, these twin sisters were primed for sympoietic SF.

Infecting each other and anyone who comes into contact with their fibrous critters, the thousands of crafters crochet psychological, material, and social attachments to biological reefs in the oceans, but not by practicing marine field biology or by diving among the reefs or making some other direct contact. Rather, the crafters stitch “intimacy without proximity,” a presence without disturbing the critters that animate the project, but with the potential for being part of work and play for confronting the exterminationist, trashy, greedy practices of global industrial economies and cultures.⁵³ Intimacy without proximity is not “virtual” presence; it is “real” presence, but in loopy materialities. The abstractions of the mathematics of crocheting are a kind of lure to an affective cognitive ecology stitched in fiber arts. The crochet reef is a practice of caring without the neediness of touching by camera or hand in yet another voyage of discovery. Material play builds caring publics.



3.4. Green turtles (*Chelonia mydas*) crawling out of the ocean onto the beach to lay their eggs. Credit: Mark Sullivan, NOAA, Permit #10137-07.

The result is another strong thread in the holobiome of the reef: we are all corals now.

Returning to the birth tendrils of the Wertheim sisters in coral reef worlds, I close this little section on the Crochet Coral Reef with a gorgeous photo of green sea turtles coming out of the ocean onto the beach to lay their eggs. Laying their eggs in more than eighty countries and endangered or threatened everywhere, green turtles are globally distributed across the tropical and subtropical belt of earth. A portrait of another green turtle flying in the ocean over the Great Barrier Reef in Australia advertises the Regional Chamber of the Rights of Nature Tribunal held in Far North Queensland in 2015.⁵⁴ About eighteen thousand female turtles nest each season on Raine Island in the Great Barrier Reef; this population is one of only two large nesting groups on the earth today.⁵⁵ The tribunal collected statements from Aboriginal witnesses about proper governance of the reef to present at the International Tribunal for the Rights of Nature during the Climate Change summit in Paris in December 2015. Sea turtles, corals, Aboriginal witnesses on the care of decolonizing Country, the holobiomes of scientists, denizens of



3.5. Page from *Tik-Tik the Ringtailed Lemur/Tikitiki Ilay Maky*. UNICEF Madagascar and the Lemur Conservation Foundation. Text by Alison Jolly and Hanta Rasamimanana. Art by Deborah Ross. Courtesy of Margaretta Jolly.

the Chthulucene, diverse environmental justice activists, and international art science crafters come together in SF, in speculative fabulation for flourishing.

THE MADAGASCAR AKO PROJECT

As a Yale graduate student studying lemur behavior in 1962 in what is now the Berenty Primate Reserve, Alison Jolly fell into noninnocent love and knowledge in her first encounter with female-led, swaggering, opportunistic ring-tailed lemurs in the spiny forest and dry gallery forest of the south of the island. Simply and transformatively, this young six-foot-tall American white woman became a lover and seeker of knowledge and well-being with and for the beings of Madagascar, especially the astonishing species of lemurs, the radically different forest ecosystems the length and breadth of the island, and the land's complex people and peoples. Author of many books and scientific papers and participant in numerous study and conservation teams, Jolly died in 2014. Her contributions to primatology, biodiversity conservation, and historically informed, passionate analyses of conservation conflicts and necessities were legion. But Jolly herself seemed especially to prize the sympoietic

gift she helped craft, the Ako Project,⁵⁶ which is tuned to practices for resurgence in vulnerable Malagasy worlds. This is the part of her work I most love.⁵⁷

In the marrow of her bones, Jolly understood the terrible contradictions and frictions in her embrace of *both* the rural people, who cut and burn the forests to make small agricultural plots called *tavy*, and her beloved prosimians with all their forest partners.⁵⁸ Of course, she knew she was not Malagasy, but at best a guest who might reciprocate appropriately, and at worst another in a long line of colonizers, always taking land and giving advice for the best reasons. Aware of the controversies over whether shifting cultivators destroyed or nurtured and managed the forest, she learned a great deal about what made contemporary, escalating *tavy* burnings lethal to the future of the forests and of all their critters, including the people who need them not just for their products (including lemurs for food), but to sustain fertility in phosphorous-poor tropical soils. She knew that making *tavy* had been part of the cycle of forest succession and biodiversity maintenance, with evidence in old stands in Ranomafana Park. But, she argued, not anymore. Nothing has time to regenerate anymore. Jolly knew in detail what the press of rapidly increasing human numbers means to the forests in the situated history of multiple land dispossessions, relocations, violent suppressions, imposition of regimes of private property, insecure markets, a succession of failed national governments, huge solicited and imposed national debt, and broken development promises. She wrote vividly about local people's accurate assessment of the effects of generations of visiting experts, while the experts and visiting research scientists often knew little or nothing about the terrible history of land seizures, colonial and postcolonial search-and-destroy operations, rapacious extraction schemes, and the impact on villagers of the failed projects of usually well intentioned but often ignorant foreign scientists and both local and foreign NGOs. She also knew what sustained committed work of real colleagues and friends could accomplish in Madagascar against the odds and across differences of all sorts. There are many possible examples and many important people, but I want to tell about one little project that might be considered a model system for sympoiesis.

Written in both English and Malagasy, each book in the Ako Project vividly narrates the adventures of a young Malagasy lemur from one of six species, from the tiny mouse lemur or *ny tsididy*, to the queer-

fingered aye-aye or *ny aiay*, to singing Indri or *ilay babakoto*. The stories are fleshed-out natural histories, full of the empirical sensuous curiosity of that genre; and they are bumptious adventures of gutsy young lemurs living the joys and dangers of their habitats and of their groups' social arrangements. Surrounding each lemur species with diverse plant and animal critters proper to their habitats, the project provides both teachers' guides in Malagasy and beautifully crafted posters showing the unique regions of Madagascar where the stories take place. The books are *not* textbooks; they are stories, feasts for mind, heart, and body for children (and adults) who have no access to storybooks or to the critters of their own nation or even region. Most Malagasy never see a lemur on the land, on television, or in a book. Those privileged enough to go to a school with books saw pictures of French rabbits, a fact Alison Jolly told me with disgust in the 1980s when I interviewed her for *Primate Visions*. Many villages are still without schools; and the formal curriculum for children, whether modeled on the older French system or newer learner-centered approaches, is irrelevant to most of the population. State financing for rural schools is extremely paltry, and most rural children are taught by community teachers with no teacher training and no income except from fees paid by very poor families. Teaching about local critters or ecologies rarely happens.

The Ako Project did an end run around the starved schools and unresponsive bureaucracies. After Jolly saw the alluring watercolors of fauna and flora by Deborah Ross, she asked the artist if she would illustrate her children's books about lemurs. Ross said yes; Jolly then contacted her old friend, the lemur biologist Hantanirina Rasamimanana. They raised money; the project was off and running.⁵⁹ In exciting, beautiful, funny, and scary stories, distributed outside the school bureaucracies, the Ako Project nurtures empathy and knowledge about the extraordinary biodiversity of Madagascar *for the Malagasy*.

The Ako Project is the generative fruit of a collegueship and friendship over decades.⁶⁰ In 1983 Alison Jolly met Hanta Rasamimanana, a scientist seventeen years her junior. They bonded as mothers doing fieldwork in challenging conditions, primatologists riveted by ring-tailed lemurs, lovers of Malagasy people and nature, and participants in global and local politics, with differently situated vulnerability and authority. Born in the capital city and part of the generation sponsored by the Soviet Union under Didier Ratsiraka's socialism, Rasamimanana



3.6. Painting for *Tsambiki Ilamba Fotsy/Bounce the White Sifaka*. UNICEF Madagascar and the Lemur Conservation Foundation. Text by Alison Jolly and Hanta Rasamimanana. Art by Deborah Ross. Courtesy of Margaretta Jolly and Deborah Ross.

trained in animal husbandry at the Veterinary Academy in Moscow. She earned a PhD at the Muséum National d'Histoire Naturelle in Paris, and she has a master's in primate conservation. She is professor of zoology and scientific education at l'École Normale Supérieure of Antananarivo. Studying ringtails, Rasamimanana has published on feeding behavior, energy expenditure, and lemur female precedence and supreme authority in their societies ("dominance"). Her responsibilities in the scientific academy of Madagascar have been multiple, and she initiated a master's degree in primate conservation run in Mahajanga and the Comoros. An adviser on the Madagascar National Curriculum, she heads the Ako Project teacher support program and wrote the Malagasy teacher's guides based on workshops she ran in rural areas.⁶¹

In the summer of 2013, Rasamimanana was the program chair for the Fifth International Prosimian Congress, held at the Centre ValBio Research Campus in Ranomafana National Park, where Alison Jolly's friend and colleague Patricia Wright and so many others had worked for decades to strengthen biodiversity and primate research *in* Madagascar and *by* Malagasy scientists.⁶² Eighty of the two hundred participants in 2013 were from Madagascar. Half of the two hundred present were students, the core of the next generation of scientists dedicated to holding open space and time for lemurs and their associates in vulnerable forest webs. Writing in her conservation diaries shortly before her death, Jolly celebrated what this congress meant: "The big change is that most papers are by Malagasy speaking on their own biodiversity, eager to advance their own careers in conservation. A contrast to the continuing bewilderment of so many other Malagasy as to why anyone would want to visit forests! And a huge swing from all the meetings in the past dominated by foreigners."⁶³

In all their attachments, working with book and poster artists, together the scientists and storytellers Jolly and Rasamimanana brought the Ako Project into the world. In this project and in their work and play across many crises in Madagascar and its conservation history, they have nurtured new generations of Malagasy naturalists and scientists, including small children, field station guides, and school and university students. Without innocence and with relentless commitment, Jolly and Rasamimanana have practiced, in solidarity, the arts of living on a damaged planet; it matters.



3.7. Cover image for *Never Alone (Kisima Ingitchuna)*. Courtesy of E-line Media, in collaboration with Upper One Games, and the Cook Inlet Tribal Council.

NEVER ALONE (KISIMA INGITCHUNA)

My third example of science art worlding for living on a damaged planet is making “world games.” World games are made with and from indigenous peoples’ stories and practices. “But what good are old stories if the wisdom they contain is not shared?”⁶⁴ These games both remember and create worlds in dangerous times; they are worlding practices. Indigenous peoples around the earth have a particular angle on the discourses of coming extinctions and exterminations of the Anthropocene and Capitalocene.⁶⁵ The idea that disaster will come is not new; disaster, indeed genocide and devastated home places, has already come, decades and centuries ago, and it has not stopped. The resurgence of peoples and of places is nurtured with ragged vitality in the teeth of such loss, mourning, memory, resilience, reinvention of what it means to be native, refusal to deny irreversible destruction, and refusal to disengage from living and dying well in presents and futures. World games require inventive, sympoietic collaborations that bring together such things as computer game platforms and their designers, indigenous storytellers, visual artists, carvers and puppet makers, digital-savvy youngsters, and community activists. The set of computer world games at the moment

I write this sentence is small; there is one. Others, however, are in the collaboration and design phase.⁶⁶

However, even though the models of sympoiesis are expandable, it is critical not to once again raid situated indigenous stories as resources for the woes of colonizing projects and peoples, entities that seem permanently undead. *Never Alone* is not a New Age game for universal oneness, a posthumanist solution to epistemological crises, a general model for collaboration, or a way to finesse the Anthropocene with Native Climate Wisdom. Nor is *Never Alone* a primer for the Chthulucene. If Inupiat “Sila” meets in SF games with the tentacular Chthulucene, it will be a risk-taking proposition, not an innocent translation.⁶⁷ *Never Alone* requires a different sort of attention; and perhaps the fact that I continue to die early and often playing the game is less a reflection of my poor gaming skills than a proper reminder that a world game is situated indigenous storytelling in specific histories. The fact that the game is narrated in Inupiaq, with English subtitles, is another reminder where worlding authority lies here. Stories, even stories offered for sale on the Internet, belong to storytellers, who share them, or not, in practices of situated worlding. The conditions for sharing stories must not be set by raiders, academic or otherwise.⁶⁸ That does *not* mean the game is restricted to native commentators in native places for native audiences in a perverse caricature of a reservation. It *does* mean the terms of telling, listening, and playing have been relocated decisively.

“*Never Alone (Kisima Ingitchuna)* is the first game developed in collaboration with the Inupiat, an Alaska Native people. Play as a young Inupiat girl and an arctic fox as they set out to find the source of the eternal blizzard which threatens the survival of everything they have ever known.”⁶⁹ No one acts alone; connections and corridors are practical and material, even if also fabulous, located in what Anglophones tend to dismiss as the spirit world. The girl Nuna’s personal courage and skills are also fundamental. These are the arts of living on a damaged planet (Anna Tsing’s term). *Never Alone* might be played in a string figure pattern with Ursula Le Guin’s *Always Coming Home*.

Game makers define the new genre “world games” as taking place inside ongoing indigenous stories. Makers of *Never Alone (Kisima Ingitchuna)* include Gloria O’Neill, the president and chief executive of the Cook Inlet Tribal Council; dozens of advisers and elders from the Alaska Native community; Alan Gershenfeld, cofounder of E-line Media; E-Line creative director Sean Vesce; the design team’s studio in Seattle; young

and old people playing the game; and a shared sense of contemporary urgency for the lands and waters with their human and other-than-human beings. “O’Neill said she loved the chance to participate in the video game because the council could be a codeveloper in the process—and because no Native American group had ever played such a role in the history of the video game industry.”⁷⁰

The sympoiesis of *Never Alone* has many threads, and one of them is hard for most modernist people, namely the symanimagenic richness of the stories and the game. The girl Nuna and her arctic fox companion go from the home village to face the unprecedented blizzard, find what is causing it, and save the people and the land. Helping each other, girl and fox learn to traverse many obstacles, and even to swim in the belly of a whale, finally escaping into the sky through the blowhole. Those kinds of sym linkages and fabled travels are not an ontological or epistemological problem, or at least not much of one. But the presence and agency of multiple spirit helpers are absolutely central to this worlding, to these stories, and to this sympoiesis in the Arctic of the Anthropocene. Digital information system ontologies, spirit helpers, and biocultural girls and foxes have to play an agile string figure game seriously for “never alone” to have its full meaning.

Working with Brazilian Amerindian hunters, with whom he learned to theorize the radical conceptual realignment he called multinaturalism and perspectivism, Eduardo Viveiros de Castro wrote, “Animism is the only *sensible* version of materialism.”⁷¹ I am not talking about people like me—or kids like Nuna—“believing” in the spirit world. Belief is neither an indigenous nor a “chthulucenean” category. Relentlessly mired in both internecine and colonizing disputes of Christianity, including its scholarly and civic secular forms, the category of belief is tied to doctrine, profession, confession, and taxonomies of errors. That is, believing is not sensible.⁷² I am talking about material semiotics, about practices of worlding, about sympoiesis that is not only symbiogenetic, but is always a *sensible* materialism. The sensible materialisms of involutionary momentum are much more innovative than secular modernisms will allow. Stories for living in the Chthulucene demand a certain suspension of ontologies and epistemologies, holding them lightly, in favor of more venturesome, experimental natural histories. Without inhabiting symanimagenic sensible materialism, with all its pushes, pulls, affects, and attachments, one cannot play *Never Alone*; and the resurgence of this and other worlds might depend on learning to play.

But, continuing to die early and often in *Never Alone*, I have not forgotten that spirit helpers favor their kin. Animism cannot be donned like a magic cape by visitors. Making kin in the ongoing Chthulucene will be more difficult than that, and even the unwilling heirs of colonizers are poorly qualified to set conditions for recognition of kinship. Plus, many contemporary Inuit, including those committed to cultural renewal, are wary of animism in their own heritage. Staying with the trouble, yearning toward resurgence, requires inheriting hard histories, for everybody, but not equally and not in the same ways.

NAVAJO WEAVING: COSMOLOGICAL PERFORMANCE,
MATHEMATICAL RHYTHM, NAVAJO-CHURRO SHEEP, HÓZHÓ

Black Mesa, on it life.

There will be life again, this is what they say.

For this reason they are weaving.⁷³

For my last model system for sympoiesis, in risky propositions I return to fibers, linking the Crochet Coral Reef to Navajo weaving. Navajo weaving is practiced all over the Navajo Nation, but I will emphasize the weavers of Black Mesa, their sheep, and their alliances.⁷⁴ It would be a serious category mistake to call Navajo weaving “art science activism,” which was a comfortable enough name for the Crochet Coral Reef. Besides bypassing robust and precise Diné namings, both the categories “art” and “science” continue to do colonizing work in this context. However, it would also be a serious category error to fence Navajo weaving off from ongoing mathematical, cosmological, and creative practice that never fit ongoing colonial definitions of “traditional.” Like the Crochet Coral Reef, Navajo weaving, especially with the wool of Churro sheep, ties people to animals through patterns of care and response-ability in blasted places of excess death and threatened ongoingness. As in the Crochet Coral Reef, the play of collective making and personal invention is everywhere in Navajo fiber work. Both the Crochet Coral Reef and Navajo weaving exist in a modernizing ecology of gendered and commodifying structures that elevate “art” over “craft.” Both the Crochet Coral Reef and Navajo weaving are done mainly by women, but men also figure in the webs of thinkers/makers.⁷⁵ Both the Crochet Coral Reef and Navajo weaving perform worlds with mathematical vitality that remains invisible in the doxa of scholarship on women’s fiber practices in both settler and colonized indigenous production. Finally, attuned to a sympoiesis



3.8. Navajo rug, Two Gray Hills. Weaver unknown. Photograph by Donna Haraway. Purchased by Rusten Hogness's father, John Hogness, in the Navajo Nation in the 1960s.

of practical coalitions, both the Crochet Coral Reef and Navajo weaving are at the heart of thinking/making for more livable politics and ecologies in the times of burning and extraction called the Anthropocene and Capitalocene. In face-to-face and hand-to-hand entanglements, the Great Barrier Reef and Black Mesa are crocheted and woven together in cosmological performances to animate the tentacular Chthulucene of a Thousand Names.

A refrain from Navajo prayers often accompanies a weaver's work: "With me there is beauty" (*shil hózhó*); "in me there is beauty" (*shii' hózhó*); "from me beauty radiates" (*shits' áá d óó hózhó*).⁷⁶ *Hózhó* is a central concept in Navajo cosmology and daily practice. Usual translations into English are "beauty," "harmony," and "order"; but I think a better

translation would emphasize right relations of the world, including human and nonhuman beings, who are *of* the world as its storied and dynamic substance, not *in* the world as a container. Disorder, often figured in the doings of Coyote, disrupts right relations, which must be restored in ceremony and daily life for proper living to be again possible, for the person to be restored in *hózhó* to the People. For the Diné, greed is the greatest source of disorder; it destroys right relations at their root.

Weaving is a useful practice, to be sure, and an economic one; but, fundamentally, weaving is also cosmological performance, knotting proper relationality and connectedness into the warp and weft of the fabric.⁷⁷ The geometric patterns of repetition and invention in weaving are performances of Diné stories and knowledge; the patterns propose and embody world-making and world-sustaining relations. The dynamic patterning continues in contemporary weavings, many of which explore new as well as inherited themes, colors, stories, and fibers.⁷⁸ Weavings are individual; they are made by a particular woman and embody her style and sensibility, recognizable by knowledgeable members of the community.⁷⁹ Names of weavers and weavers' lineages matter, but weavings are not made to be possessed as property. Neither that nor the entanglement of the creative personal and the cosmological is a contradiction. The *sensible* order inherent in the storied cosmos of Changing Woman, the Holy Twins, Spider Woman, and the other world-making Holy People is the pattern for right living. Weaving is neither secular nor religious; it is *sensible*. It performs and manifests the meaningful lived connections for sustaining kinship, behavior, relational action—for *hózhó*—for humans and nonhumans. Situated worlding is ongoing, neither traditional nor modern.

Navajo weaving relied especially on the so-called rough sheep brought to the Americas by the Spanish in the sixteenth century and developed by Navajo herders over a long time as a distinct kind of sheep, named T'aa Dibei or Navajo-Churro sheep, who are particularly well adapted to the lands of Diné bikéyah on the Colorado Plateau.⁸⁰ In Western historical temporalities, Navajo matrifocal pastoralism and farming developed in the eighteenth and nineteenth centuries, with sheep as core companions for living and dying in *hózhó*. The art of weaving and care of Churro sheep reciprocally enact Diné relations of natural and cosmic order.

The Diné endured two intense periods of efforts by U.S. officials to exterminate their Churro sheep. The first such genocide, called Hwéeldi and effected in 1863 under Kit Carson for the U.S. War Department,

was the Long Walk of all the People who could be forcibly rounded up from Dinetah and marched for hundreds of miles to Bosque Redondo in New Mexico. The Hwéeldi followed a scorched-earth campaign led by Carson against the Navajo. Killing of Navajo animals was a central act of the removal. From the beginning, across the Southwest and West U.S. modernizers saw Spanish-introduced stock as rough and unimproved. Exterminating flocks, cutting down peach orchards, and forcing the removal of people to Fort Sumner/Bosque Redondo were, in effect, normal actions of U.S. colonizing officials pacifying and civilizing an unruly mobile population. The correct name is attempted genocide. Full of suffering and death, this forced march was followed by four years in a prison camp and then the walk back to their lands. The Hwéeldi is remembered in the flesh of land and people; it is an “originary” trauma, of the kind Toni Morrison understood in her novel *Paradise*.⁸¹

The Diné returned to the Navajo reservation on the Colorado Plateau. Churro sheep had been carefully tended by people who escaped Kit Carson’s soldiers in the deep canyons and remote areas of Dinetah, including Big Mountain/Dzil ni Staa/Black Mesa. The boundaries of the reservation extended gradually until the 1930s; and, despite the failure of the U.S. government after the Diné return from Bosque Redondo to provide promised stock, sheep flocks grew much faster than the human population. This growth was partly driven by the trading post system, which turned wool into blankets to realize value and bought these blankets by the pound in a system of perpetual indebtedness. To obtain basic necessities in this system of debt, the Navajo were forced to produce more and more wool from more and more sheep. The traders sold the weavings in the art and tourist market, but purchased the women’s weavings as if they were low-value raw wool. Despite the efforts of federal agents, most of the Diné continued to prefer multipurpose, hardy Churro sheep to merinos and other “improved” breeds. Sheep, goats, horses, and cattle were all part of the pattern of Navajo pastoralism, ordered by complex clan and gender relationships. The animals and the people made kin together.⁸² Sheep and goats were especially crucial for women’s abilities to feed and provision their families, as well as to their authority in the clans.

With intensifying erosion, severe grazing, and sustained drought, by the 1930s the system was increasingly out of harmony, a condition recognized by both whites and Navajos. The second intense efforts of the U.S. government to exterminate Navajo-Churro sheep occurred in

this context; like the first originary trauma, this lethal event can be neither forgotten nor effectively mourned. It bears evil fruit to this day. Restoring the land, animals, and people to *hózhó* is an ongoing process that continues to require continuous weaving. The colonial and capitalist structures of both exterminations have not been dismantled. The first Churro sheep extermination was conducted by U.S. military men; the second was also conducted by force, this time by U.S. progressive agricultural authorities within the ideology and apparatus of the New Deal. These officials worked within the ecological concept of carrying capacity, the patriarchal colonial concepts of male-headed households, and the modernizers' concepts of progress. Without asking how colonial economic structures like the unequal wool trade might be a significant cause of both poverty and ecological damage and judging the erosion of Navajo lands to be due to overstocking as a biological sort of fact, U.S. government scientists in the Department of Agriculture and others in 1934 killed most of the women's goats, the primary source of subsistence meat for families. White-settler divisions of the world into nature and culture split Navajo lifeways into colonial apparatuses of ecology and economics, practiced by different sorts of scientific specialists who could not systematically think even with each other, much less with Navajo herders and weavers. In 1935, officials killed vast numbers of sheep. Churro sheep, many known individually by their people, were preferentially killed, often in front of their human families. Evident in photographs, piles of bones from these animal murders were still prominent in the 1970s; and people still dramatically narrated the trauma, even describing particular animals in their flocks.

Following the killing of about a million sheep and goats (without significant compensation to this day), stocking quotas were imposed, and collective ownership of land was not recognized. The census by which stock quotas and permits were allocated recognized only heads of households, who could not be married women, which was a major blow to Diné matrifocal ways of ordering their relations with land, animals, and each other. Transhumance was disrupted as land boundaries were redrawn into Land Management Units, exacerbating erosion as both seasonal and dynamic rain-pattern-sensitive movements for grazing became difficult across such boundaries. Besides an act of scientific colonial arrogance and culpable ignorance, the animal exterminations of the 1930s effected a profound decapitalization of the whole people, whose existing poverty, itself linked to the consequences of the first Hwéeldi,

was structurally intensified. With the failure to restore the health of lands, waters, animals, and people in *hózhó*, balanced pastoralism was not reconstructed; resurgence on the Colorado Plateau was wounded. Stock levels and erosion remain a major problem, intensified by deep resentment of forced controls, including colonial conceptual apparatuses within the Navajo Nation.

In a crisis of drought and multispecies lifeways out of balance in the 1930s, the opportunity was missed to bring scientific ecological ideas like carrying capacity into difficult but necessary conversation with Navajo concepts and practices of *hózhó*. Neither carrying capacity nor *hózhó* is a fixed, deterministic concept; both are relational, contextual, tuned to some ways of living and dying and not others. It matters what concepts think concepts, and vice versa; but in this case, colonial structures assured that the important concepts would not be allowed to think each other, would not be allowed perhaps to issue in something that did not yet exist in thought for either people, but might be needed by both. When one system of thinking and practice can only disparage and nullify another in colonial recursions, there can be no sympoiesis and no *hózhó*. The consequences of the failure to invent the needed decolonial conversations ramifies into the present. Since this period, pastoralism has not been able to support the Diné; and poverty is perpetuated by the post-World War II wage-based economy in the context of extreme under- and unemployment, federal subsidies, tourism, and income from uranium and coal mining.⁸³

However, there is also an extraordinary story of resurgence and partial healing to be told, one that belongs to the Diné and their allies in the ongoing Chthulucene and the ongoing Diné Bahane' / Story of the People / Navajo Creation Story. By 1970, only about 430 Navajo-Churro sheep survived, scattered across the reservation. The traditional Diné of Black Mesa and others had protected what sheep they could in remote places. Other Churro sheep survived from a research population studied from 1934 to 1967 at the Southwest Range and Sheep Breeding Laboratory at Fort Wingate, New Mexico. When the research project shut down, 165 Churro sheep were auctioned off in 1967 to a rancher in Gonzales, California, who used them in a shoot-in-a-barrel safari enterprise for Hollywood notables. Besides their double coat, long fibers, high-lanolin wool, ability to survive on scrubby pasture, and excellent mothering skills by the ewes, Churro rams frequently have a double set of horns that incite hunting fantasists to pay to turn them into tro-

phies. The story of Navajo-Churro resurgence—with Navajo herders and weavers; an Anglo scientist committed to Churro sheep and their people; Navajo and Anglo students; Hispanic and Anglo ranchers; Tarahumara/Rarámuri Indians of the Sierra Madre Occidental of northern Mexico, who interbred Churro from the Navajo Sheep Project with their own rough sheep to recover genetic diversity; activists on Black Mesa; and more—begins at these crossroads. Over decades Diné herders nurtured remnant flocks in spite of the odds, and Buster Naegle, who had taken over the ranch in Gonzales in 1970 to raise paint horses, donated six ewes and two four-horned rams to Lyle McNeal, an animal scientist then at Cal Poly San Luis Obispo, as seed animals. In ensuing lifelong coalitional work, McNeal founded the Navajo Sheep Project in 1977.⁸⁴

The story of Navajo-Churro restoration is complexly tentacular and fibrous, braided by many actors and full of obstacles as well as successes. Collecting sheep on the reservation from Diné cooperating to help rebuild the flocks, Lyle McNeal donated some of the first rams born from his seed flock in the 1980s to Women in Resistance on Black Mesa. Keeping his nucleus flock and operations alive involved thirteen moves in four states over twenty-five years with many adventures with the law, especially private property law. With Diné Churro sheep herders and weavers including Glenna Begay, Lena Nez, and others, Carol Halberstadt, a poet, activist, and lover of wool from Massachusetts, cofounded Black Mesa Weavers for Life and Land as a fair trade cooperative association to better the economic and social conditions of Black Mesa Diné through supporting sheep herding, wool buys, and weaving.⁸⁵ A Navajo-Churro flock has been established at the Diné College in Tsaile, Arizona, for teaching. Diné be'íina/The Navajo Lifeway was founded in 1991 to nurture community-based partnerships to restore economy and culture. The college hosts the Dibé be'íina/Sheep Is Life celebration every summer.⁸⁶ Churro are central to cultural renewal through weaving and taking care of sheep. Reconnecting generations broken by boarding schools and forced stock exterminations and encouraging Navajo language use among the young are also tied to these sheep.⁸⁷ Kosher Navajo-Churro sheep jerky, guard llamas, the American Livestock Breeds Conservancy, the Navajo-Churro Sheep Association, the Agricultural Research Service National Center for Genetic Resources Preservation, the Slow Food Foundation for Biodiversity, Two Grey Hills Trading Post, the Teec Nos Pos Chapter and its regional wool-processing facility, the Ganados del Valle Hispanic agricultural development corporation, Tierra

Wool and Los Ojos Handweavers, the Crownpoint Auction, and Heifer International are all involved in diverse configurations.⁸⁸

Not least, the sheep themselves are active participants in the interlaced relational worlds. Like all sheep, they recognize hundreds of faces; they know their people and their land.⁸⁹ Weaving is cosmological performance, relational worlding, with human and nonhuman fibers from the Holy People, ordinary human beings, plants, soils, waters, and sheep. The critters are critical to taking care of country, to environmental justice, to robust ecosystems for humans and nonhumans, to *hózhó*. It matters which beings recognize beings.

So the sheep lead back to Black Mesa and to a concluding sympoiesis with the activists—the thinkers/makers—of the Black Mesa Water Coalition (BMWC). Supporting the weavers, herders, and sheep of the region, BMWC partners with Diné be'íina and holds wool buys; they even partner with a sheep-farming outfit in Maine called Peace Fleece.⁹⁰ BMWC is thoroughly entangled with sheep and their people across damaged lands and blasted histories. But my reason for tying the threads of cosmological performance and continuous weaving together through BMWC is grounded in coal, water, indigenous environmental justice movements, and surging coalitions for Just Transition toward still possible worlds in urgent times. Probably still possible. Barely still possible. Still possible *if* we render each other capable of worlding and reworlding for flourishing. I want to propose the Black Mesa Water Coalition as a sympoietic model for learning to stay with the trouble together, for *hózhó*.

The BMWC was founded in 2001 by a group of young intertribal, interethnic people, mostly students at the time, committed to addressing water depletion, natural resource exploitation, and health in Navajo and Hopi communities.⁹¹ Quickly focusing on Peabody Energy, they were central to the actions that closed down the Black Mesa Mine and Mohave Generating Station in 2006. But that was the beginning, not the end. The coalition sees Black Mesa as a critical place for learning to transition out of coal-based economies and ecologies and into abundant solar and other renewable power, situated on damaged lands, as a needed practice for multispecies environmental justice. Black Mesa itself is not just any place; within Navajo cosmology Black Mesa is the mother encircled by the four sacred mountains. The waters are the mother's blood, and coal is her liver. That condensed Diné geo-anatomy is only an indication of the corporeal relational cosmology of place that is utterly illegible to Peabody Energy—and to settler colonialism more broadly,

to this day. My colleague Anna Tsing talks about “worlds worth fighting for”; Black Mesa is such a world.⁹²

The BMWC’s Just Transition Initiative, beginning in 2005, is a comprehensive vision and practice for building on the strengths of local people, culture, and land, in alliance with many partners, to make resurgence on Black Mesa and beyond a reality. Pilot projects for restoring regional watersheds and for economic development, the vision and work toward a Black Mesa Solar Project, the Food Security Project, the Navajo Wool Market Project, the Green Economy Project, and the Climate Justice Solutions Project are all part of the BMWC’s work. These activists aim to develop a strong regional, integrated environmental and social justice movement led by indigenous communities and organizations, as well as to ally with the worldwide Climate Justice Alliance.⁹³ These are big, important ideas and actions; these kinds of continuous weaving are at the heart of staying with the trouble in a damaged world. Continuing to be led by young adults within a multigenerational web, the BMWC proposes the sort of resurgence that can face the originary, repeating traumas of history without denial and without cynicism or despair. In my idiom, the Black Mesa Water Coalition is a strong tentacle in the surging Chthulucene.

Conclusion: Tying Off the Threads

We relate, know, think, world, and tell stories through and with other stories, worlds, knowledges, thinkings, yearnings. So do all the other critters of Terra, in all our bumptious diversity and category-breaking speciations and knottings. Other words for this might be materialism, evolution, ecology, sympoiesis, history, situated knowledges, cosmological performance, science art worldings, or animism, complete with all the contaminations and infections conjured by each of these terms. Critters are at stake in each other in every mixing and turning of the terran compost pile. We are compost, not posthuman; we inhabit the humusities, not the humanities. Philosophically and materially, I am a compostist, not a posthumanist. Critters—human and not—become-with each other, compose and decompose each other, in every scale and register of time and stuff in sympoietic tangling, in ecological evolutionary developmental earthly worlding and unworlding.

This chapter began with Lynn Margulis’s proposition of symbiogenesis and segued into the biologies that make an extended evolutionary

synthesis necessary to thinking well about multispecies living and dying on earth at every scale of time and space. The involutory momentum of a vanishing bee and its faithful orchid enfolded the EcoEvoDevo biologies into four natural social ecologies of a damaged planet. Actual places, these are worlds worth fighting for; and each has nourished brave, smart, generative coalitions of artists/scientists/activists across dangerous historical divisions. The biologies, arts, and politics need each other; with involutory momentum, they entice each other to thinking/making in sympoiesis for more livable worlds that I call the Chthulucene.⁹⁴

Isabelle Stengers's sense of cosmopolitics gives me courage.⁹⁵ Including human people, critters are in each other's presence, or better, inside each other's tubes, folds, and crevices, insides and outsides, and not quite either. The decisions and transformations so urgent in our times for learning again, or for the first time, how to become less deadly, more response-able, more attuned, more capable of surprise, more able to practice the arts of living and dying well in multispecies symbiosis, sympoiesis, and symanimagensis on a damaged planet, must be made without guarantees or the expectation of harmony with those who are not oneself—and not safely other, either. Neither One nor Other, that is who we all are and always have been. All of us must become more ontologically inventive and sensible within the bumptious holobiome that earth turns out to be, whether called Gaia or a Thousand Other Names.