

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 holobionts 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 Subtitled 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

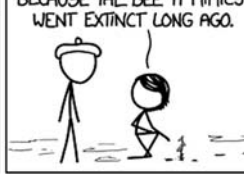
But what happens when a partner involved critically in the life of another disappears from the earth? What happens when holobionts break apart? What happens when entire holobiomes crumble into the rubble of broken symbionts? This kind of question has to be asked in the urgencies of the Anthropocene and 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 — *OPHRYS APIFERA* — MAKES FLOWERS, BUT NO BEES LAND ON THEM BECAUSE THE BEE IT MIMICS WENT EXTINCT LONG AGO.

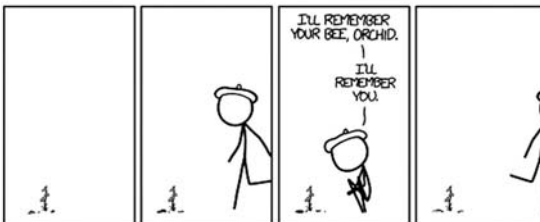
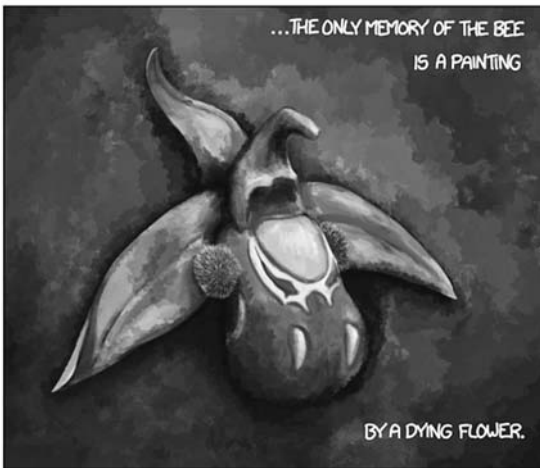



WITHOUT ITS PARTNER, THE ORCHID HAS RESORTED TO SELF-POLLINATING, A LAST-DITCH GENETIC STRATEGY THAT ONLY DELAYS THE INEVITABLE. NOTHING OF THE BEE REMAINS, BUT WE KNOW IT EXISTED FROM THE SHAPE OF THE FLOWER.



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.

Infesting 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.

- 66 “Medousa and Gorgones.”
- 67 Suzy McKee Charnas’s *Holdfast Chronicles*, beginning in 1974 with *Walk to the End of the World*, is great SF for thinking about feminists and their horses. The sex is exciting if very incorrect, and the politics are bracing.
- 68 Eva Hayward first drew my attention to the emergence of Pegasus from Medusa’s body and of coral from drops of her blood. Hayward, “The Crochet Coral Reef Project,” writes: “If coral teaches us about the reciprocal nature of life, then how do we stay obligated to environments—many of which we made unlivable—that now sicken us? . . . Perhaps Earth will follow Venus, becoming uninhabitable due to rampaging greenhouse effect. Or, maybe, we will rebuild reefs or construct alternate homes for the oceans’ refugees. Whatever the conditions of our future, we remain obligate partners with oceans.” See Wertheim and Wertheim, *Crochet Coral Reef*.
- 69 I am inspired by the 2014–15 Monterey Bay Aquarium exhibition *Tentacles: The Astounding Lives of Octopuses, Squids, and Cuttlefish*. See Detienne and Vernant, *Cunning Intelligence in Greek Culture and Society*, with thanks to Chris Connery for this reference in which cuttlefish, octopuses, and squid play a large role. Polymorphy, the capacity to make a net or mesh of bonds, and cunning intelligence are the traits the Greek writers foregrounded. “Cuttlefish and octopuses are pure *áporai* and the impenetrable pathless night they secrete is the most perfect image of their *metis*” (38). Chapter 5, “The Orphic Metis and the Cuttle-Fish of Thetis,” is the most interesting for the Chthulucene’s own themes of ongoing looping, becoming-with, and polymorphism. “The suppleness of molluscs, which appear as a mass of tentacles (*polúplokoi*), makes their bodies an interlaced network, a living knot of mobile animated bonds” (159). For Detienne and Vernant’s Greeks, the polymorphic and supple cuttlefish are close to the primordial multisexual deities of the sea—ambiguous, mobile and ever changing, sinuous and undulating, presiding over coming-to-be, pulsating with waves of intense color, cryptic, secreting clouds of darkness, adept at getting out of difficulties, and having tentacles where proper men would have beards.
- 70 See Haraway and Kenney, “Anthropocene, Capitalocene, Chthulucene.”
- 71 Le Guin, “‘The Author of Acacia Seeds’ and Other Extracts from the *Journal of the Association of Therolinguistics*,” 175.

Chapter 3: Sympoiesis

This chapter is written in honor of Lynn Margulis (1938–2011) and Alison Jolly (1937–2014).

- 1 See *Never Alone* (Kisima Ingitchuna).
- 2 The large high-resolution giclée reproduction was printed on canvas with non-fading inks. Inspired by Margulis and Sagan, *Dazzle Gradually*, Dubiner’s original gouache painting was 23 by 35 inches. Dubiner wrote, “The large red protozoan is *Urostyla grandis* based on a 1959 drawing by Stein in Leipzig. The purple protozoan

with 2 rows of cilia is *Didinium* . . . The blue feathered dragon-like creature at the center was inspired by a microscope image of a phospholipid cylinder by David Deamer . . . I wanted individual organisms to be accurate enough so a biologist would recognize them, but I allowed the overall painting to be a totally imaginary bioscape” (Dubiner, “New Painting”). For her blog writing on the painting, see Dubiner, “Endosymbiosis.” John Feldman is making a documentary film titled *Symbiotic Earth: How Lynn Margulis Rocked the Boat and Started a Scientific Revolution*. Born in 1938, Margulis died in 2011. On her UMass Amherst website, she described herself as a professor of microbial evolution and organelle heredity. See Mazur, “Intimacy of Strangers and Natural Selection”; Margulis, *Symbiotic Planet*; Margulis and Sagan, *Microcosmos*; Margulis and Sagan, *Acquiring Genomes*. See Hird, *The Origins of Sociable Life*, an important work rooted in ethnographic sociology in Margulis’s laboratory.

- 3 In 1991, “Margulis proposed any physical association between individuals of different species for significant portions of their lifetime constitutes a ‘symbiosis’ and that all participants are bionts, such that the resulting association is a holobiont” (Walters, “Holobionts and the Hologenome Theory”). See Margulis, “Symbiogenesis and Symbiointicism.” In 1992 the term *holobiont* was used by Mindell, “Phylogenetic Consequences of Symbioses,” to describe a host and its primary symbiont. In the same issue of this journal, see Margulis, “Biodiversity.” Subsequently, Rohwer et al., “Diversity and Distribution of Coral-Associated Bacteria,” used *holobiont* to mean the host plus all of its symbiotic microorganisms, including viruses. For an excellent recent summary of principles for holobionts and hologenomes, which nonetheless cannot evade the language of “host plus the rest,” see Bordenstein and Theis, “Host Biology in Light of the Microbiome.” “Safe and sound” as a meaning for *holo-* is from the *Online Etymology Dictionary*, accessed March 17, 2016.
- 4 Margulis, then publishing as Lynn Sagan, published her radical theory of the origin of the nucleated cell in 1967. Like many revolutionary contributions in science, such as Raymond Lindeman’s paradigm-resetting “Trophic-Dynamic Aspect of Ecology,” Margulis’s 1967 paper was rejected many times before being accepted for publication. See Sagan, “On the Origin of Mitosing Cells”; Margulis, “Archaal-Eubacterial Mergers in the Origin of Eukarya.” For an explication of Margulis’s autopoiesis and strong argument for continued use of the concept for Margulis’s essential work on second-order Gaian systems theory, see Clarke, “Autopoiesis and the Planet.”
- 5 Lovelock, “Gaia as Seen through the Atmosphere”; Lovelock and Margulis, “Atmospheric Homeostasis by and for the Biosphere.”
- 6 Autopoietic systems theory and the figure of Gaia proved crucial to formulating the concept of the Anthropocene. Not a nurturing mother, Gaia can flip out, in system collapse after system collapse; there are limits to the power of systemic processes of homeostasis and reformulating order out of chaos at ever more complex levels. Complexity can unravel; earth can die. It matters to become response-able.
- 7 Dempster, “A Self-Organizing Systems Perspective on Planning for Sustainability.” In 1998 Dempster thought that biology supported the conceptualization of

organisms as units, and only ecosystems and cultures are sympoietic. I argue, on biological grounds, that we can no longer think like that.

- 8 Margulis and Sagan, "The Beast with Five Genomes."
- 9 Poulsen et al., "Complementary Symbiont Contributions to Plant Decomposition in a Fungus Farming Termite." On these termite-bacterial-fungal symbioses, see the superb science writer Yong, "The Guts That Scrape the Skies."
- 10 For a closely argued analysis of the dead ends of competition/cooperation binaries and the relentless assumption that explanation in the last instance in biology must be competitive and individualistic, as well as for a fleshed-out description of more adequate explanatory practices, which are more and more in play among venturesome evolutionary, ecological, and behavioral biologists, see van Dooren and Despret, "Evolution."
- 11 Gilbert and Epel (*Ecological Developmental Biology*) document the evidence for what the authors call an "extended evolutionary synthesis," encompassing the modern synthesis, eco-devo, and eco-evo-devo.
- 12 Mereschkowsky, "Theorie der zwei Plasmaarten als Grundlage der Symbiogenese." See also Anonymous, "History."
- 13 Gilbert, "The Adequacy of Model Systems for Evo-Devo," 57. See Black, *Models and Metaphors*; Frigg and Hartman, "Models in Science"; Haraway, *Crystals, Fabrics, and Fields*.
- 14 "King Lab: Choanoflagellates and the Origin of Animals."
- 15 Alegado and King, "Bacterial Influences on Animal Origins."
- 16 Choanoflagellates and their bacterial associates make an attractive model partly because sponges, long held to be the "most primitive" critters most closely related to animals, have choanoflagellate-like cells in their bodies that do things like capture their prey (bacteria and detritus). However, recent work argues that ctenophores (comb jellies) are genetically more closely related to animals than sponges are. Halanych, "The Ctenophore Lineage Is Older Than Sponges?" See Ed Yong's beautifully written science news story "Consider the Sponge." I do not know of any work exploring ctenophore-bacteria interactions, although, managing infections and responding to biofilm formations, ctenophores are tuned to bacteria and archaea, as are we all. In any case, phylogenetic relationships are not the only criteria of a good model. Up to 60 percent of the biomass of sponges is microbes. See Hill, Lopez, and Harriott, "Sponge-Specific Bacterial Symbionts in the Caribbean Sponge." What a gold mine for the study of holobionts! No wonder Nicole King started looking into all those attachment sites and signaling activities that might tie choanoflagellate-like cells in sponges to her free-living choanoflagellates, their eating, their infections, and their rosette clumping habits. If anything is, eating—not fundamentalist neo-Darwinian selfishness—is "evolutionary explanation in the last instance"; and eating is definitely both infectious and social! Biologically, eating trumps sex for innovative power; and eating is what made sex possible in the first place.
- 17 McGowan, "Where Animals Come From"; Yong, "Bacteria Transform the Closest Living Relatives of Animals from Single Cells into Colonies."

- 18 McFall-Ngai, “Divining the Essence of Symbiosis,” 2. See McFall-Ngai’s website from the University of Wisconsin. She has since moved to the Pacific Biosciences Research Center at the University of Hawaii. Other emerging model systems for symbiosis tuned to EcoEvoDevo include mouse gut development with bacterial symbionts (Jeffrey Gordon’s lab at Washington University in St. Louis) and mouse brain development as well as immune system development tuned to signals from specific gut bacteria (Sarkis Mazmanian’s lab at CalTech). See also EcoEvoDevo research with spadefoot toads (David Pfennig’s lab at UNC Chapel Hill). Working on pea aphid symbiosis with *Buchnera*, Nancy Moran’s lab at the University of Texas has done wonderful work on the coevolution of aphids and symbionts, but they have not emphasized development. Thanks to Scott Gilbert, personal communication, June 10, 2015.

The inaugural meeting of the Pan-American Society for Evolutionary Developmental Biology was held August 5–9, 2015, on the campus of University of California, Berkeley. Out of three hundred EvoDevo scientists who indicated an interest in attending, the ten organizers invited twenty-five attendees from a broad range of scientific backgrounds and approaches and set up an online portal for other EvoDevo participants. The European Society for Evolutionary Developmental Biology was founded in Prague in 2006. The international research community in EcoDevo and EvoDevo, as well as EcoEvoDevo, is both sizable and growing. Rudolf Raff edits the journal *Evolution and Development*, founded in 2011. See Abouheif et al., “Eco-Evo-Devo.” A strong Russian tradition established by late nineteenth- and early twentieth-century workers contributed prominently to the conceptual formation of what became EvoDevo and EcoDevo. See Olsson, Levit, and Hossfeld, “Evolutionary Developmental Biology.” See also Tauber, “Reframing Developmental Biology and Building Evolutionary Theory’s New Synthesis.”

- 19 McFall-Ngai, “Divining the Essence of Symbiosis.”
- 20 Moran, “Research in the Moran Lab,” website for “Nancy Moran’s Lab.”
- 21 See Gilbert, Sapp, and Tauber, “A Symbiotic View of Life”; McFall-Ngai et al., “Animals in a Bacterial World.” This multiauthored paper is the result of a workshop supported by the National Evolutionary Synthesis Center (NES). Michael Hadfield first introduced me to Margaret McFall-Ngai in Hawaii in 2010, and their collaborative thinking and publishing deeply informs mine. Asking Sapp (a historian of biology who writes on evolutionary biology beyond the neo-Darwinian framework) and Tauber (biochemist, philosopher, and historian of science who writes on immunology) to join him, Gilbert (developmental biologist and historian of biology) cowrote a separate paper because of unresolved disagreement at the NES workshop over the extent of deviation from neo-Darwinian evolutionary theory (“competition in the last instance” and the power of cheaters in evolutionary game theory) that is in Gilbert’s theory of the holobiont as a unit of selection. Gilbert thinks immune systems are very good at managing a dialogue with (not exterminating) cooperation-destroying cheaters in holobionts. Gilbert et al., “Symbiosis as a Source of Selectable Epigenetic Variation.” Gilbert emphasizes that we have always been lichens. See also Guerrero, Margulis, and Berlanga, “Symbiogenesis.”

- 22 McFall-Ngai et al., “Animals in a Bacterial World,” 3229.
- 23 At Hadfield and McFall-Ngai’s request, I provided minor help in revising the introduction and conclusion to McFall-Ngai et al., “Animals in a Bacterial World.” Hadfield began teaching me about invertebrate marine developmental and ecological biology in the early 1970s when we were in a commune together in Honolulu. Gilbert and I have been close friends and colleagues exchanging papers and ideas since he was a PhD biology student at the Johns Hopkins University, and I was an assistant professor in the History of Science Department and Gilbert’s advisor for his simultaneous MA in history of science.
- 24 Wertheim, *A Field Guide to Hyperbolic Space*. Hyperbolic space might be defined as “an excess of surface,” the title of the first section of Wertheim’s book. The very existence of such a thing seemed frankly pathological to Euclidean thinkers until the curves of worlding became undeniable to mathematicians. Such crenellated realities had long been in the repertoire of other critters, including a proud woman of the silk-weaving families in nineteenth-century Spitalfields, as she crocheted a nice ruffle onto the edges of a milk jug cover while she listened to Darwin talking about fancy racing pigeons with her husband and sons.
- 25 Hustak and Myers, “Involutionary Momentum,” 79, 97, 106.
- 26 Hustak and Myers, “Involutionary Momentum,” 77.
- 27 xkcd, Bee Orchid, <https://xkcd.com/1259/>, accessed August 10, 2015. Although gone from everywhere but one region, the not-quite-extinct solitary bee is from the genus *Eucera*. The orchid is *Ophrys apifera*. See “Bee Orchid.”
- 28 On resurgence, see Tsing, “A Threat to Holocene Resurgence Is a Threat to Livability.” Tsing argues that the Holocene was, and still is in some places, the long period when refugia, places of refuge, still existed, even abounded, to sustain reworlding in rich cultural and biological diversity after tremendous disturbance. Perhaps the outrage meriting a name like Anthropocene is about the destruction of places and times of refuge for people and other critters. My Chthulucene, even burdened with its problematic Greek-ish tendrils, entangles myriad temporalities and spatialities and diverse intra-active entities-in-assemblages—including the more-than-human, other-than-human, inhuman, and human-as-humus. The symchthonic ones are not extinct, but they are mortal. One way to live and die well as mortal critters in the Chthulucene is to join forces to reconstitute refuges, to make possible partial and robust biological-cultural-political-technological recuperation and recomposition, which must include mourning irreversible losses.
- 29 Meaning “real or genuine person,” *Inupiaq* refers both to the person and to the language, which is closely related to Canadian Inuit and Greenlandic dialects and is distinct from the Yupik of western Alaska. Referring to the people collectively, *Inupiat* is the plural of *Inupiaq*. See University of Alaska Fairbanks, “Alaska Native Language Center.”
- 30 “Crochet Coral Reef”; “Ako Project”; “Never Alone”; “Black Mesa Water Coalition”; “Black Mesa Trust” (founded by Hopi activists); “Black Mesa Weavers for Life and Land”; “Navajo Sheep Project”; “Diné be’iiná/The Navajo Lifeway”; “Black Mesa Indigenous Support.”

- 31 Hustak and Myers, “Involutionary Momentum,” 77.
- 32 In “Welcome to a New Planet,” Michael Klare cites the figure from the World Wildlife Fund report in September 2015 of 850 million people depending on coral reef ecologies for food security. The same report notes that 85 percent of the reefs are listed officially as “threatened” in the so-called coral triangle, which encompasses the waters of Indonesia, Malaysia, the Philippines, Papua New Guinea, Solomon Islands, and Timor Leste, including Raja Ampat off the coast of West Papua, considered the global epicenter of marine biodiversity. Irreversible failure of the reefs, a real possibility by as early as 2050, could set off human misery and mass migrations of unprecedented proportions, not to mention nonhuman misery and double death. Climate justice and environmental justice are truly multispecies affairs. Raja Ampat is also the epicenter of ongoing innovative coalitional work for resurgence. See World Wildlife Fund, “Living Blue Planet.”
- 33 The deepwater coral refugia hypothesis is difficult to test, but see Greenwood, “Hope from the Deep.”
- 34 “The regrowing forest is an example of what I am calling *resurgence*. The cross-species relations that make forests possible are renewed in the regrowing forest. Resurgence is the work of many organisms, negotiating across differences, to forge assemblages of multispecies livability in the midst of disturbance. Humans cannot continue their livelihoods without it” (Tsing, “A Threat to Holocene Resurgence Is a Threat to Livability”). Not all reforestation is equal, not everything that grows on disturbed land constitutes resurgence. Reforestation in Madagascar with native species is very difficult because the soils of deforested areas are severely damaged. Reforestation with exotic species, some of which become invasive, is practiced with eucalyptus, pine, silver wattle (an acacia), silky oak, and paperbark. See “Deforestation in Madagascar.” Plantation system “reforestation,” for example, with oil palms, has not been common until recently in Madagascar.
- 35 For an example of Navajo, Hopi, and settler environmental alliance, see “Sierra Club Sponsors ‘Water Is Life’ Forum with Tribal Partners.” The Sierra Club was a major ally with Black Mesa Navajo and Hopi activists who shut down the Mohave Generating Station and the Black Mesa mine in 2005. See Francis, *Voices from Dzil’jjiin (Black Mesa)*. The Sierra Club was founded in the late nineteenth century as a white settler colony institution joining the category of nature to conservation, eugenics, and native exclusion from land. The Sierra Club’s current efforts to learn to be a decolonial ally with indigenous peoples is heartening.
- 36 Lustgarten, “End of the Miracle Machines.” Lustgarten’s twelve-part series from ProPublica, “Killing the Colorado,” is indispensable reading for thinking about how to nurture the Chthulucene in the midst of the Anthropocene’s practices of fossil making by ceaseless fossil burning.
- 37 The website of Peabody Energy insists on a very different picture, one filled with restored native plants, productive revitalized grasslands, prize-winning safety records, economic benefits for everybody, and happy people. In 2006, “Peabody’s environmental and community practices on Black Mesa were recognized as a world model for sustainability at the Energy Globe Awards in Brussels, Belgium”

(Peabody Energy, “Powder River Basin and Southwest”); see also Peabody Energy, “Factsheet: Kayenta.”

In the early 1990s Fred Palmer, Peabody’s main lobbyist in 2015 for government affairs, founded the Greening Earth Society, which actively promoted the idea that climate change is beneficial to plants and public health. Peabody Energy led the charge against President Obama’s efforts at the end of his second term to regulate coal emissions more forcefully through the EPA. In the 2000s, as its chief environmental officer, Peabody hired Craig Idso, cofounder and former president of the Center for the Study of Carbon Dioxide and Global Change, a think tank dedicated to attacking mainstream climate science. Greg Boyce, Peabody’s CEO in 2015, regularly criticizes “flawed computer models” as the basis of “climate theory.” See Goldenberg, “The Truth behind Peabody Energy’s Campaign to Rebrand Coal as a Poverty Cure.” Critical to the industry’s attempt to rebrand coal-generated electricity as the solution for the world’s poor, Peabody is a major force behind Advanced Energy for Life. “Advanced Energy for Life” produces a slick procoal website that argues that more not less investment in coal, coupled to ever more elaborate and expensive technologies, is critical to global well-being. Peabody Energy is the only non-China-based partner in the Shenhua Coal Group. See Peabody Energy, “Peabody in China.” Nonetheless, Peabody is facing serious economic losses as the global coal industry becomes less and less sustainable in the face of competition from fracking-related natural gas abundance. Including the People’s Climate Movement and the Indigenous Environmental Movement, among others, the growing global movement to leave fossil fuels in the ground could have profound effects. “Leave It in the Ground,” <http://leave-it-in-the-ground.org/>, accessed March 17, 2016. Peabody Energy declared bankruptcy in 2016.

- 38 For pictures of the Navajo Generating Station and much more, see Friberg, “Picturing the Drought.” For the Black Mesa mine site, see the photos by Minkler in “Paatuaqatsi/Water Is Life.”
- 39 For Navajo-Hopi-Peabody issues on Black Mesa, see Nies, “The Black Mesa Syndrome: Indian Lands, Black Gold.” This is my source for the \$2.7 million payout to Boyden. See Nies, *Unreal City*; Ali, *Mining, the Environment, and Indigenous Development Conflicts*, 77–85. For Navajo voices, see Benally, *Bitter Water*.
- 40 See the Academy Award–winning documentary film (1986) by Floria and Mudd, *Broken Rainbow*, on the scandal of coal extraction and the relocation of Navajo from Black Mesa, beginning in 1864, to aid mining speculation.
- 41 I am indebted to many activist sources for my condensed synopsis of Black Mesa issues: Lacerenza, “An Historical Overview of the Navajo Relocation”; “Short History of Big Mountain–Black Mesa”; Begaye, “The Black Mesa Controversy”; Rowe, “Coal Mining on Navajo Nation in Arizona Takes Heavy Toll”; Black Mesa Water Coalition, “Our Work.”
- 42 Wertheim, *A Field Guide to Hyperbolic Space*, 35.
- 43 Wertheim and Wertheim, *Crochet Coral Reef*, 17. This is a two-hundred-plus-page book of sumptuous photographs and astute essays, plus the names of everybody who crocheted for this experimental art science model ecosystem.

- 44 New Zealand TV series, 1995–2001. “Dreamworker” was an episode of series 1, in September 1995, when I imagine Christine and Margaret glued to the screen, concocting their own material dream passage. “Gabrielle is kidnapped to become the bride of Morpheus, the god of dream, so Xena has to go through her Dreamscape Passage to save her friend.” See *Xena Warrior Princess*, “Dreamworker.”
- 45 On the crochet coral reefs as experimental life-forms, in some ways analogous to ALife worlds, but with very different narrative, material, political, and human and nonhuman social ecologies, see Roosth, “Evolutionary Yarns in Seahorse Valley.”
- 46 Wertheim and Wertheim, *Crochet Coral Reef*, 21.
- 47 See Hayward, “The Crochet Coral Reef Project.”
- 48 Wertheim and Wertheim, *Crochet Coral Reef*, 23.
- 49 Wertheim and Wertheim, *Crochet Coral Reef*, 17.
- 50 Wertheim and Wertheim, *Crochet Coral Reef*, 202.
- 51 Margaret Wertheim, “The Beautiful Math of Coral.”
- 52 Christine Wertheim, “CalArts Faculty Staff Directory.”
- 53 Metcalf, “Intimacy without Proximity.”
- 54 See the Australian Earth Laws Alliance website. This uncredited photo appears on <http://www.earthlaws.org.au/wp-content/uploads/2014/09/turtle-and-reef.jpg>, as well as many other places on the Internet, always uncredited. Accessed August 11, 2015. The geo-eco-techno materiality of visual cultures matters to holding open space for critters in place.
- 55 National Oceanic and Atmospheric Administration, “Green Turtles.”
- 56 See “Ako Project: The Books,” written by Alison Jolly, illustrated by Deborah Ross, Malagasy text by Hantanirina Rasamimanana, 2005–12. The Lemur Conservation Foundation publishes the books in the United States and Canada. The books are published by UNICEF in Madagascar (fifteen thousand of each book and six thousand of each poster). Outside Madagascar, unilingual books are available in English and Chinese, with more translations planned. Each book features a different lemur species in a different kind of habitat, including the aye-aye, ring-tailed lemurs, sifaka, indri, red ruffed lemurs, and mouse lemurs.
- 57 See Jolly, *Thank You, Madagascar*, for a funny, astute, quirky, informed, gorgeously written, often tragic account of major tangles in the history of Malagasy-Western conservation encounters and projects over the late twentieth and early twenty-first centuries, all of which Jolly participated in. I am grateful to Jolly’s daughter Margaretta Jolly for copies of documents and correspondence on the Ako Project.
- 58 Patricia Wright, a friend and colleague of Alison’s, must also be foregrounded for her extraordinary knowledge and work; Wright plays a large role in *Thank You, Madagascar*. Without her, Ranomafana National Park, with its projects for Malagasy and foreign scientists, wildlife, and local people, would not exist. See “Centre ValBio: Ranomafana National Park”; “Patricia Wright”; and Wright and Andriamihaja, “Making a Rain Forest National Park Work in Madagascar.” None of that stops me—or Jolly or Wright—from recording that many local people around the park consider that their land, including graves of their ancestors, was illegitimately taken from them to make the park and its kind of boundaries in ongoing scientific

and state colonial practices. Similarly, none of that stops informed players in this region from judging that the trees and critters of this specific area would now be gone if the park had failed; there is no innocent or simple way to stay with all the faces of the trouble; that is precisely why we must do so. See Jolly, *Thank You, Madagascar*, 214–28.

Shifting cultivators like the Malagasy, who clear small hillside plots and also use irrigated paddies for rice, are conventionally accused of destroying land and its future productivity; the truth has often been the opposite. The issue is controversial, but see Survival International, “Shifting Cultivation,” and Cairns, *Shifting Cultivation and Environmental Change*. Kull, *Isle of Fire*, is the harshest critic of the history of conservation through fire suppression in Madagascar. He argues for community-based fire management rather than ongoing—and ineffective—criminalization of burning. Regeneration from plots used by shifting cultivators and then left fallow has been critical to forest species diversity and abundance in most tropical areas for a long time—unless fallow times are too short and pressure for new croplands too heavy. Private property regimes and their state apparatuses have a hard time with shifting cultivators (and with pastoralists called nomads). To put it mildly, the state wants people to settle down with definite property boundaries.

In solidarity with other pastoral/mobile peoples pressed by centralizing, resource-extracting, national governments, on July 13, 2015, the Black Mesa Water Coalition (BMWC) posted on its Facebook page a *New York Times* article on the current Chinese government’s efforts to settle, forcibly if necessary, the “nomads” of its tribal western regions. The relation of the stepped-up efforts of sedentarization are hardly independent of intensified coal and other energy and mineral extraction in western China, and similar forces on Black Mesa on Navajo and Hopi lands since the mid-nineteenth century. See Jacobs, “China Fences in Its Nomads.” The poster for BMWC commented, “This story sounds very familiar doesn’t it? It’s like what BIA has been doing to Diné people and it continues to happen today on NPL and HPL.” NPL, Navajo Partition Lands; HPL, Hopi Partition Lands. <https://www.facebook.com/blackmesawc?fref=ts>. Accessed August 9, 2015. See the last section of this chapter, “Navajo Weaving.”

A recent study in Madagascar attempted to quantify whether and how much fallow times have decreased in shifting cultivation/tavy land use in one rain forest corridor region of eastern Madagascar. The study claims to have instigated methods to ensure taking the knowledge systems and statements of both agricultural experts and local farmers equally seriously. See the conclusion in Styger et al., “Influence of Slash-and-Burn Farming Practices on Fallow Succession and Land Degradation in the Rainforest Region of Madagascar,” 257: “Over the last 30 years, fallow periods decreased from 8–15 years to 3–5 years. Hence, fallow vegetation is changing within 5–7 fallow/cropping cycles after deforestation from tree (*Trema orientalis*) to shrub (*Psidium altissimum*, *Rubus moluccanus*, *Lantana camara*) to herbaceous fallows (*Imperata cylindrical* and ferns) and grasslands (*Aristida* sp.), when land falls out of crop production. This sequence is 5–12 times faster than previously reported. The frequent use of fire is replacing native species with exotic, ag-

gressive ones and favors grasses over woody species, creating treeless landscapes that are of minimal productive and ecological value.” The study highlights that the local people, the Betsimisaraka, have rich knowledge of fallowing and regeneration but are pressed by multiple forces in a spiraling process of land degradation. Ecological, ethnic, social hierarchal, populational, regional, national, international, and economic pressures tangle to strangle biodiversity and diverse livelihoods for people and other critters.

Typically, shifting cultivators have not traditionally wanted large families and have used many means to limit births. Why demographic spirals and land pressure have developed as they have since the mid-twentieth century in the upland rice plots and forests of Madagascar is not simple; but private property, nation state, and colonial apparatuses bear much of the responsibility, but not all the responsibility; the heavy toll of human numbers on today’s earth cannot be addressed by laying all the responsibility on someone else’s plate (or womb). Population in Madagascar is hard to estimate in part because no census has been taken since 1993; the first census was taken in 1975. The “method” for the following statements is inference: “According to the 2010 revision of the World Population Prospects the total population was 20,714,000 in 2010, compared to only 4,084,000 in 1950 . . . UN projections give about 50 million by 2050. Birthrates have fallen in both urban and rural areas, more in urban. 70 percent of population is rural/subsistence farming” (United Nations, “World Population Prospects”).

- 59 Deborah Ross is a book artist with work in major magazines and in zoos and botanical gardens. She has run watercolor workshops for Walt Disney Studios, DreamWorks, Pixar, and Cal Arts. Most significant for the Ako Project have been her rural art workshops for the Malagasy villagers of Kirindy and Tampofo. See Ross, “Deborah Ross Arts.” With degrees in scientific illustration and ecology and environment, Janet Mary Robinson is the poster artist for the Ako Project. Thanks to Margaretta Jolly for information on the origin of the project; e-mail from Jolly to Haraway, June 28, 2015.
- 60 Jolly, “Alison Jolly and Hantanirina Rasamimanana,” 45. For the story of her first meeting and then working with Rasamimanana, see Jolly, *Lords and Lemurs*. For a taste of Rasamimanana and Jolly thinking with each other as scientists, see Jolly et al., “Territory as Bet-Hedging.”
- 61 Without giving up, Jolly laments that even Rasamimanana’s promotion of teaching and research related to the Ako books has not yet been able to overcome the reticence of many teachers to use such unorthodox materials. Jolly, *Thank You, Madagascar*, 51. In “Conservation Education in Madagascar,” Dolins et al. argue “that while nongovernmental organizational efforts are and will be very important, the Ministry of Education urgently needs to incorporate biodiversity education in the curriculum at all levels, from primary school to university” (abstract).
- 62 Fifth International Prosimian Congress, website; Durrell Wildlife Conservation, “World Primate Experts Focus on Madagascar.” For a list of related publications, see ValBio, “ICTE-Centre ValBio Publications.”
- 63 Jolly, *Thank You, Madagascar*, 362.

64 The quotation is the English subtitle on a screen shot in *Never Alone*, Announcement Trailer, showing Nuna, the arctic fox, and a spirit helper. For extracts from an interview with Amy Fredeen of the Cook Inlet Tribal Council and Sean Vesce of E-Line Media for National Public Radio, see Demby, “Updating Centuries-Old Folktales with Puzzles and Power-Ups.” From the interview: “The last living person to tell the story was a master storyteller named Robert Cleveland. Amy and her team did an amazing job, and they located the oldest living offspring of Robert—a woman named Minnie Gray, who is in her 80s, I believe. They discovered that Minnie lived just a few blocks from the Cook Inlet Tribal Council headquarters. And we brought her in and we were able to start a series of conversations with her. We introduced her to the team and what we wanted to do. And we were delighted when she really was encouraging us not only to use her father’s story for inspiration, but to adapt it and evolve it for the game context. One of the things she taught us was that storytelling is not a fixed act.” The process of making the game is described in detail. One consequential decision: “We made the creative decision to keep the only [spoken] audio in the game in Inupiaq, and it’s presented in 10 languages for subtitles. What we were looking to do was re-create the experience of being told a story by an elder in their own language. It’s hard to describe that sense, but we wanted to try to re-create that for players so they got a sense of how powerful it would have been to hear one of these stories back then.” In the interview, Amy Fredeen quotes Daniel Starkey, an American Indian game reviewer on *Eurogamer.net*, who writes, “*Never Alone (Kisima Ingitchuna* in Inupiaq) is different. Its very existence challenges me. Instead of eliciting self-pity, it stands in absolute defiance of everything that I’ve grown to be, not only telling me to be better, but showing me how” (Starkey, “*Never Alone* Review”).

About forty members of the Inupiat community supported the project in various ways throughout its making, and many more at key points. Making sure the game was grounded in Inupiat environmental conditions, experience, and ideas was a central concern of the indigenous collaborators, including the kids who helped by playing early versions. The NPR interview described the kids who were very engaged in deciding which animal—fox? owl? wolf?—should be the human girl Nuna’s companion character.

65 *Never Alone* tells a story about an endless storm that threatens the people. Contemporary arctic peoples have well-developed accounts of climate alterations and of the changes in their environments, but the relevant idiom is not the Anthropocene. For example, see the website for the ISUMA film, *Inuit Knowledge and Climate Change*, which states, “Nunavut-based director Zacharias Kunuk (*Atanarjuat The Fast Runner*) and researcher and filmmaker Dr. Ian Mauro (*Seeds of Change*) have teamed up with Inuit communities to document their knowledge and experience regarding climate change. This new documentary, the world’s first Inuktitut language film on the topic, takes the viewer ‘on the land’ with elders and hunters to explore the social and ecological impacts of a warming Arctic. This unforgettable film helps us to appreciate Inuit culture and expertise regarding environmental change and indigenous ways of adapting to it.”

- See Callison, *How Climate Change Comes to Matter*, for fieldwork exploring the vernaculars in which one group of Alaskan Inuit address climate change.
- 66 Situated in complex histories and politics, there are many formats besides computer games to consider when thinking about indigenous digital cultures. There are also computer games designed with indigenous cultural material, but not like *Never Alone*. See Ginsberg, “Rethinking the Digital Age”; Ginsberg, Abu-Lughod, and Larkin, *Media Worlds*; Lewis, *Navajo Talking Picture*.
- 67 The notion of “Sila” is explained in a “Cultural Insight” that has to be earned by players of *Never Alone*. I always die before I get that far in the game, but it is possible to cheat on YouTube. See “*Never Alone* Cultural Insights—Sila Has a Soul,” in which Fannie Kuutuq and others discuss Sila. A pan-Inuit term, *Sila* means something like “the weather” to Anglophone southerners, but only if the weather means the sky and the air, breath-soul, the element that enfolds the world and invests beings with life, as well as the environment from the earth to the moon, with its dynamic changes and powers. See Merker, “Breath Soul and Wind Owner.” The concept of climate change will not engulf Sila, nor vice versa; but these ideas/work objects have met each other. There will be consequences for what counts as agencies, temporalities, and response-abilities. It matters what thoughts think thoughts, what stories tell stories, what knowledges know knowledges.
- 68 I am in agreement with William Elliott on these cautions and with his engagements with native stories and thinkers, including new approaches to located animisms. He generously shared two manuscripts with me: Elliott, “Ravens’ World: Environmental Elegy and Beyond in a Changing North,” and Elliott, “*Never Alone*: Alaska Native Storytelling, Digital Media, and Premodern Posthumanisms.” In an NPR interview, speaking of the collaboration with E-Line Media, Cook Inlet Tribal Council member Amy Fredeen noted, “I know this may come across a little strong, but when we talked about creating the first indigenous video game company, we wanted to set the bar high. And we wanted to own this space around telling traditional cultural stories through video games” (Demby, “Updating Centuries-Old Folktales”). Fredeen is clear that sharing indigenous stories outside the usual terms of colonizing appropriation depends on owning the stories and the storytelling apparatus.
- 69 Quotation from *Never Alone (Kisima Ingitchuna)* website.
- 70 Takahashi, “After *Never Alone*, E-Line Media and Alaska Native Group See Big Opportunity in ‘World Games.’” Takahashi continues: “[The game] got more than 700 reviews in a wide array of publications (including *GamesBeat*), and it has been discussed around the world. It was on more than fifty ‘best of 2014’ awards. YouTube and Twitch player videos have drawn millions of views.” Thanks to Marco Harding for the reference and for teaching me how to play the game.
- 71 Eduardo Viveiros de Castro, personal communication, October 2, 2014.
- 72 That is one of the reasons that “belief” has nothing to do with the practices of the sciences. Sciences are sensible practices, in all their material semiotic workings, including mathematics and physics. Isabelle Stengers has been relentlessly cogent on this point; her love for Galileo’s inclined planes depends on understanding

that science is sensible. Asking if one “believes” in evolution or climate change is a Christian question, in both religious and secular formats, for which only a confessional reply is accepted. In such worlds, Science and Religion reign, and there it is impossible to play *Never Alone*. Harding, “Secular Trouble,” is my guide to the history of the category of belief, especially in Protestant colonizing cultures. See Harvey, *The Handbook of Contemporary Animism*.

73 “Dzit Yíjiin bikáá’gi iiná náánásdláadóó ha’núigo biniiyé da’jitt’ó,” translated by Mae Washington. See Black Mesa Weavers for Life and Land, “Black Mesa Weavers and Wool.”

74 Continuous weaving is a material-semiotic practice in my idiom. The Black Mesa Water Coalition posts pictures of wonderful contemporary blankets for sale and of the weavers, including children learning the skill, as well as pictures of blankets in process, on its Facebook page.

Black Mesa Weavers for Life and Land commissioned three limited editions of Black Mesa Blankets. A sympoietic work, these blankets were designed by Diné shepherds and weavers, spun from Navajo-Churro fleece, produced in collaboration with the Black Mesa Weavers for Life and Land, the San Jose Museum of Quilts and Textiles, the Christensen Fund, and the Pendleton Woolen Mills. For a picture of the Black Mesa Blanket, see San Jose Museum of Quilts and Textiles, “Black Mesa Blanket.”

A late nineteenth-century giant in wool blankets targeting the Indian trade, Pendleton Woolen Mills played a large role in the history of harsh conditions for Navajo weaving. The “major blanket manufacturers usurped the Native American market and also appropriated a large portion of the Anglo market” (M’Closkey, *Swept under the Rug*, 87). Today, Pendleton’s American Indian College Fund blankets provide scholarships for indigenous students, and Navajo families often treasure their own Pendleton blankets as well as Navajo weaving.

75 “Thinker/maker” is a way of designating those engaged in the inextricable thinking/making practices called art that I learned from Loveless, “Acts of Pedagogy.”

76 Willink and Zolbrod, *Weaving a World*, 8. This volume is based on extensive discussions in the 1990s of weavings and weaving with more than sixty elders from the eastern part of the Navajo Nation in and around Crownpoint, New Mexico. The beginnings of the Crownpoint Navajo Rug Auction in 1968 and the founding of the Crownpoint Rug Weavers Association, composed of Navajo weavers throughout the Southwest, mark critical junctions in strengthening weavers’ well-being and control of their markets, designs, and stories. Buyers from all over the world purchase directly from the weavers, who run the auction. See “Crownpoint Navajo Rug Auction” and Iverson, *Diné*, 268. However, most weavers still get much too little for the work, much less everything else that goes into making a blanket. The Crownpoint Auction experienced lethal financial problems in 2014 and reorganized as the new Crownpoint Rug Auction.

By 1996 Willink and Zolbrod had worked together for more than twenty-five years. A member of the faculty at the University of New Mexico, Roseann Willink is a member of the Mexican Clan and was born for the Towering House Clan.

Arguing that Navajo poetics and stories are intimately enfolded into the conduct of daily life, tying together relations among persons of the community with the cosmos, Paul Zolbrod published *Diné bahane': The Navajo Creation Story*, the most complete version in English. See Denetdale, *Reclaiming Diné History*, 23–26.

For Navajo artisans' stories of economic and cultural survival through the art of weaving, see the film written and directed by Bennie Klain, *Weaving Worlds*.

- 77 M'Closkey, *Swept under the Rug*, 17–23, 205–52, argues persuasively for Navajo weaving as cosmological performance. She draws from her own work with weavers, as well as from previous scholarship, especially Witherspoon and Peterson, *Dynamic Symmetry and Holistic Asymmetry*, as well as Willink and Zolbrod, *Weaving a World*. Because of the long history of Navajo weavers selling their blankets under highly unequal terms to traders, as well as working with patterns, fibers, and dyes dictated by the art and tourist markets, most scholars and museologists have treated Navajo weaving as a commodity or an art product, but not as indigenous cosmological performance essential to maintaining *hózhó*. Among other things, that has meant no legal copyright protection for Navajo patterns and reproduction of cheap knock-offs in places like Oaxaca and Pakistan under all-too-imaginable conditions of labor. See M'Closkey and Halberstadt, "The Fleecing of Navajo Weavers."

Both the number and quality of contemporary Navajo weavings are extraordinary; and contemporary weavers have to compete in a market crowded both by copies produced abroad and by older exquisite and authentic Navajo blankets, which were sold from the late nineteenth century until the 1960s *by the pound* at reservation trading posts to get credit to buy necessities. These heritage blankets sometimes sell for hundreds of thousands of dollars today in an art market that returns none of that money to the families of the original weavers, while blankets of similar or better quality, using both old and new designs, sell at auction to individual buyers as well as to craft market buyers at better prices than in the past, but still at rates that cannot sustain most of the weavers and their families. See M'Closkey, *Swept under the Rug*, for detailed analysis of the exploitation of Navajo weavers and weavings. Much of M'Closkey's information comes from archives of the Hubbell Trading Post, which became a National Historic Site in 1967. See Hubbell Trading Post, "History and Culture."

Chapter 1, "Playing String Figures with Companion Species," argued that Navajo *na'at'lo'*, string figure games, are tied to the creation stories and performances of Spider Woman and the Holy Twins. *Na'at'lo'* is also called "continuous weaving."

- 78 See Begay, "Shi'Sha'Hane (My Story)," 13–27. For an exhibit of the innovative fourth-generation weaver D. Y. Begay's tapestries at UC Davis's Gorman Museum in 2013, see Dave Jones, "Navajo Tapestries Capture the Soul of Her Land." See also the "Weaving in Beauty" website and Monument Valley High School, "Ndahoo'aah Relearning/New Learning Navajo Crafts/Computer Design." Ndahoo'aah is a summer program in design, computer programming, mathematics, and traditional Navajo crafts held every summer at Monument Valley High School. The website states, "Ndahoo'aah teaches some of the Navajo crafts that are still practiced on

the Reservation . . . At the same time, Ndahoo'aah teaches LOGO graphics programming, focusing on mathematics (especially geometry). Graphics tools are then used to produce traditional designs and colorations." For stories by weavers and other thinkers/makers, click on the "Stories" button of the Ndahoo'aah website. See also Eglash, "Native American Cybernetics." Learning with young people from Black Mesa as well as the Diné College, and with weavers who helped the visitors understand their algorithms, Eglash and his coworkers link the robustness of such knowledge worlds to what he and his collaborators call "generative justice." The point of such an approach is *not* mixing Indigenous and Western knowledge practices and stirring, but rather exploring the fraught possibility of generative contact zones without denying long histories of violence. E-mail from Ron Eglash to Donna Haraway, March 2, 2016.

- 79 "Inherent in the beauty of rug weaving is the artistic achievement reflecting every weaver's frame of mind, creating designs of continual mathematical movement and regeneration of symbolism acknowledged for the Diné" (Clinton, "The Corn Pollen Path of Diné Rug Weaving"). In her book-in-progress, "Attaching, for Climate Change: A Sympoiesis of Media," Katie King proposes *kipu*, Inca knotted strings, as a model for, but also a performance of, complex systems, media, and geo-change as "transcontextual transdisciplinary tangles." King writes, "Fiber arts and ethnomathematics are necessarily transdisciplinary resources for the kind of scholarship being continually re-created [in *kipu* worlds] in a zone of unusual cultural continuity even after conquest. The Andes are a multitemporal geo-political zone for caring for object/ecology" (draft book proposal, 2015). See King, "In Knots."

Coral reefs, forests in Madagascar, the Inuit Arctic, and the Navajo-Hopi Black Mesa are also "multi-temporal geo-political zones for caring for object/ecology even after conquest" (King, draft proposal, 2015). In particular, continuous weaving, cosmological performance, world games, and "writing without words" in *kipu*, *Never Alone*, Navajo weaving, and the Crochet Coral Reef form complex string figures of thinking/making/acting. Again in King's borrowings, these are "reciprocities made visible." Boone and Mignolo, *Writing without Words*. For "reciprocities made visible," see Salomon, *The Cord Keepers*, 279. Thanks to Katie King for these references.

- 80 When I was researching Spanish rough sheep (Churro sheep) in the U.S. desert Southwest, I stumbled onto one of my favorite indigenous media projects—a Shoshoni Claymation video. The Gosiute of eastern Nevada and western Utah are Shoshone peoples. Like all peoples of the U.S. Southwest, the Gosiute are embroiled in the ecologies, economies, and politics of nuclear mining, war, waste processing, and storage. Their relatives have lived in these deserts for more than a thousand years; and, living and dead, they are indigenous to the ongoing Chthulucene, tangled in the grip of the colonial and imperial Anthropocene and Capitalocene. A sort of audio collage, the sound track for the Claymation video *Frog Races Coyote/Itsappeh wa'ai Wako* was constructed from the archives of several Shoshone-language storytellers by the Gosiute/Shoshoni Project of the University

of Utah. Frogs think-with frogs; frog wins the race against coyote around the lake. Collective action can defeat the wiliest opponent.

The Frog and Coyote story is taught today in the Utah Indian Curriculum Guide, “The Goshutes.” Listening to and learning a Shoshoni language today in public schools and on the Internet is part of indigenous America *not* disappearing, but traveling in tongues to unexpected places to reopen questions for ongoingness, accountability, and lived storytelling.

On the importance of fostering actual indigenous language use, in all its “emergent vitalities,” among the young who are no longer fluent native speakers, see Perley, “Zombie Linguistics.”

- 81 See Denetdale, *Reclaiming Diné History*, 62–86; Johnson, *Navajo Stories of the Long Walk Period*; Morrison, *Paradise*. The twentieth-century Navajo-Hopi reservation land partition laws and forced removal of thousands of Navajo from Black Mesa/Big Mountain/Dzil ni Staa to make way for industrial coal mining are sometimes called the second great Hwéeldi. Beginning in 1977, Pauline Whitesinger, her clan allies, and other Diné elders started a resistance that has not ceased. “By 1980, Big Mountain Dineh resisters and their few but growing non-Native allies began network strategies that reached as far as Washington State, Southern California, and the east coast. Non-Native support collectives began bringing themselves and logistics out to the now restricted zones. Both the indigenous community and non-Natives shared the need to document the deliberate violations of human rights, to stop forcible occupation to extract fossil fuel, to halt the desecration of human religions, and to let the world know that the U.S. is committing genocide” (NaBahe [Bahe] Keediniihii [Katenay], “The Big Mountain Dineh Resistance”). Efforts to relocate sheep-herding Navajo and their animals intensified again in 2014, with strong BIA and tribal police efforts to break the bond between Diné and non-Native allies. See the Black Mesa Indigenous Support website. Black Mesa Indigenous Support runs Big Mountain spring training camps for activists. I owe “originally trauma” to Kami Chisholm.
- 82 For a rich argument about Native Americans making kin with each other and with plants and animals—processes disrupted by forced commodity relations and Christian kinship systems—see Kim TallBear, “Failed Settler Kinship, Truth and Reconciliation, and Science.” TallBear drew from Dakota histories for this blog post. TallBear is a leader in thinking about the “making of love and relations beyond settler sexualities.”
- 83 Several sources inform my sketch of the near extermination of Navajo-Churro sheep in the 1930s, but especially the thoroughly researched book by Weisiger, *Dreaming of Sheep in Navajo Country*. See also Weisiger, “Gendered Injustice”; the website of the Navajo Sheep Project; White, *The Roots of Dependency*; Johnson and Roessel, *Navajo Livestock Reduction*; and McPherson, “Navajo Livestock Reduction in Southeastern Utah, 1933–46.” In *A Plague of Sheep*, Melville argues that Spanish sheep were devastatingly effective colonizers, creatures of empire, which forever altered the ecology and native society of highland central Mexico in favor of the conquerors. The same could be said of sheep in the U.S. Southwest. True enough,

but origins are not closed destinies; and sheep and indigenous and allied peoples of these lands have forged remarkably durable multispecies ways of living and dying with each other on the Colorado Plateau, in complex resistance to ongoing colonial practices.

- 84 Horoshko, “Rare Breed,” and Navajo Sheep Project, “History.”
- 85 See Black Mesa Weavers for Life and Land, “Diné Navajo Weavers and Wool,” and Halberstadt, “Black Mesa Weavers for Life and Land.”
- 86 Diné be’iina/The Navajo Lifeway, “Dibé be’iina/Sheep Is Life.”
- 87 Strawn and Littrel, “Returning Navajo-Churro Sheep for Weaving.”
- 88 For a story about Roy Kady, one of the Navajo Nation’s best-known male weavers, who has dedicated his life to the well-being of Navajo-Churro sheep, see Kiefel, “Heifer Helps Navajos Bolster Sheep Herd.” Blystone and Chanler, *A Gift from Talking God*, is a moving DVD produced in 2009, narrated by Jack Loeffler, featuring Roy Kady, Jay Begay, Lyle McNeal, and Gary Paul Nabhan. See also Kraker, “The Real Sheep,” and Cannon, “Sacred Sheep Revive Navajo Tradition, for Now.”
89. “Behavioural studies in our laboratory using choice mazes and operant discrimination tasks have revealed quite remarkable face-recognition abilities in sheep, similar to those found in humans . . . These experiments showed that sheep could discriminate between sheep and human faces, between different breeds of sheep and between sexes in the same breed” (Tate et al., “Behavioural and Neurophysiological Evidence for Face Identity and Face Emotion Processing in Animals,” 2155).
- 90 Says cofounder Peter Hagerty, a sheep and horse farmer who bought wool in 1985 from the Soviet Union to somehow unknot the Cold War, “I used to describe Peace Fleece as an international yarn company doing business with historic enemies like Palestinians and Israelis and Russians and Americans. Today that description still holds true but recently I have grown to see it more as a place where very normal people come together on a regular basis to help each other get through the day” (Peace Fleece, “The Story”). See Peace Fleece, “Irene Bennialley.” On Irene Bennialley, see Benanav, “The Sheep Are Like Our Parents.”
- 91 Black Mesa Water Coalition, “About.” On the founding and goals of BMWC, see Paget-Clarke, “An Interview with Wahleah Johns and Lilian Hill.” Johns is Diné from Forest Lake, a community on Black Mesa (Johns, website). Working out of the San Francisco Bay Area beginning in 2013, Johns was the Solar Project Coordinator of the BMWC. Hill is from Kykotsmovi, Tobacco clan. Living in Kykotsmovi, she is a Certified Permaculture Designer and Natural Builder (Hill, “Hopi Tutskwa Permaculture”). BMWC activists were active at COP21 in Paris in 2015 in the Peoples Climate Justice Summit/Indigenous Rising. Executive Director of BMWC Jihan Gearon testified on September 23, 2015, at the Peoples Tribunal. For an audio recording, go to Gearon, Peoples Tribunal.
- 92 Haraway and Tsing, “Tunneling in the Chthulucene.” For thinking with another people of the Southwest, see Basso, *Wisdom Sits in Places*.
- 93 BMWC, “Our Work”; Communities United for a Just Transition, “Our Power Convening.” See BMWC, “10th Anniversary Video,” narrated by Executive Director Jihan Gearon. For a video of codirectors of BMWC in 2009, see Johns and Begay,

Speech at Power Shift '09. See also BMW, "Green Economy Project." For a powerful reflection in 2015 on how to continue working together across time and difference, see Gearon, "Strategies for Healing Our Movements." Tódích'i'í'nii (Bitter Water) clan and African American, Gearon earned a BS from Stanford in earth systems, focusing on energy science and technology. See Afro-Native Narratives, "Jihan Gearon, Indigenous People's Rights Advocate." In her generation, the urgent conversation between needed concepts and practices is more possible—politically, culturally, spiritually, scientifically. Gearon made *Grist* magazine's "Grist 50: The 50 People You'll Be Talking About in 2016," <https://grist.org/grist-50/profile/jihan-gearon/>, accessed March 17, 2016.

- 94 Giovanna Di Chiro, professor of environmental studies at Swarthmore College, has for many years been my guide to bringing together the feminist movement, multi-ethnic and antiracist environmental justice, critters of the seas and inland waters, urban antitoxic coalitions, and action research. We are also linked by research on symbiosis and evolutionary relationships. String figures linking women—and men—through friendship, mentoring, and research projects in all these worlds have shaped the pattern. See DiChiro, "Cosmopolitics of a Seaweed Sisterhood," "A New Spelling of Sustainability," "Acting Globally," and "Beyond Ecoliberal 'Common Futures.'" Part of a sympoietic seaweed sisterhood that shaped her life, in 1979 Giovanna was an undergraduate at UC Santa Cruz working with phycologist Linda Goff. Giovanna was a collector for the team at the Oahu, Hawaii, coral reef research site off Coconut Island that characterized *Prochloron didemni*, the cyanobacterial symbiont living in the gut of its ascidian partner. The molecular and ultrastructural analysis provided evidence of an evolutionary relationship between *Prochloron* and eukaryotic chloroplasts of green plants. See Giddings, Withers, and Staehlin, "Supramolecular Structure of Stacked and Unstacked Regions of the Photosynthetic Membranes of *Prochloron*." A few years before, teaching biology and the history of science at the University of Hawaii on Oahu, I had written chapters of my PhD thesis on organismic metaphors that shape embryos in developmental biology while living on Coconut Island in a commune that included Michael Hadfield, an important marine developmental and ecological biologist in the current flowering of EcoEvoDevo, discussed in the first part of this chapter. See Haraway, *Crystals, Fabrics, and Fields*. I was Giovanna's PhD adviser in History of Consciousness at UCSC; her degree was awarded in 1995. Cat's cradle, indeed.
- 95 Stengers, *Cosmopolitics I* and *Cosmopolitics II*; Stengers, "The Cosmopolitical Proposal."

Chapter 4: Making Kin

- 1 Intra-action is a concept given us by Karen Barad, *Meeting the Universe Halfway*. I keep using interaction too in order to remain legible to audiences who do not yet understand the radical change Barad's analysis demands, but probably out of my linguistically promiscuous habits, as well.
- 2 Tsing, "Feral Biologies."