Gaia in Turmoil

Climate Change, Biodepletion, and Earth Ethics in an Age of Crisis

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Intimations of Gaia

Eileen Crist

The most compelling contribution of Gaian science, which has complemented the evolutionary and ecological perspectives on life, is that organisms do not merely adapt to the environmental conditions they find themselves in but actively shape them. In his four decades of Gaian thought, James Lovelock (2004: 1) has always insisted that "organisms are not mere passengers on the planet"—they are more like pilots. On the basis of the Earth case, Gaia theory postulates that once life becomes abundant enough to have considerable environmental effects, it takes over its planet home: life in the universe, in general, is likely to be a planetary phenomenon. Besides existing everywhere and mostly profusely on the Earth's surface, life is also found, albeit more sparsely, fifty kilometers above the surface and at depths a few kilometers into the crust.

What Gaia Taught Us

On Earth the composition of the air is 99 percent biogenic, life has a strong influence on global ocean chemistry and possibly on the retention of the planet's water, and soil is a Gaian phenomenon in which living and nonliving components are thoroughly hybridized. Atmosphere, hydrosphere, and upper lithosphere are markedly different from what they would have been were life absent from Earth. The Gaian perspective thus submits that a planet with life becomes more akin to a biological composition than a geophysical body: biological and geological forces merge, and a new kind of entity—a geophysiology—is born. Lovelock called that entity "Gaia." W. E. Krumbein and A. V. Lapo (1996) offered the neologism "bioid" to describe Gaian-type planets at large in the universe as opposed to "geoids" that support no life.

As life spreads and becomes abundant so do the effects of its activities and metabolisms, until those effects become first large scale then global in scope. Inevitably, life-driven environmental modulations feed back on life itself—on the groups of organisms that caused the particular changes as well as on other groups. Environmental changes that turn out detrimental to the life that generated them tend to be self-limiting by boomeranging on the creatures that instigated them (Lenton 2004). Effects that happen to be beneficial, on the other hand, may tend (other things being equal) to be self-enhancing by promoting the instigating organisms (ibid.). Of course, there is nothing to stop organisms that foul their environments (in a way that rebounds upon them) from arising, and even thriving for a while, but they are less likely to persist.

Gaian inquiry has offered a renewed perspective on life's grandeur by foregrounding what Lovelock has evocatively called life's "cosmic lifespan." Life has existed on Earth for about 3.8 billion years—a quarter of the age of the universe. Conditions on the planet have varied greatly through life's eons, yet all have been habitable for life. (Conditions that have been extreme—too hot or too cold, for example—have been tolerated by a narrower spectrum of life, which then may have contributed to the emergence of environmental parameters viable for a broader spectrum; see McMenamin 2004.) Although it is a point of debate within the Gaian community, Gaia theory proposes that the endurance of life through vast passages of time has not been accidental. To be sure, life's longevity could have been simply a matter of luck. The shortcoming of this idea, however, is that it does not encourage interesting thinking nor research into the possibility of life's participation in securing its own survival. Gaian inquiry, on the other hand, keeps alive the fascinating question of how an ever-changing biota can have the power to contribute to sustaining an ever-changing yet always viable world.

The Gaian logic proceeds as follows: when organisms drive environmental variables toward uninhabitable conditions, the growth of those organisms is likely to be eventually suppressed while organisms that enhance habitability, especially for themselves, are selected for (Lenton 1998). Further, if the community models of Tim Lenton and his colleagues apply to real Earth conditions, then "ecosystems or communities that 'foul their nest' [may tend to] lose out to those that improve their local conditions" (Lenton and Williams, chapter 5 in this volume). Scaling up these insights to the level of the biosphere—and adding the reinforcement of viable effects via strong linkages between successful, pervasive groups of organisms that are metabolically complementary with one another (more on this shortly)—we might conjecture that environment-enhancing life, as a networked and emergent whole, has a hand in maintaining a gradient of habitability for a broad phenotypic gamut of organisms, from tropical butterflies to penguins (to borrow from Volk, chapter 3 in this volume).

Once life got seriously underway—which is to say after microbes became pervasive on Earth—organisms have always evolved under conditions formed by life. As Lovelock has poetically put it, organisms "live in a world that is the breath and the bones and the blood of their ancestors and that they themselves are now sustaining" (1996: 19). After four decades of Gaian inquiry, the view that life has a (trans)formative impact on the environment now enjoys broad consensus—even as many scientists may shy away from the idea that a tightly coupled living and nonliving world "regulates" conditions on the planet.

Earth's average surface temperature is a key example of life's enormous influence on environment—"influence," in this context, seeming too weak a concept, even as "regulation" may sound too strong. Quantifying life's impact on the planet's surface temperature—via its role in removing CO_2 from the atmosphere (biotic enhancement of weathering) and seeding clouds through the biological production of dimethyl sulfide (DMS)—Tyler Volk and David Schwartzman have estimated that biotic processes may presently cool the planet by 35 to 45 degrees centigrade (Schwartzman and Volk 1989; Schwartzman 1999; Volk 1998). In other words, an abiotic Earth in present time would be at least 35 degrees hotter. From this example alone we can discern why Gaian scientists maintain that "the global environment is being transformed by life into a state very different from a planet without life" (Volk 2004: 27).

Early Gaian literature offered the metaphor of "superorganism" for the Earth. On this metaphor the biosphere became comparable, for example, to a beehive whose ranges of temperature, humidity, and other conditions suitable for the bees happen to be created by the bees. (Subtract the bees, and conditions in and out of the hive swiftly equilibrate.) Similarly, Gaians argued, the biota as a whole shapes environmental parameters to be suitable for life. Such was the early formulation of Gaia (which generated a storm of protest): this is a planet constructed by and for the biota. For example, in an evocative, albeit contentious, metaphoric description of how life molds the Earth's atmosphere, Lovelock submitted that "the interaction between life and environment, of which the air is a part, is so intense that the air could be thought of as being like the fur of a cat or the paper of a hornet's nest: not living but made by living things to sustain a chosen environment" (1987: 88).

The superorganism metaphor enjoyed only brief popularity in Gaian literature: eventually it was conceded that unlike the members of a bee or ant colony, organisms on Earth are not genetically similar enough to participate in co-creating a home. (Also the mechanism for the evolution of beehives is kin—possibly along with group—selection, with no analogues for Gaia.) In the beehive, what benefits one bee is likely to benefit all, since they can be regarded as extended phenotypes of one genetic blueprint; in the biosphere, on the other hand, organisms are genetically very different and often adapted to widely divergent conditions.

Yet even as the superorganism metaphor has fallen into disuse, it is conceivable that the Earth is more like a beehive than we are able to grasp or formulate rigorously. For while the biosphere's organisms are not genetically identical, they *are* genetically related, all having descended from a single common ancestor. There is only one form of life on Earth, a form of life possessing a shared genetic mechanism, cellular infrastructure, and (to a large extent) biochemical language. All life forms are evolved expressions of an ancestral form, and that they may participate in co-creating and sustaining a particular range of environmental conditions—within which they survive and often flourish—seems intuitively probable, even if a scientific specification of how exactly this emerges is, now or perennially, elusive.

A new generation of Gaian scientists—Tyler Volk, Tim Lenton, David Wilkinson, and David Schwartzman, among others—have sharpened Gaian thinking while at the same time responding to neo-Darwinian critiques of Gaia as a teleological concept. They have argued that organisms do not evolve by-products (or traits) *in order to* control their physical and chemical environments; rather, the by-products of organisms end up having side effects that are both inevitable and potentially consequential. As previously described, the side effects will feed back (one way or another) on their creators and also delimit the evolution of other organisms that must, on the extremes of a continuum, either adapt or perish. To revisit the example of Earth's viable surface temperature: it is not so much that life has contributed to creating a global climate regime that is habitable, as that it has contributed to creating a global climate regime that became inhabited by life forms that were able to evolve within it, having found it at least tolerable if not ambient. (Speaking only partly tongue in cheek, Lynn Margulis likes to quip that the Earth is "room temperature.") The organisms that evolved within such partly life-driven conditions often reinforce the effects of their ancestors, being relatives of these predecessor life forms with compatible biochemistries and metabolic outputs. The maintenance of certain environmental effects—whether or not we choose to call this outcome "Gaia's self-regulation"—thus becomes a self-reinforcing phenomenon.

Once Gaia gets going, in other words, it keeps itself going. (At the dawn of life, however, and perhaps after major setbacks like mass extinctions, the starting physical and chemical conditions are critical for life's (re)ascent into prominence.) The biosphere, or Gaia, is thus an emergent phenomenon of life's *abundance*, because it is only through being abundant that life can (chemically and physically) shape its surroundings consequentially enough to generate feedback for itself and constraints (enabling or limiting) for other organisms.

Teleology, as has been duly and often noted by Gaians, is redundant. The biota does not need to be purpose-driven or cooperative to shape life-sustaining surroundings, but instead environmental feedback takes care of that end result. Charles Darwin recognized such a feedback mechanism in the case of earthworms that, by moving through, chemically processing, and physically triturating earth, create soil on which their food—plants—grows (Darwin 1881).[1] (Earthworms thus cultivate their food; Darwin called them "gardeners.") This feedback process that Darwin identified for one group of soil invertebrates can be generalized to all soil organisms (Carson 1962; Lavelle 1996; Volk 1998). Soil, created by and virtually composed of life, is good for every creature that lives in it. Furthermore none of the creatures that collectively make the commonwealth of soil through their behaviors, their excretions, their body parts, and ultimately their corpses are being either selfish or collaborative in so doing.

Groups of organisms not only impact their surroundings by putting out metabolic byproducts the effects of which feed back upon them; their abundant by-products also create opportunities for the evolution of other kinds of organisms that can metabolize or utilize those by-products (Volk 1998). (By-products include such things as feces, urine, leaf litter, corpses, oxygen, and nitrogen compounds.) The latter organisms will then create other by-products that change the surroundings in ways that will reverberate back upon them, and also create opportunities for yet other groups to evolve and grow. Feedback cycles arise and exchanges are created, some of which may involve the reciprocal consumption of each other's excretions. Large-scale partnerships between successful, pervasive groups with complementary metabolisms, feeding on one another's "wastes," may emerge and stabilize: for example, between land organisms and marine creatures (Harding 2006), between autotrophs and decomposers (Rinker, chapter 6 in this volume), as well as between photosynthesizers and respirators or, more colloquially if less exactly, plants and animals (Volk, chapter 3 in this volume). Organisms become interlinked in matrices of chemical exchanges. For Gaian scientist Scott Turner (2004), groups of organisms that reciprocally enhance each other's survival and growth—creating what he calls "closed loops of nutrient flows"—can form enduring, mutually favorable, and environmentally dominant associations.

Life is a fundamentally imbricating phenomenon, an elaborate edifice of nestings that stabilize for extended periods into complex, in-flux equilibrated states (e.g., of atmospheric composition, climate regimes, life-forms, or ecosystems). The intricate webbing of life has happened, and continues to occur, from the most intimate dimension of endosymbioses that created and sustain complex life, to the exchange of nutrients via the trading zones of air, water, and soil (Margulis 1981; Lovelock 1988). Gaia is this interconnected flux, what Darwin called the "entangled bank." Strictly speaking, there is no selfishness or cooperation in life's activities within the biosphere—only a whirl of obligate interconnectedness. For some, the absence of selfishness and cooperation may be testimony to a morally indifferent natural world, one neutral to direction, outcome, and relationship. And yet, the obligate interconnectedness of life, from which mutual benefit is constantly flowing to all, can also be interpreted as evidence that goodness is profoundly rooted in a primordial and objective condition of being (see Kropotkin 1902; Bookchin 1996). Goodness, in other words, can be understood as the distilled concept and conscious practice of what life does simply as a matter of fact. In this light, human ethics (for which service and benevolence are universal ideals) are continuous with, not extrinsic or epiphenomenal to, Nature's ways.

For Gaian thought "the environment" is not a range of external conditions that sets the stage for life's "struggle for survival," but more like a physiological matrix or co-created interface that eases the flow of matter and energy between an abundance of organisms. Elsewhere I called atmosphere, hydrosphere, and upper lithosphere "the commons" of the biota (Crist 2004a). By playing such a significant role in creating their surroundings, organisms are essentially protagonists in creating and changing themselves, a process that Gaians call "autopoiesis" or self-creation (Margulis and Sagan 1995; Clarke, chapter 17 in this volume). But the fact that organisms modify their interfaces in ways that turn out to facilitate vital communication in a variety of biochemical dialects does *not* mean that life is in control of its environment or its own destiny. Life's exquisite powers offer absolutely no guarantee for the persistence or even the resilience of the biota that constitutes it.

Despite life's awesome ability (thus far in its long history) to renew itself and rebound with the passage of time, the biota has been exceedingly vulnerable to the human onslaught. And what remains of Earth's biological diversity today is all too clearly as fragile and ephemeral as fireballs over marshes.

The Danger of Overtheorizing the Earth as "System"

Life's unimaginably long tenure on Earth, along with its capacity to survive massive blows (e.g., asteroid strikes and extreme climatic shifts), so enthralled Gaian thinkers that many, especially in the early days of the Gaia hypothesis, tended to overemphasize Gaia's intrinsic toughness. The discovery that life has the "power to tame the forces of the universe," as Eugene Linden puts it (chapter 19 in this volume), led Gaians to privately underestimate and publicly understate the human-driven devastation of the biosphere. How much damage could arrogant but puny humankind inflict on tough Gaia? Such questioning put Gaian thought at loggerheads with environmental sensibilities.

Indeed, if we focused solely on cultural appropriations of Gaia—on the New Age enthusiasm with which the goddess-Earth concept has been embraced—the paradox of a tense relationship between environmentalism and a Gaian perspective would be missed. Yet tensions between the two have existed from the early days of the Gaia hypothesis. In comparison to Gaia's self-regulating power, to her robustness and longevity, the Gaian paradigm seemed to dismiss human beings as a relatively trivial force—hell-bent, perhaps, on our own destruction, but incapable of jeopardizing the Gaian system. "The environmentalist," Lovelock averred in the 1980s, "who likes to believe that life is fragile and delicate and in danger from brutal mankind does not like what he sees when he looks at the world through Gaia. The damsel in distress he expected to rescue appears as a robust man-eating mother" (1987: 96). The ecologically minded naturally worried about the implications of this position. Environmental ethicist Anthony Weston, for example, challenged the emphasis on Gaia's "powers, not our responsibilities," on ground that it could "undercut rather than reinforce many of the legal safeguards that environmentalists have established." For, he continued, "it can be argued that nature is not fragile, on the whole, and therefore, that many of the protections we have enacted based on our fears of its fragility are probably unnecessary" (1987: 219–20).

Underestimating the human impact went hand-in-hand with the emphasis on *homeostasis*, a term transposed from systems theory and cybernetics to conceptualize Gaia. For example, Lovelock and Margulis (1989) described "the world system, which is Gaia," as having "the thermostat-like capacity to maintain the earth temperature constant, in spite of an increase of heat from the sun, and also to maintain the chemical composition relatively stable." Homeostasis, sustained through built-in or autopoietic negative feedback mechanisms, refers to a system's tendency to keep its basic states relatively stable in response to perturbation. The early Gaia literature, in particular, found evidence for homeostasis in the biosphere's "maintenance of relatively constant conditions by active control" having prevailed for thousands of millions of years (Lovelock and Margulis 1974). The ostensible capacity of Gaian system to self-regulate, maintaining stable parameters of temperature, chemical composition, and other variables, was unfortunately often taken to imply that human beings have considerable latitude to perturb the Earth with impunity: not only was the Earth system thought potent enough to withstand human perturbation, it was sometimes also deemed capable of automatically countering it.

Whether Gaian scientists intended such erroneous inferences to be drawn from an Earth systems perspective, commentators did in fact draw them. In his review of Lovelock's *Homage to Gaia*, for example, Adolfo Olea-Franco (2002: 602) wondered: "Since Gaia is resilient and homeostatic, why should we care about pollution and global warming?" The Earth system's supposed ability to handle disturbance could thus be glibly interpreted as proverbial "license to pollute." This implication was also picked up by ecofeminist Val Plumwood (1992: 63). "It does not matter," she noted about the potential Gaian environmental message, "if we don't wash our dishes and throw our dirty linen on the floor because Gaia, a sort of super housekeeping goddess operating with whiter than white homeostatic detergent, will clean it all up for us. In this form the concept…denies the need for any reciprocal human responsibilities towards Gaia. Such a Gaia may have the trappings of a

goddess but is really conceived as a sort of super-servant." This was fair if caustic commentary on problematic environmental "uses of the Gaia concept" (ibid.).

These problematic uses of Gaia, far from reflecting indifference toward the fate of an overexploited biosphere within the Gaian community, stemmed from an overzealous application of systems theory. Systems theory, too rigidly or literally applied, may have propped the underestimation of humans' disruptive power, on the one hand, and encouraged an irrelevant emphasis on Gaia's capacity to survive and triumph in the long haul, on the other.

When the idea of system is applied loosely to the biosphere—simply to highlight the physical and energetic interconnectedness of elements within a whole—then no overwrought conceptual repercussions follow. A loose use of "system" resonates with its connotations as a suffix in the word *ecosystem*. Indeed Lynn Margulis (1996), who has resisted the notion of the Earth as a "singularity," has often preferred to describe Gaia as "a set of interacting ecosystems" rather than in cybernetic terms. But when systems theory is literally and vigorously applied to the Earth, the emergent perspective suffers from enormous flaws. For one, it props technological metaphors for describing the Earth—the most widely used having been the comparison of Gaia to "thermostat." The technological idiom tends to reinstate a mechanistic conception of the biosphere—the worldview most implicated in ecological destruction, as historians, philosophers, and scientists have compellingly argued.[2] Ironically the resurrection of a vision of *anima mundi*, in the scientific form of Gaia, intended to supersede deadened concepts of Earth and cosmos (Abram 1996; Harding 2006).

Moving forward, the most insidious repercussion of a newly minted mechanistic biosphere (of Earth as cybernetic system, thermostat, etc.) is taking shape in the increasingly aired proposals to solve anthropogenic climate change via so-called geoengineering methods. The most widely discussed possibility is the idea of shooting aerosols into the stratosphere to mask global warming via the effect of global dimming (see Crutzen 2006). Geoengineering schemes constitute dangerous strategies for addressing our ecological predicament, at both ideological and real-worldly levels.[3] But geoengineering schemes are also profoundly dubious for being premised on the assumption that the Earth is *literally* a single gigantic cybernetic contraption that we might manipulate as a whole. As David Abram (1996: 238) has pointed out about the repercussions of mechanistic thinking, "the mechanical metaphor...not only makes it rather simple for us to operationalize the world..., it also provides us with a metaphysical justification for any and all such manipulations." An emergent technological metaphor of Earth as "cybernetic system" is the hidden empirical assumption, and the underlying metaphysical justification, of geoengineering proposals: both the empirical *and* metaphysical underpinnings are highly suspect.

A stringently applied systems-theoretic framework for Gaia is unfalsifiable—another gaping cognitive flaw. As was noted in the Preface to the volume *Scientists Debate Gaia*, "the direction of feedback [in the Gaian system] is not clear and is likely to be destabilizing as stabilizing at different times and scales" (Schneider et al. 2004: xv). Thus any planetary state (whether a consequence of stabilizing or destabilizing feedback) can be rendered conformable to systems theory: from the extreme climatic episodes of snowball Earth or the Eocene's runaway heating, to oscillations between glacial periods and interglaciers, and the onslaught of feedbacks that are currently strengthening rather than offsetting global warming—all can be rationalized within a systems perspective. This is partly because systems theory offers a range of concepts able to account for *both* stability and change. While early Gaian thinking emphasized the former (negative feedback and homeostasis), the current documentation of anthropogenic climate change has set in motion the marshalling of the latter (positive feedback and chaos).

Gaian scientists began to steer away from stressing homeostasis (negative feedback), both because of growing knowledge that global environmental parameters have ranged widely in geological time (sometimes settling into extreme regimes dangerous for life's tenure) and because of a growing understanding of what is unfolding with global warming. Indeed, if the hope that "homeostatic Gaia" might counter the human-driven amplification of the greenhouse effect ever induced comfort—namely that the system would kick in with negative feedback to offset adverse heating—such comfort has evanesced in the face of steadily increasing temperatures, melting ice and glaciers, and rising sea levels (Lovelock 2006; Flannery 2006; Aitken, chapter 8 in this volume). Yet the apparent failure of homeostatic mechanisms to emerge in response to the human-driven CO_2 forcing has not (necessarily) inspired the abandonment of Gaia-qua-system. Instead, an alternate panoply of system concepts is being marshaled—in particular, those of threshold, tipping point, amplifier, and positive feedback (Lovelock 2006). Applied to our current greenhouse predicament these concepts generate an apocalyptic vision, as the Earth system becomes conceived on the verge of shifting rapidly and irreversibly (for a human time scale) to a new hot state (see Crist 2007).

Here is how Lovelock (1996: 24) summarily captured the dynamics of Earth-system shifts in an earlier publication: "Gaia theory sees the Earth as a responsive supra-organism that will at first tend to resist adverse environmental change and maintain homeostasis. But if stressed beyond the limits of whatever happens to be the current regulatory apparatus, it will jump to a new stable environment where many of the current range of species will be eliminated." As this classic formulation crisply demonstrates, systems theory reasoning is *digital*, tending to deliver a binary storyline: on the one hand, the Earth-system is assessed robust enough to withstand some disturbance through actively maintaining homeostasis; on the other hand, too much disturbance is regarded as forcing a threshold-crossing that throws the Earth-system off kilter before it stabilizes into a new state.

But this two-tiered takeaway picture, which emerges through an overly stringent application of systems theory to the biosphere, may be assessed as far too unrefined: it entirely bypasses the fact that, as a consequence of human colonization, the Earth has suffered profound losses of ecosystems and species without adverse whole system consequences. The losses that have occurred, and continue to unfurl, can only be discerned through *analogue* thinking: biodiversity destruction has been a continuous, incremental, and cumulative event—and the binary systems-theory construct of *stability* to *chaos* (whatever truth it may hold for extreme climate forcings) has not much to do. In fact the vast diminishment of life's richness has unfolded within apparently stable system conditions; it has not resulted from, nor (to our knowledge) led to, the overstepping of any global thresholds; and it has proceeded as a linear unraveling—species by species, population by population, habitat by habitat, and today (after the steady chiseling of centuries if not millennia) acre by acre.

In brief, systems theory applied to the biosphere has been conceptually unequipped to capture the import of the biodiversity crisis (which includes the mass extinction underway), except insofar as this crisis emerges as consequence (or potential cause) of a jump from one Earth-system state to another. This cognitive failure of systems theory is a straightforward consequence of systems thinking. For when the Earth is conceived as a system, inevitably quandaries about environmental troubles become posed in terms of whether *the system* is endangered; the question of whether the biosphere is being destroyed becomes coextensive with the question of whether the Earth-system, as we know it, is breaking down. For those of us, however, who understand the scope of biodepletion as the precipitous loss of life's richness, as a profound crisis for the composition of the biosphere (and not necessarily a crisis for the biosphere's stability, whatever that means), the systems view has not been a sufficiently nuanced theoretical instrument to register, and thereby bring into discursive view, the anthropogenic devastation of life.

This is not simply a normative grievance; it is a cognitive grievance as well. Systems theory, especially in its unpalatably mechanistic metaphors, is simply no match for the Earth's mystery and immensity. By laying the biosphere on the Procrustean bed of overtheorizing, systems theory ends up reducing it to fit its framework. Every theory obscures at least as much as it reveals and is therefore *reductionist* in some sense. The celebrated holism of systems theory can make it all the more deceptive an instrument of knowledge. Holistic theories are invisibly reductionist because by making the implicit validity claim of "capturing the whole" they blindside us to what their framing crops out. (I discuss what is cropped out with respect to Gaia in the next section.) And so it is with an overtheorized systems view of the biosphere. Fortunately neither Gaian inquiry nor our intuitive sense of the Earth's oneness hang on a systems-theoretic conception of the living planet.

The whirl of intensely interactive, abundant, diverse, and complex life that shapes the wondrous commons of the biosphere does not need cybernetics for clarification.

Restoring the Holocene

The famous Daisyworld computer model, elaborated by Andrew Watson and Lovelock in the early 1980s, gave the idea of biospheric self-regulation a tremendous boost, by simulating how the differential growth of black and white daisies could tune a planet's temperature (as a kind of albedo dial) within relatively ambient zones for the daisies, even as the sun's heat output gradually increased. The model was "a splendid rhetorical asset," as Jon Turney (2003) put it, in demonstrating that systemic regulation can occur as an automatic consequence of organismal growth, life's environmental input, feedback from input, and natural selection.

The model demonstrated that the abundant, differential growth of black and white daisies can do the global work of modulating temperature over time in the face of a heating sun. Yet within the habitable climatic conditions thereby created, what is arguably *the main event* on Daisyworld starts to unfold: gray daisies evolve and spread in the life-molded, life-supporting matrix they find. It was the neo-Darwinists who brought up the "gray daisies"—a pigment-free variety that could exploit the comfortable environment without investing any work in sustaining it—as a challenge to the ultimate tenability of the self-regulation of Daisyworld. Within a neo-Darwinian framework that elevates competition to a first-line biological principle, the gray daisies were naturally construed as the so-called cheats (see Lenton and Williams, chapter 5 in this volume). (It is only by over-inflating the status of competition and struggle in living processes that such loaded language has descriptive purchase.) But in a broader evolutionary and biospheric perspective, the "gray daisies" represent something much less inflected and much more important than freeloaders—they represent *biodiversity*, the influx of evolutionary proliferation within partly life-created niches that afford living means and habitat. If what the biosphere epitomizes is a capaciousness in creating life, then the gray daisies are its very essence—even though, from a systems perspective, their regulatory functions may be auxiliary, redundant, or even nonexistent.

Systems-theory reasoning places an ontological premium on the whole. The component parts are considered important, of course, but primarily because of the functional roles they play. As a consequence systems thinking produces a discursive blind spot for those components of life, or levels of taxonomy, that do not have critical functions within the system. Importantly, thinking along such functionalist lines leads to the inference that any number of life forms may be "redundant," vis-à-vis the (adequate or even healthy) functioning of the (eco)system, for any of the following reasons: they are too rare to have a serious impact; they are fungible, which is to say replaceable with functional equivalents; and/or they are simply taking a free ride in a system that more biochemically robust groups are running.

The idea of redundancy of life forms within the Gaian system (or within ecosystems) insidiously mutates into a notion of *dispensable* life forms. But the notion that certain life forms are, or may be, dispensable is completely theory-laden: dispensability gets its façade of empirical coherence only within a theoretical framing that prioritizes the functionality of some imagined whole. Defenders of biodiversity—who naturally recoil at the implications of dispensability in a time when life's richness is critically imperiled—are often duped by the pseudorationality of the notion of dispensability, and driven to the weak argument that we should protect all life forms because we cannot know which ones are, or are not, dispensable, or because the dispensable ones are backups—spare parts, as it were—in the system.

But it is the *very idea* of dispensability that needs to be deconstructed and jettisoned as intrinsically incoherent. Were the world's old-growth forests dispensable? What if remaining old-growth forests are replaced with oxygen-producing and carbon-absorbing fast-growing tree plantations—are the rest of them (also) dispensable? Was Costa Rica's golden toad, driven to extinction by climate change, dispensable? How about the Tasmanian wolf, hunted to oblivion? Seventy percent of flowering plants are endangered or threatened: what fraction of them is dispensable? Until the recent devastation of marine ecosystems, the oceans were home to "a great abundance of whales, walruses, sea cows, seals, dolphins, sea turtles, sharks, rays, and large fish" (Jackson 2007). That abundance is no longer: Was it dispensable?

It is the flaw of systems paradigms—be they social or biological—to lack the conceptual tools for honoring the member parts for their intrinsic existence, their unknown (or even trivial) roles, their sheer contribution to complexity, their sheer contribution to diversity and/or biomass, and their unknowable destinies. In what is a purely reductive move, systems thinking is only equipped to appreciate component parts as functional cogs in the whole. It is systems thinking that is dispensable, not life forms.

Concluding Remarks

If life in the biosphere has an essence, it might be expressed under the rubric of three interconnected qualities: diversity, complexity, and abundance. These qualities have been captured peerlessly by the perspectives of Darwinian evolution, ecological science, and Gaian inquiry in their complementary paradigms that, together, hold the potential to create a Zeitgeist of deep understanding and harmonious living on Earth. The tendency of life to become increasingly diverse, increasingly complex, and increasingly abundant has, over the course of eons, created and recreated a living Earth that in the temporal and spatial unfolding of the

universe can be celebrated as a *cosmos*—a world of intrinsic order and beauty. Amazingly the time frame within which *Homo sapiens* evolved and proceeded to develop a cornucopia of cultures coincided with what biologists believe may have been the most biodiverse era of Gaia's natural history (Wilson 1999).

But we are living in a time that we are daily inundated by overwhelming news about the biosphere's predicament. Wherever we turn there is a crisis: an amphibian crisis, a climate crisis, an ocean crisis, a water crisis, a coral reef crisis, a bird crisis, a rainforest crisis, a carnivore crisis—the list is endless. As sorrowful as the specifics are, the deepest tragedy lies in the scope they add up to: human beings have taken aim at the very qualities that define the living planet, dismantling, with an intent that seems paradoxically both blind and demonic, the diversity, complexity, and abundance of life on Earth. Elsewhere, I collectively called these properties *the flame of life*, because they form the matrix of Earth's life-generating creativity and of the biosphere's robustness so celebrated by Gaians (Crist 2004b).

Extinction of species is occurring at a rate thousands of times the rate of natural (also known as background) extinction. Life scientist Peter Raven (2001) has calculated (using an estimate of ten million extant species and an average species lifetime of four million years) that in the absence of the human impact, between two to three species would be going extinct each year. By contrast to this natural rate, thousands (if not tens of thousands) of species are vanishing yearly. And the biosphere is not only hemorrhaging species, it is losing its abundance of wilderness and wild creatures. The great masses of flocks, schools, and herds of animals are vanishing, and so are their migrations. The populations of top predators—tigers, lions, jaguars, wolves, grizzlies, sharks, and others—are a mere fraction of what they were even a hundred years ago. The numbers of ocean fish are rapidly shrinking, and on land the same holds for the once globally abundant forested tracts of the Holocene. Half of the world's wetlands, intensely rich in biodiversity, were lost in the twentieth century alone. On landscape and seascape levels such losses are tantamount to the accelerating dismantling of ecological complexity. The impoverishment can be large or small, depending on the particulars, but the global trend has been in the direction of simplification of one ecosystem after another. Simplification is ratcheted up by the frenetic mixing of the world's biota, brought on by globalization, that is swiftly homogenizing the biosphere. In contrast to mixing cultures, where loss of cultural diversity may be offset by the gain of greater mutual acceptance and equality between peoples, there is *no silver lining* to the biological melting-pot: the generalists win, and diversity—the unique loveliness of each place—first recedes, then vanishes.

Will the biodepletion underway generate a resource problem for humanity? I submit that fear of resource depletions is all but a red herring: it distracts attention from the fact that the transformation of the biosphere into a stock of resources is what has devastated it in the first place. We have in fact gained a world of resources by forfeiting the living Earth. Misplaced anxiety about resources occludes from view that the resourcist worldview has been, and is, destroying the beauteous wealth of the biosphere (see Foreman 2007). Fear of losing resources will not generate the vision we need to preserve and restore the Holocene's richness, but instead will encourage technological fixes (e.g., geoengineering the atmosphere or the oceans) and managerial approaches to land, water, and air. The day may not be far when, for example, instead of working toward restoring the abundance, diversity, and beauty of marine ecosystems, we start farming the oceans to produce "protein."

In Bill McKibben's opening words, this is our moment. It is the moment to face the root of the terrible trouble we have unleashed for the biosphere and for ourselves: our expansionism, arrogance, and domination within the biosphere. In acts of beauty, and without fear, this is our moment to put Gaia first.

Notes

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1. For an analysis of Darwin's last book—often called his "worm book"—in a geophysiological or Gaian light, see Crist (2004a).

2. Carolyn Merchant, for example, in her celebrated work *The Death of Nature* (1980: 193), wrote that "the removal of animistic, organic assumptions about the cosmos constituted the death of nature." More recently Stephan Harding (2006) echoed this assessment, condemning the "mechanistic view" as "literally killing the Earth as it was configured at the time of our birth as a species."

3. For a more elaborate critique of geoengineering that for reasons of space I cannot reiterate here, see Crist (2007).

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