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# James Lovelock's The Ages of Gaia: A Biography of Our Living Earth (review essay)

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THE AGES OF GAIA: A BIOGRAPHY OF OUR LIVING EARTH. By James Lovelock. New York: Norton, 1988. Pp. xx, 252. $16.95.

Nature has long been conceptualized as a discrete entity, the object of inquiry for natural scientists, the opposite of culture for literati. In contrast, American law does not reify nature, that is, define the environment as a thing under the law. Many other abstractions, for instance future interests in land, have definite legal identities. Nevertheless, American courts have considered nature only as an interest held by a potential party, such as a right to remove fish, an opportunity for recreational activities, or a repository for waste.

In response to global warming and other recent degradations of the environment, society is changing its ideas about, and even definitions of, nature. Gaia theory provides one of the most important new approaches to nature. Named after the Greek goddess of the earth, the theory was developed by James Lovelock, and is presented most fully in *The Ages of Gaia: A Biography of Our Living Earth*. Though Lovelock is a scientist, this book and its predecessor, *Gaia: A New Look at Life on Earth*,[1] are written so that one "only needs a dictionary."[2] Timely and manageable by the educated laity, these books have propelled Lovelock to a level of popularity enjoyed by few scientists.

This Book Review describes Gaia theory, and relates the new definition of nature to environmental litigation. While *The Ages of Gaia* says little about law, if Gaia theory is adopted by society at large, environmental law will be restructured.

Gaia theory maintains that the Earth is alive. Lovelock means this literally: the entire planet should be considered a living thing. A thing is alive if it has a boundary and acts to preserve its identity; that is, if it acts to achieve stability and continuity, so that it is recognizable over time. In other words, living things are discrete entities. They are bounded by walls, skin, waxy coverings, bark, or membranes, which distinguish the body of the living thing from its environment. The living also use energy, which they take from the outside world, in order to maintain their particular patterns of organization. Waste, the byproduct of this process, must cross the

1. J. LOVELOCK, GAIA: A NEW LOOK AT LIFE ON EARTH (1979).

2. J. LOVELOCK, THE AGES OF GAIA: A BIOGRAPHY OF OUR LIVING EARTH at xv (1988).

boundary and be flushed into the environment.[3] This dynamic balance, the continuity of complex organic relationships despite material exchange, is called homeostasis. For Lovelock homeostasis is the defining activity of living things. More technically, "if life is defined as a self-organizing system characterized by an actively sustained low entropy [or high level of organization], then, viewed from outside each of these boundaries, what lies within is alive."[4]

No one doubts that earth has complex systems, for instance the web of relationships between carbon dioxide, oxygen, and the respiration of plants and animals. But what "actively sustains" such systems or keeps them at "low entropy?" In a cosmos ruled by the second law of thermodynamics, in which each step in any given relationship results in a net increase of disorder, what explains the highly organized systems on Earth?

Lovelock describes the mechanism which maintains organization on Earth with a computer model of the imaginary planet Daisyworld. Daisyworld is a planet hospitable to and solely inhabited by daisies of various shades. Temperature is the only variable in the model. Daisyworld's sun is gradually getting hotter. If the temperature falls below 5°C or rises above 40°C, the daisies die. Daisies breed more successfully somewhat within these margins, and do best at 20°C. Because darkly colored daisies absorb more energy, and consequently raise the temperature in their immediate neighborhoods, they are more successful than light daisies at the low temperature margin. Conversely, light daisies are more successful than dark daisies as the temperature approaches 40°C. Finally, great numbers of lighter or darker daisies change the albedo, the average shade, of the planet itself, and thereby affect its temperature.

At the beginning of time in the model, the temperature is low. All daisies can live only near the equator, and dark daisies are

3. The second law of thermodynamics demands that total entropy, the tendency for disorder, must increase. Consequently, the maintenance of low entropy structures, such as living organisms, must be counterbalanced by the release of high entropy elsewhere. "By the act of living, an organism continuously creates entropy and there will be an outward flux of entropy across its boundary . . . . I say that only by pollution do we survive." *Id.* at 25–26. The important point is that waste is a necessary, not an accidental, by-product of living.

4. *Id.* at 27.

favored even there. As the dark daisies proliferate, the temperature of Daisyworld rises. Seeking cooler temperatures, the dark daisies move toward the poles, and light daisies become more successful near the equator. Eventually, only light daisies can survive near the equator. But as light daisies proliferate and lower the albedo of Daisyworld, the planet absorbs less energy from the sun, and the temperature drops. Eventually, the light and dark daisies will balance their populations so that the albedo of the planet yields a mean temperature of 20°C. As the sun grows hotter, light daisies increasingly will be more successful than dark daisies, "until, finally, the heat flux is so great that even the whitest daisy crop cannot keep enough of the planet below the critical 40°C upper limit for growth. At this time flower power is not enough."[5] But until Daisyworld succumbs, the flowers maintain the planetary temperature at a level comfortable for daisies. At the same time, Daisyworld influences the daisies by providing the context in which the flowers exist and evolve.

Academically, the model illustrates how biology (daisies) and metereology (temperature) reciprocally influence one another, that is, combine to form a recursive system.[6] Gaia theory is the application of this insight to Earth, where species act in concert and are acted upon, in a manner suitable for the maintenance of life. Gaia is the self-regulating system which tends to maintain optimal states. Lawyers should find all this strangely familiar: Gaia theory is a geophysical analogue to the Coase theorem.[7]

Gaia theory emerged from Lovelock's work at NASA in the late 1960's. NASA's plans for voyages to the moon and the planets raised the classic science fiction theme of Martians, albeit soberly phrased as scientific inquiry into the possibility of other life forms. For the NASA designers, this posed a technical question: how

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5. *Id.* at 37.

6. Classical ecology, in contrast, describes the relationships between living things in an environment unresponsive to the activities of its member species. *Id.* at 62.

7. The Coase theorem, named after the economist Ronald Coase, is a set of ideas which relates the allocation of legal entitlements to market forces. Interpretation of the theorem, which Coase never baldly stated as a formula, remains controversial. The basic thesis, however, is that markets will shift legal entitlements to achieve socially optimal results. *See* Coase, *The Federal Communications Commission*, 2 J.L. & ECON. 1 *passim* (1959); *see also* Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1 *passim* (1960). For a brief and detailed history of the idea, see 1 THE NEW PALGRAVE: A DICTIONARY OF ECONOMICS 455–60 (1987).

does one test for life? One cannot test for properties that happen to characterize life on Earth but do not define life per se. What then would a test for life measure?

Lovelock noted that the presence of living things in the Earth radically changes the chemical makeup of its atmosphere. For instance, oxygen and methane each exist in our atmosphere naturally, even though both react in sunlight, producing water and carbon dioxide. One might expect the oxygen and methane to disappear over time, and indeed, to have disappeared already.[8] But oxygen and methane are continuously produced as a by-product of Earth's living organisms, maintaining stable levels despite their chemical instability. Life involves the taking in, the reconstitution, and the release of chemicals into the environment. Thus, the presence of living things creates an environment altered by the pursuit of life, an atmosphere in constant disequilibrium.

By the 1960's, astronomers using infrared telescopes had determined the makeup of the Martian atmosphere. If the appropriate elements were placed in a beaker and exposed to a source of energy—such as the sun—for a few billion years, the result would resemble the atmosphere on Mars—unadulterated geology. Since there was no evidence of any biological activity in the composition of the Martian atmosphere, Lovelock reasoned that we did not need the Viking voyages to know there was no life on Mars. The Viking voyages did not, in fact, find any life. The expansion of Lovelock's insight into the vastly different atmospheres of Earth and Mars led to the publication of Gaia theory in the early 1970's.

Conceptually, *The Ages of Gaia* is divided into three parts. The first explains Gaia theory and its origins and attempts to answer some of its critics. The second divides the life of Earth into three ages. The Archean age "runs from the Earth's assembly 4.5 eons ago to 2.5 eons ago when oxygen first dominated the chemistry of the atmosphere."[9] The Proterozoic age, which lasted until about 600 million years ago, saw the atmosphere—and thus the ecosystem—switch from an anoxic—largely methane—to an oxygen base, and also saw the development of cells with internal structures. The third period, the Phanerozoic, extends from the end of the Proterozoic to the present day. This is the age of

8. J. LOVELOCK, *supra* note 2, at 28–29. Lovelock's treatment, here and elsewhere in the book, is considerably more technical.

9. *Id.* at 66.

multicelled organisms. Describing each age, Lovelock discusses mechanisms through which Gaia keeps a livable environment, for instance ocean salinity, free atmospheric oxygen, or temperature, within ranges tolerable to living organisms.

The book's final section contains a disparate set of ideas which might be loosely characterized as the practical—moral and political—uses of Gaia theory. Lovelock discusses the deleterious impact of human action on Gaia's complex systems. Less familiarly, he argues that we should attempt to seed life on Mars and sketches a plan for making the planet biologically viable. In another chapter, Lovelock struggles with what Gaia means and with the relationship of a holistic vision of ecology to traditional visions of God. Engagingly candid, he tries to articulate his own beliefs, and finds the Virgin Mary revealed, renewed, as Gaia. Just as the Virgin has long personified the abstractions of Christianity, Lovelock imagines Gaia as a mother, circumscribing the lives of her creatures. Lovelock concludes with thoughts on living in accord with Gaia, creating an ethic for the maintenance of a healthy planet.

Lovelock writes movingly, and sometimes even brilliantly. But the presentation of these disparate concluding ideas, the results of the Gaia thesis for humanity, suffers from the author's inexperience with religious or philosophical discourse. The quick insight into a tangential issue, the melange of personal opinion and academic history, even the dash of English eccentricity, are refreshing elsewhere in the book, for instance in polemics against academe, or stories of a theory's birth. But the deeper passages are marred by the lack of either rhetorical or philosophical rigor. Lovelock's inexperience is aggravated by an all too human insensitivity to the questions posed by Gaia theory. Like many popularizers of science, and perhaps like anyone enthralled by a great idea, Lovelock suffers from egoism of thought, from an insensitivity to his idea's effects and ramifications, to its *feel* in a world of competing truths.

Over the past two decades, when the mainstream scientific community has paid attention to Gaia theory, it has often been to attack the implication that Gaia has a goal, or a purpose, in acting as it does.[10] In response, Lovelock has moderated his claims,

10. The purposive implications of Gaia were attacked at an American Geophysical Union Conference on Gaia in 1988. James Kirchner and John Harte of the University of California at Berkeley charged that the "traditional teleological [goal-oriented or purposive]

stating that "the nonliving and the living represent a self-regulating system" that maintains conditions necessary for life.[11] However, this limited restatement leaves unanswered the central question about Gaia theory, whether Gaia is purposive, responsive or is survivably diverse in reacting to changing conditions. The first two answers would be controversial, the last would be banal.

Outside of the scientific community, Gaia theory has gained a sizeable following. Lovelock has received widespread credit for shaking up the hidebound scientific disciplines and creating a broad interdisciplinary debate on planetary, human, and economic existence.[12] Lovelock stresses that even an incorrect theory is valuable if it stimulates new thinking and new productive research.[13] His stated goal is to break down the "apartheid"[14] that separates the scientific disciplines. His description of the systematic academic restraints on free-thinking makes enlightening reading at a time when the list of taboo subjects seems to grow daily.

Lovelock is not a garden variety environmentalist. Lovelock wants to look at the world from Gaia's point of view. In speaking out for Gaia, he often comes into conflict with more conventional views of the environment, which reflect a humanist perspective. Lovelock minimizes many environmental issues, such as the threat of nuclear radiation or a nuclear winter. He points out that Gaia exists in a nuclear-powered universe and is herself the product of a primeval nuclear explosion. It is humankind, not Gaia, who must fear such hazards.[15] Lovelock is worried that nuclear "hype . . . [will] divert us from the real and serious problem of living in harmony with ourselves and the rest of the biota."[16]

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strong hypothesis is simply not testable, . . . while the weaker forms, in which life merely influences the environment, are so obviously correct that they do not merit status as hypotheses." Kerr, *No Longer Willful, Gaia Becomes Respectable*, 240 SCIENCE 393, 393 (1988).

11. *Id.*

12. Typical is reaction in the *Economist*, which said Gaia "can serve in forming . . . desperately needed new ideas . . . about this small blue planet." 310 ECONOMIST 82, 82 (1989).

13. J. LOVELOCK, *supra* note 2, at 42.

14. *Id.* at 30, 168.

15. The aftermath of the accident at Three Mile Island nuclear power plant indicated at least one form of nuclear tolerant life. The cleanup effort was "plagued with algae that flourished in water exposed to radiation fields that would kill a human in minutes." *After the Meltdown, Lessons from a Cleanup*, N.Y. Times, Apr. 24, 1990, at C1, col. 2.

16. J. LOVELOCK, *supra* note 2, at 173–74. Lovelock's key to understanding the problem is to answer the questions: "How stable is the present system? What will perturb it? Can the effects of perturbation be reversed? Without natural ecosystems in their present form, can the world maintain its present climate and composition?" *Id.* at 181–82.

In Lovelock's view, the greatest threat to Gaia is environmentally damaging, large-scale farming and grazing undertaken to feed a bourgeoning world population.[17] This is especially true where such agricultural activities are replacing tropical rain forests. These forests, along with the waters of the continental shelves, are Lovelock's two candidates for "ecosystems . . . crucial for keeping the environmental status quo."[18]

Lovelock describes various maladies in the environmental movement, such as the exploitation of cancer fears by "environmentalist demagogues,"[19] and what he calls the "zero shibboleth": the argument that a substance that is carcinogenic at any dosage must be removed from the environment completely.[20] Lovelock does not adopt such a hands-off approach to nature. He argues that the zero-shibboleth ignores the fact that many potentially harmful substances are essential to the environment in small amounts. For example, even oxygen can have harmful and potentially carcinogenic effects on the human body.[21]

Lovelock stresses that a diverse ecosystem is more resilient than a simple one. Survival is rooted in the ability of diverse systems to adapt to changing externalities. It is the complex interactions of the living and the non-living that maintain an environment suitable for life. In this dynamic model, a diverse system has a greater capacity to respond to external changes and survive. Thus, under Gaia theory, large-scale, one-crop agriculture becomes a planetary liability, and diverse tropical rain forests become planetary assets. In a dynamic system, the strengths of a diverse ecosystem are analogous to the strengths of a diverse local economy in coping with a dynamic market. It is the seeming responsiveness of this system that makes Gaia theory controversial.

Despite Lovelock's feeling that "science and law do not mix well,"[22] Gaia theory offers a solution for a central problem of environmental litigation. Currently, the legal system is structured around human conflicts. When an environmental harm only tangentially involves conventional human injuries, environmental law-

17. *Id.* at 179.
18. *Id.* at 178.
19. *Id.* at 177.
20. *Id.* at 167.
21. *Id.* at 168.
22. *Id.* at 167.

yers have difficulty stating a legally cognizable claim. As a result, environmental issues are frequently litigated in terms of implausible harms which might be inflicted on human plaintiffs. For example, a litigator might argue against a dam building project that flooding the wilderness will injure humans by impairing recreational uses of the land.

In *Sierra Club v. Morton*,[23] the Supreme Court denied the Sierra Club standing in a suit to stop the Walt Disney Corporation from building a resort in the wild Mineral King valley. The Sierra Club "failed to allege that it or its members would be affected," and consequently had no case.[24] Justice Douglas dissented, saying, "contemporary public concern for protecting nature's ecological equilibrium should lead to the conferral of standing upon environmental objects to sue for their own preservation . . . . The voice of the inanimate object therefore should not be stilled."[25] The majority presumably found this argument too outrageous to merit a reply, and the courts remain unwilling to confer standing upon natural objects.

Justice Douglas cited with approval Professor Christopher Stone's now-famous article, *Should Trees Have Standing?*, which argued that natural objects should have rights, and that interested groups, such as the Sierra Club, should be appointed guardians ad litem for the protection of those rights.[26] Stone argues that a legal right entails three procedural capabilities: the ability to institute a legal action, an injury cognizable in the eyes of the court, and a remedy which can benefit the rightholder.[27] The second and third capabilities, and thus the entire argument that natural objects should have rights, are logically dependent upon the capability of the rightholder to hold an interest.

Environmentalists frequently minimize the difficulties of establishing what is in nature's interest. Stone, for instance, illustrates our ability to determine the needs of nature by his ability to know when to water his lawn.[28] But this view of nature, and natural interests, stems from two controversial perceptions. First, it treats

23. 405 U.S. 727 (1972).
24. *Id.* at 735.
25. *Id.* at 741–42, 749.
26. Stone, *Should Trees Have Standing?*, 45 S. CAL. L. REV. 450, 458–59 (1972).
27. *Id.* at 458.
28. *Id.* at 471.

the status quo as natural. Nature is perceived as the untouched, the unchanged, and the timeless counterpart to the vicissitudes of human activity. Thus, politics and the environment are basically at odds; the only policy in nature's interest is preservation. Second, the classic environmentalist vision underplays the artificial aspects of what we experience as nature, such as the human introduction of non-native plants and animals or huge deer populations resulting from the decimation of predators. Environmentalists—once called preservationists—often see a bright line separating the natural from the artificial sphere. Both these perspectives place human activity in absolute conflict with nature's interest. As a result, environmental litigation is a tale told in terms of victory and defeat, not fruitful cooperation between nature and humankind.

Viewing nature in a Gaian manner resolves these difficulties of the Douglas/Stone position, placing its goals more within the reach of environmental litigation. Since it accounts for evolution and the complex stability of the ecosystem, Gaia theory is in many ways more satisfying than traditional conceptions of nature. Environmentalists can use the health of a particular ecosystem to judge the merits of a case, rather than using a hypothetical pristine state, or a status quo which is a lesser evil than a proposed future, as a rigid standard of the good. Gaia's health can determine the wise allocation of particular legal rights, for example, whether to water a lawn during a drought, whether to promote monoculture agriculture in California's Owens Valley, or how to manage Yellowstone National Park. In contrast, traditional environmentalism has had to settle for ad hoc balancing of environmental and other interests. Working within the traditional paradigm, environmental concerns have often fared badly, because they have seemed impractical, elitist, or otherwise insensitive to competing political goals.

In a Gaian framework, political actions and policies that promote the health of Gaia are in the Earth's interest. The law *can* consider Earth's interest without referring to the interests of any single species, much less the interests of individual humans. Nor must environmental law adopt an equally implausible anthropomorphic fiction, like litigious trees. As a species, trees do not receive standing, that is, are not accorded due process rights

analogous to those enjoyed by human litigants. Gaia theory suggests that the life that is nature, the entire geophysiological system, must have standing.

Although Gaia theory makes natural interests far more justiciable, the theory does not give natural objects "rights." Gaia theory dissolves the split between culture and nature, not by extending human qualities to natural objects, but rather by putting human affairs in an environmental context. Human activity is a part of the planetary organism, as bacterial life is a part of human life. This approach heals the perverse anthropomorphism for the sake of nature in which we speak of the "rights" of natural objects.

Gaia theory enlarges our perception so that what was once an alien interest, a "right" to be awarded to a natural object, is now seen as a characteristic of our own condition, an aspect of the dynamic harmony in which we constituents of Gaia live. Human activity is not non-natural or bad. It is simply the activity of another species, with one difference. *We* can ponder the extent to which our actions are in accord with the health of the whole.

Because the line between human and natural becomes so blurred, the argument that the courts should give rights to natural objects analogous to those held by human individuals is philosophically incoherent. More practically, Gaia theory resolves a jurisprudential dilemma which has long stymied environmental litigation. Gaia theory neither ignores environmental issues except as they impinge on human interests, nor anthropomorphically considers natural objects as rights-bearers. Instead, consciousness of Gaia's life, the web in which we live, informs our policies, and is thus inevitably the subject of our litigation.

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