Gas Guzzling Gaia, or: A Prehistory of Climate Change Denialism

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Introduction

Consider the following excerpt from a 1995 advertorial published by the oil and gas conglomerate known today as ExxonMobil:

> To those who think industry and nature cannot coexist, we say show a little respect for Mother Nature. She is one strong lady, resilient and capable of rejuvenation. The environment recovers well from both natural and man-made disasters. . . . Does this justify or lessen the impact of industrial pollution? Of course not. Our main point is that nature, over the millennia, has learned to cope. Mother Nature is pretty successful in taking on human nature.[1]

The ad is often pointed to by social scientists as illustrative of a distinct genre of climate change denialism, in which fossil-fuel corporations sowed doubt not by denying the phenomenon of global warming but by naturalizing it. Comparing ExxonMobil's public messaging with its private reports, Geoffrey Supran and Naomi Oreskes have shown that ads like these were part of a public relations campaign meant to downplay the risks of climate change, mounted while the company's own scientists were internally sounding the alarm.[2] This essay, however, contends with a different dimension of this marketing strategy. I am concerned less with the social or political ends of ads like

1. Quoted in Geoffrey Supran and Naomi Oreskes, "Assessing ExxonMobil's Climate Change Communications (1977 2014)," *Environmental Research Letters* 12, no. 8 (2017): 8.

2. See ibid. See also Katie Jennings, Dino Grandoni, and Susanne Rust, "How Exxon Went from Leader to Skeptic on Climate Change Research," *Los Angeles Times*, 23 Oct. 2015, graphics.latimes.com/exxon research/

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these than with the reasoning that first brought them into existence. I want to know: By what logic did it become possible to think of the planet as an entity "resilient and capable of rejuvenation"? Why was it the case that a statement about the natural world's ability to restore itself in the face of pollutants—as having "learned to cope," in ExxonMobil speak—made sense to begin with? What I am after here are the *conditions of possibility of climate change denialism*: the epistemic and conceptual conditions that made certain statements about fossil fuels' effect on the climate not only possible but also plausible. These are the conditions—the modes of knowledge production and the theoretical assumptions about the very nature of the climate—that defined the range of possibilities for climate change denialism. If the climate crisis is a defining feature of contemporary life, and if, following Michel Foucault, societies are implicitly circumscribed by a set of precepts that define "the limits and forms of the *sayable*," then a study of the historical conditions that lent legibility to denialism as a discursive domain would go a long way toward a project of historicizing the present.[3]

In this spirit, my object of inquiry is the Gaia hypothesis, the theory—first elaborated by James Lovelock in the 1970s—that the Earth is a homeostatic system sustained by life itself. Gaia proposes that, through a series of tightly coupled biochemical feedback loops, the whole of planetary life collectively and autonomously works to maintain the planet's environmental conditions within a narrow range of habitability. In Gaia, the enduring stability of the Earth's climate—never too cold nor too hot for life to survive—is not merely a happy coincidence; it is the result of a host of biological self-regulating mechanisms working to actively regulate the temperature in the face of perturbations.

This essay traces a lineage between the Gaia hypothesis and the discursive strategies of denialism; without this vision of the climate as a fundamentally stable system, I argue, claims about the planet's ability to "recover" from pollution would have been simply incoherent. To make my case, I zero in on a key dimension of Gaia's history, one that has until now gone largely unexamined by historians: Lovelock's professional relationship with Royal Dutch

3. Michel Foucault, "Politics and the Study of Discourse," trans. Colin Gordon et al., in Foucault et al., *The Foucault Effect: Studies in Governmentality*, ed. Graham Burchell, Gordon, and Peter Miller (Chicago, 1991), p. 59.

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Shell, the multinational oil and gas company. As I will explain, Lovelock elaborated the Gaia hypothesis and gave it evidential depth through a series of Shell-sponsored research projects meant to identify organisms whose biological activities might double as climate-stabilizing mechanisms. In the aftermath of his research on such creatures as sulfur-excreting algae and iodine-emitting seaweeds, Lovelock came to argue that the metabolic off-gassings of these tiny organisms were evidence of a kind of "regulatory response," one meant to "neutralise the [warming] effect" of fossil fuels on the climate.[4] Lovelock eventually expanded these arguments into the Gaia hypothesis and invoked these "regulatory response[s]" to cast doubt on the threat that a host of anthropogenic pollutants—from fossil fuels to CFCs—posed to the atmosphere.

Perhaps this pollution-centric Gaia comes as a surprise. Indeed, for most readers, Gaia is likely synonymous with the "goddess" Mother Earth ecotopian philosophies of the 1970s (or, more recently, a political philosophy fit for a warming world).[5] But what I want to show is that, much like its cybernetic forebear, the body of environmental knowledge produced under the auspices of Gaia ultimately proved capacious in its sweep of possible meanings.[6] In positing a reality in which the most miniscule of life forms could affect the atmosphere at a planetary scale, Gaia dislodged the human from the center of all possible explanation—no longer could it be said that *Homo sapiens* were unique in their status as a species that could effect permanent environmental change. This decentering has historically made Gaia equally appealing to free-market evangelists, Earth-systems scientists, ecofeminists, and science-studies scholars alike; such a displacement of human exceptionalism can be leveraged equally for a doctrine of neoliberal environmental governance or for an embrace of radical biological alterity. Indeed, the history I chronicle here is a testament to this malleability. Gaia's subversion of the conventional order of nature—the suggestion that organisms of all sizes and stripes could contribute equally to the history of the Earth—laid the foundation for a vision of the climate as a resilient entity, immune to the effects of fossil fuel combustion or any other anthropogenic pollutant. At the same time, it paved the way for a new mode of knowledge production

4. James E. Lovelock, "Air Pollution and Climatic Change," *Atmospheric Environment* 5, no. 6 (1971): 409; hereafter abbreviated "AP."

5. See Bruno Latour, *Facing Gaia: Eight Lectures on the New Climatic Regime*, trans. Catherine Porter (Medford, Mass., 2017). See also Latour and Timothy M. Lenton, "Extending the Domain of Freedom, or Why Gaia Is So Hard to Understand," *Critical Inquiry* 45 (Spring 2019): 659 80.

6. I am thinking here of Peter Galison's work on the migration of cybernetics into post modern theory despite its origins in the violence of World War II era weapons research; see Peter Galison, "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision," *Critical Inquiry* 21 (Autumn 1994): 228 66.

within climate science, one that took as its starting point the idea that life and its atmosphere form a mutually constitutive system.

This essay thus approaches Gaia as a study in agnotology, the strategic production of ignorance.[7] In contrast to a more classic case of climate change agnotology, the relationship here between knowledge and obfuscation is not one-to-one—it is not the case that Gaia was a direct outgrowth of the fossil-fuel industry's concerted campaigns to produce uncertainty about the scientific consensus on global warming. On the contrary, Gaia's elaboration predated any sort of scientific consensus by nearly a decade and was born of a moment when oil and gas companies were more preoccupied with market shocks and supply shortages than environmental gainsay. Instead, Gaia is a story in which a theory about the Earth's climate was put into the world that promptly made a range of new knowledge claims possible—including claims about the self-regulating stability of the climate later harnessed to sow doubt about global warming. A history of a theory like Gaia, then, is a history of the structures of thought that were first necessary for the production of doubt.

The Biochemical Trace of Life (1919–1968)

Technically speaking, Lovelock is not a climate scientist. Born in 1919, trained as a chemist, Lovelock spent the years of World War II in London, registered as a conscientious objector (his family was Quaker) and working as a technician with Britain's National Institute for Medical Research (NIMR). During his tenure it became apparent that Lovelock had a knack for invention, especially in the realm of gas chromatography devices. His most famous of these, the electron capture detector, was capable of detecting molecules in the atmosphere at a scale of parts per billion—a magnitude of precision that until then had been literally unfathomable. The device brought him acclaim across the disciplinary spectrum. Case in point: In 1961 Lovelock left NIMR to join an instrumentation research group at the Jet Propulsion Laboratory (JPL), a NASA spaceflight engineering center in Pasadena, California. Lovelock was tasked with developing a gas chromatograph for use during a series of robotic missions to the moon.

By 1964, Lovelock had given up the NASA post and returned to England to embark on a career as an "independent scientist"—a freelance inventor of sorts.[8] His client list came to include Hewlett-Packard, Dupont, Pye Unicam, and, most importantly for our purposes, Shell Research Limited, the research arm of Royal Dutch Shell. It was an arrangement that came about through

7. See *Agnotology: The Making and Unmaking of Ignorance*, ed. Robert N. Proctor and Londa Schiebinger (Stanford, Calif., 2008).

8. Lovelock, *Gaia: A New Look at Life on Earth* (New York, 1979), p. 8; hereafter abbreviated *G*.

the efforts of Victor Rothschild, a renowned biologist and the director of research at Shell who knew of Lovelock from his NIMR work. Lovelock's early work concerned inventions, and resulted in a number of patents for the company. But around 1966, Rothschild asked Lovelock to advise the company on questions of an entirely different nature: the "possible global consequences of air pollution from such causes as the ever-increasing rate of combustion of fossil fuels" (*G*, p. 8).

Until recently, the principal form of air pollution associated with fossil fuels was atmospheric turbidity, the reduction of air transparency that results when particles in the air scatter light—haziness, in essence. The most significant contributor to turbidity was ammonium sulfate, the end product of a chemical reaction catalyzed by the emission of sulfur dioxide during coal and gasoline combustion. Ammonium sulfate was the primary cause of smog in cities (including the Great London Smog of 1952 in which at least four thousand Londoners died). In the 1960s, however, a second type of atmospheric effect had come into focus: changes in the Earth's climate. How, exactly, fossil fuels affected the climate remained subject to debate. In 1960, Charles Keeling of the Scripps Institution demonstrated that, since the beginning of the twentieth century, the overall concentration of atmospheric carbon dioxide had steadily increased.[9] But despite this amassing of data in support of a greenhouse-gas theory of global warming, in 1961 atmospheric chemist J. Murray Mitchell found that, since about 1940, the average global temperature had been steadily *decreasing*—leading him to conclude that the increase in carbon dioxide "appear[s] to be insufficient to account for the recent cooling."[10] The decline was a phenomenon whose cause no one could yet explain, but some speculated it too was an effect of atmospheric turbidity (the idea here: particles in the air might have a cooling effect by inhibiting sunlight from reaching the surface of the Earth).[11] Lovelock had become versed in the science of atmospheric pollution over the course of several stopovers at the recently established National Center for Atmospheric Research (NCAR) in Boulder, Colorado, where many of the scientists involved in these debates were based.

Lovelock's 1966 report, "Combustion of Fossil Fuels: Large Scale Atmospheric Effects," brought Shell up to speed on the latest fossil-fuel climate research, explaining that scientific consensus held that from about 1850 to 1940

9. See Charles D. Keeling, "The Concentration and Isotopic Abundances of Carbon Dioxide in the Atmosphere," *Tellus* 12 (May 1960): 200 03.

10. J. Murray Mitchell, Jr., "Recent Secular Changes of Global Temperature," *Annals of the New York Academy of Sciences* 95 (Oct. 1961): 249.

11. See Robert A. McCormick and John H. Ludwig, "Climate Modification by Atmospheric Aerosols," *Science*, 9 June 1967, pp. 1358 59.

the climate had grown appreciably warmer but that, beginning around 1940, the trend had reversed; scientists theorized that both trends were caused by fossil-fuel combustion. "The rise," he explained, "attribute[s] to the greenhouse effect," while the fall "is due to the opposing effects of increased atmospheric turbidity."[12] The central prospect that Lovelock entertained, then, was not that the climate would warm but that it would continue its decline—perhaps precipitously so. Such a decline was not in and of itself cause for alarm; it might in fact prove good for business: "it certainly would encourage the sales of products for winter heating" ("CFF"). Of concern, however, was the fact that there was no telling when the downward trend would end, and the decline itself might spur something of an atmospheric chain reaction: "there is no indication that the downfall in temperature will cease at the 1850 level; more serious is the possibility of an increase in the extent and duration of snow cover, in which circumstances the back reflection of sunlight would be much greater and the downfall of temperature would accelerate" ("CFF").

Such a forecast was certainly disquieting. Upon reviewing the document, Graham Sutton, inaugural chairman of Britain's recently established Natural Environment Research Council, stressed that "by no means" should the report be "dismissed as 'science fiction,'" though he conceded that "one cannot yet tell if the decline in temperature is part of an old old story of natural fluctuations or is something triggered off or enhanced by pollution."[13] Rothschild's response was to insist that Lovelock refrain from discussing the topic—"the weather getting colder, and the cause possibly being fossil fuel combustion products in the atmosphere"—with "non-Shell people."[14] He encouraged Lovelock to continue his visits to NCAR in order to "monitor the work [being] done" on the issue.[15]

At no point did Lovelock countenance uncertainty that these climatic trends were fossil-fuel related. On the contrary, his report presumed blame lay with the petroleum industry: "What seems to be important is not the explanations and whether they are correct in detail but rather the almost certain fact that the climate is worsening and the probability that the combustion of fuel is responsible" ("CFF").

12. Lovelock, "Combustion of Fossil Fuel: Large Scale Atmospheric Effects," 9 June 1966, box 34, Archive Collection of Professor James Lovelock, Science Museum Library and Archives, Science Museum at Wroughton; hereafter abbreviated "CFF."

13. Graham Sutton, letter to Victor Rothschild, 24 Jan. 1967, box 76, part 3, Archive Collection of Professor James Lovelock.

14. Rothschild, letter to Lovelock, 27 Jan. 1967, box 76, part 3, Archive Collection of Professor James Lovelock.

15. Rothschild, letter to Lovelock, 6 July 1967, box 76, part 3, Archive Collection of Professor James Lovelock.

Yet in the wake of this report, Lovelock's thinking about the sources and effects of air pollution evolved into another order of meaning entirely; understanding why requires a brief digression into the world of NASA instrumentation research. In 1965, simultaneous to his consulting work for Shell, Lovelock returned to JPL to join a research group tasked with designing devices for detecting life elsewhere—places like Mars. While others in the group trained their efforts on inventing instruments to probe Mars's soil for Earth-like microbial forms—a design philosophy premised on a logic of likeness—Lovelock, drawing on his gas-chromatography knowledge, proposed an utterly original life-detection technique: atmospheric analysis. Considered from the vantage of its chemistry, Earth's atmosphere was highly anomalous. It contained oxygen and methane—two gases that were highly combustible when mixed together, and yet their concentrations had historically remained constant, with oxygen at a concentration of 21 percent and methane at 1.5 parts per million. The likely explanation for this constancy, he observed, was that both gases were being continuously produced by the biota of the planet. Similarly, the presence of nitrogen and nitrous oxides in the atmosphere was in all likelihood attributable to soil-dwelling bacteria that metabolized and excreted the gases. If there were life on Mars, one would expect its existence to register in the atmosphere in the form of a persistent chemical disequilibrium—a deviation from what the laws of chemistry alone would predict.[16]

What Lovelock had arrived at was a profound observation: that life affects its environments on a truly planetary scale, literally making its world. It amounted to a theory about the *index* of life—an argument concerning the types of chemical traces in a planet's atmosphere that might be read as indicative of life's existence.[17] More to the point, such an observation evinced the extent to which life—human or otherwise—could affect the atmospheric conditions of a given planet. And while the name *Gaia* was still far from his mind, Lovelock was already beginning to reflect on the wider implications of this observation. Specifically, it was around this time (1968) that Lovelock suggested an eliding of the distinction between life *affecting* the conditions of the atmosphere and life *actively controlling* them. He framed the move as a logical leap: "If the atmosphere of the Earth is a biological contrivance, then it is reasonable"—so the scientist contended—"to consider that the components are maintained at an optimum or near optimum composition

16. See Lovelock, "A Physical Basis for Life Detection Experiments," *Nature*, 7 Aug. 1965, p. 568.

17. For more on biochemical traces as they constitute indices of life, see Stefan Helmreich, "The Signature of Life: Designing the Astrobiological Imagination," *Grey Room* 23 (Spring 2006): 66 95.

for the ecosystem."[18] Lovelock had learned from Carl Sagan, for example, that the sun "has not always been as bright as it is now, and in the beginning, it was thought to be some twenty-five to thirty per cent less luminous"—a fact that in theory meant the Earth historically should have been much too cold for life to thrive.[19] And yet, "apart from a few brief ice ages," the Earth had always remained warm enough to support life's existence. To Lovelock's mind, such an otherwise-puzzling observation might be explained by the existence of a temperature-control mechanism, a thermostat-like entity working to maintain the planet's temperature at a "comfortable steady state" in the face of the Sun's dramatically changing luminosity.[20] As it was life that affected the atmosphere's chemical composition, and chemical composition that affected the climate, perhaps it was life that acted as the maintainer of such a "biological cybernetic system."[21]

Biochemical Relativism and "Natural" Pollutants (1970–1975)

It remains unclear the extent to which, at this stage in his thinking, Lovelock drew a connection between his ideas about the cosmic signal of life and his work for Shell. In 1966 Lovelock shared a draft of his life-detection techniques article with Rothschild, who attempted to have it published in the *Proceedings of the Royal Society* (to no avail). Yet evidently this planetary perspective of life opened up new possibilities for explaining atmospheric change back on Earth, as this notion of a biological cybernetic climate became the conceptual framework that would radically reshape Lovelock's approach to the problem of climate change.

Back at Shell, around December 1970, Lovelock proposed a program of research to identify what he described as biological sources of atmospheric turbidity—organisms whose biotic processes might generate haziness and smog just as fossil fuels did. "It was considered important to know," Lovelock explained, "how far the products of the petroleum industry were contributing to the increase of turbidity and thence to climatic change."[22] As turbidity was attributed primarily to ammonium sulfate (the end product of a reaction catalyzed by fossil fuel combustion and sulfur dioxide emission, recall), Lovelock set out to discern "how much of this [ammonium sulfate] is formed

18. Lovelock and Charles Giffin, "Planetary Atmospheres: Compositional and Other Changes Associated with the Presence of Life," *Advances in the Astronautical Sciences* 25 (Washington, D.C., 1969): 185.

19. Lovelock, *Homage to Gaia: The Life of an Independent Scientist* (New York, 2000), p. 253.

20. Ibid.

21. Lovelock and Giffin, "Planetary Atmospheres," p. 192.

22. Lovelock, "Research Proposal: The Source and Role of Minor Atmospheric Components," n.d., box 34, Archive Collection of Professor James Lovelock; hereafter abbreviated "RP."

from the *natural* atmospheric sulfur carrier if the contribution of sulfur of industrial origin is to be accurately determined" ("RP"; my emphasis). His proposed object of study: algae. Lovelock had gleaned from the extant literature that certain species of marine algae were known to emit "hefty quantities of dimethyl sulphide"; dimethyl sulfide, like the sulfur dioxide of fossil fuels, was a chemical precursor to the turbidity-causing ammonium sulfate.[23] And so, in April 1971, Lovelock began collecting samples of algae from the beach near his summer cottage in Ireland and found that in fact dimethyl sulfide was "pouring out" ("O," p. 308). Later that year, in a dramatic scaling up of the study, Lovelock set sail on the *RRS Shackleton*, a British research ship bound for Antarctica. Lovelock traveled as far as Montevideo, collecting samples of seawater along the way. A graduate student named Bob Maggs boarded the ship on its return from Antarctica and continued the collecting process en route back to the UK in 1972. Upon their respective returns, the two researchers analyzed their specimens: dimethyl sulfide was detected in every single sample.

The central lesson that Lovelock drew from his sojourn at sea was that nonhuman creatures could not be discounted as planetary-scale agents merely because of their size. In a 1972 *Nature* article announcing the finding, Lovelock and his coworkers remained circumspect, suggesting only that these pelagic organisms' sulfide emissions "may therefore be a lesser potential source of sulphate aerosol than are the inorganic sulphur compounds which enter the atmosphere."[24] In his report to Shell, however, Lovelock pushed the observation to its logical extreme. The discovery of a biogenic source of dimethyl sulfide meant that Shell must "therefore treat with caution any reports that impute industrial origins to newly discovered contaminants merely because at first sight they appear unlikely to be of natural origin" ("RP").

Extending his findings far beyond the narrow realm of marine biochemistry, what Lovelock was tilting towards was a kind of biochemical relativism, a world in which any conventional sense of the relationship between *species* of organism and *scale* of environmental effect was dissolved—in effect unseating the human from the center of all possible explanation of environmental change. Such an account hinged on an understanding of the natural world in which life was reduced to its basic metabolic functions—whether in the form of excretion of dimethyl sulfide or, aided by a host of technological apparatuses, emissions of carbon dioxide via fossil-fuel consumption. It was an undeniably potent approach to the world; here even the smallest creatures

23. Lovelock, "An Oral History of British Science," interview by Paul Merchant, *National Life Stories*, 4 July 2010, p. 189, www.psichenatura.it/fileadmin/img/James Lovelock Interviewed by Paul Merchant 2010.pdf; hereafter abbreviated "O."

24. Lovelock, R. J. Maggs, and R. A. Rasmussen, "Atmospheric Dimethyl Sulphide and the Natural Sulphur Cycle," *Nature*, 23 June 1972, p. 453.

became forces of natural historical change. Yet it afforded an equally propitious version of reality for Shell. If the metabolic products of organisms like algae were a source of atmospheric turbidity, one that could provide climatic counterweight to the effects of fossil fuels, then such a phenomenon might be interpreted as evidence of "the adaptability of the biosphere and its ability to neutralize perturbations of composition or turn them to its advantage" ("RP").[25]

Here I want to read this last statement in its environmental historical context. It would be difficult to overstate the extent to which, circa the early 1970s, atmospheric chemists were puzzling over the meaning of the recently discovered phenomenon of global *cooling.* Amid this uncertainty, Lovelock offered an explanation predicated on a key assumption: that the climate was a biologically maintained, cybernetic system. In such a world, the phenomenon of algae-emitted dimethyl sulfide could be interpreted as "a regulatory response of the ecosystem to combustion emissions for it tends to neutralise the effect (temperature increase) of the perturbing stimulus (the accumulation of carbon dioxide), thereby restoring the status quo" ("AP," p. 409). Even more radically, Lovelock suggested, if such an account were valid, then it became possible to imagine that "the direct aspects of combustion are the *least* harmful of all the major disturbances by man of the planetary ecosystem, for the system may have the capacity to adapt to the input of combustion gases" ("AP," p. 410; my emphasis). He explained:

> The peppered moth provides a comforting instance of adaptability; in a few decades it has responded to the soot now covering trees in industrial regions by a change of wing-colour. If this creature can adapt so rapidly to the foulest of combustion emissions, then so might the ecosystem. ["AP," p. 410]

In the algae blooms of the sea, Lovelock discerned proof that the planet could—and would—naturally restore itself to a climate status quo. A novel claim about the world that doubled as an ethic of corporate skepticism was quietly taking shape.

It was in the aftermath of this research that Lovelock gave a name to the theory undergirding his talk of *regulatory responses* and *restoring the status quo.* His first published discussion of Gaia took the form of a letter to the editor in a 1972 issue of the relatively obscure journal *Atmospheric Environment.* Gaia captured the idea that "life at an early stage of its evolution acquired the capacity to control the global environment to suit its needs and that this capacity has persisted and is still in active use." For evidence, Lovelock pointed

25. By biosphere, Lovelock was referring to the entirety of planetary life.

to the astounding fact that, despite wildly changing environmental conditions throughout the history of the Earth—an atmosphere that had evolved from oxygen deficient to oxygen rich; a sun that had increased in radiant energy output by "approximately one astronomical order"—the climate had historically remained constant, allowing for life's continued existence. As the chemistry of the atmosphere was the unique product of the ongoings of life, and as "she who controls the atmospheric composition must also be able to control the climate," Lovelock believed that that life itself was responsible for such climate constancy. Just as a single living organism maintained its internal conditions in a state of homeostasis, so too did life at the planetary scale "homeostat the planetary environment."[26]

His dimethyl sulfide research for Shell aside, Lovelock acknowledged that in this initial articulation, Gaia remained "a vague word," a mere limning of "an entity that somehow regulated the climate and chemistry of the Earth."[27] That the task of demonstrating how various biochemical phenomena doubled as mechanisms of Gaian control threatened to devolve into circularity was not lost on him. "How may one describe a multiple system of closed loops all interdependent and self regulating without using circular arguments???. I wish that I were a Professor of Teleology it would be easier then," he lamented to the journal's editor.[28] Where he remained resolute, however, was in the teleology's implications for ideas about pollution. In 1975, Gaia reached a wider reading public via a feature story in *New Scientist*, an industry-friendly magazine, that Lovelock coauthored with Sidney Epton, an upper-level manager at Shell (fig. 1). Gaia, the pair explained, derived from two propositions: "1. Life exists only because the material conditions on Earth happen to be just right for its existence; 2. Life defines the material conditions needed for its survival and makes sure that they stay there."[29] The first statement was self-evident. Life could exist on a given planet only if the conditions necessary for its existence endured. It was this second observation, that life defined and maintained conditions in a state "optimum for survival," that formed the basis for Gaia ("Q," p. 304). Within the rubric of an optimum for survival, Lovelock and Epton allowed teleology to seep in. "If Gaia is a living entity, we have the right to ask questions such as 'what purpose does constituent *X* serve in the atmosphere?'" ("Q," p. 305). Theirs was an approach that allowed for

26. Lovelock, "Gaia as Seen Through the Atmosphere," *Atmospheric Environment* 6, no. 8 (1972): 579.

27. Lovelock, *The Ages of Gaia: A Biography of Our Living Earth* (New York, 1995), p. 15.

28. Lovelock, letter to James P. Lodge, 9 Dec. 1970, box 55, part 2, Archive Collection of Professor James Lovelock.

29. Lovelock and Sidney Epton, "The Quest for Gaia," *New Scientist*, 6 Feb. 1975, p. 304; hereafter abbreviated "Q."

FIGURE 1. Cover of the 6 February 1975 issue of *New Scientist.*

extended musings on the roles that bacteria-emitted methane and algae-extruded sulfur might play in the maintenance of atmospheric conditions. And through this naturalization of teleology, this conviction that there was a Gaian "purpose" behind every biogenic gas's presence in the atmosphere, the two scientists contested the very meaning of pollution. "Could it be," Lovelock would later ask, "that pollution is natural? If by pollution we mean the dumping of waste matter there is indeed ample evidence that pollution is as natural to Gaia as is breathing to ourselves" (*G*, pp. 108–09). In *New Scientist*, Lovelock and Epton brought these natural pollutants to bear on the "present puzzling climate." Scientists pointed to "the products of man's activities" as the cause of the recent phenomenon of "unprecedented temperature decreases." But Lovelock and Epton suggested an alternative explanation:

> Another possibility which we are exploring is that one of the trace gas emissions such as that of nitrous oxide serves as a biological climate regulator. Nitrous oxide is produced naturally by soil micro-organisms at a rate of hundreds of millions of tons annually. . . . We do not know how nitrous oxide could modify the climate, but the evidence suggests that it has been increasing in concentration. ["Q," p. 306]

Before science had settled on a consensus about the causes or directionality of climate change, before something called the Intergovernmental Panel on Climate Change existed, before climate change denialism had become a well-funded, well-oiled public relations machine, Lovelock sowed the seed of skepticism in the form of a novel claim about the nature of pollution itself. This presumption of the planet as a fundamentally adaptive system would become the starting point for a new genre of natural knowledge: "Any attempt to understand the consequences of air pollution would be incomplete and probably ineffectual if the possibility of a response or an adaptation by the biosphere was overlooked" (*G*, p. 9). What began as a modest, Shell-sponsored study of algae biochemistry and "natural" sources of atmospheric turbidity was now a universalized environmental condition. In Gaia, human pollutants were historically no different in kind or consequence from the metabolic waste products of any other creature that inhabited the Earth.

Gaia as PR Strategy (1974–1975)

As a theory that bore intimately on questions of atmospheric pollution—and one sprung into the world at a moment when chemical companies the world over were coming under increasing regulatory scrutiny for the danger their products posed to the environment—Gaia had much to offer to a range of corporations, not only Shell. Indeed, while Shell funded the research that led to Gaia's articulation, it was not the first company to publicly invoke the findings as a PR strategy. This title belongs to Dupont, the American chemical conglomerate. In the mid 1970s, Dupont recruited Lovelock to appear as an expert witness during a series of US congressional hearings on a proposed ban on chlorofluorocarbons (CFCs). CFCs were a class of chemicals used in refrigerants and aerosol propellants (think: hair sprays and air conditioners); Dupont was the world's largest supplier of them. CFCs had long been touted for their status as inert chemicals that posed no threat to either human health or the environment. In 1974, however, University of California, Irvine chemists Sherry Rowland and Mario Molina discovered that, while CFCs remained inert in the *atmosphere*, they became highly reactive once they reached the *stratosphere*.[30] There, in a reaction catalyzed by ultraviolet (UV) light, the chlorine atoms of CFCs reacted with the ozone layer, essentially depleting it and causing holes to form. The concern was that a depleted ozone would allow more UV light to reach the surface of the Earth, which in turn would lead to a dramatic increase in the incidence of skin cancers. Calls for a CFC ban soon followed the announcement of Rowland and Molina's discovery.

In a twist of history, Lovelock's own studies of atmospheric pollution had in fact laid the groundwork for the discovery of these ozone holes. But he disputed Molina and Rowland's presumption that CFCs were the only source of the offending chlorine in the atmosphere. Over the course of his research on dimethyl sulfide, Lovelock had identified a possible alternative provenance of chlorine in the atmosphere. This was methyl chloride, the product of a reaction between methyl iodide emitted by several species of *Laminaria* seaweeds (often referred to as kelp) and chloride ions in seawater. The theory required a few imaginative leaps: methyl chloride was not nearly as inert as CFCs, and almost certainly reacted with other molecules in the atmosphere long before it reached the stratosphere. Nevertheless, Lovelock made his skepticism known in a 1974 *Nature* article: "If there is a sizeable natural chlorocarbon cycle it will give, so to speak, a stay of execution" to human-produced CFCs.[31]

During the 1975 congressional hearing, Lovelock testified that "nature is making as much as 25 million tons of [methyl chloride] yearly from marine sources"—an amount, he contended, that accounted for seventy five percent of the total chlorine in the atmosphere (with CFCs accounting for the other 25 percent).[32] Without explicitly invoking Gaia, he explained that he found it "interesting" that "the biosphere finds it prudent to make this very large quantity" of such an "ozone destroyer"—implying that, if nature was constantly producing an excess of chlorine, then perhaps there was a Gaian purpose behind its presence in the atmosphere. Elsewhere that same year, Lovelock elaborated. "In this debate," he explained,

30. See Mario J. Molina and F. S. Rowland, "Stratospheric Sink for Chlorofluoromethanes: Chlorine Atom Catalysed Destruction of Ozone," *Nature*, 28 June 1974, pp. 810 12.

31. Lovelock, "Atmospheric Halocarbons and Stratospheric Ozone," *Nature*, 22 Nov. 1974, p. 293.

32. Lovelock, "Statement of James E. Lovelock, Clean Air Act Amendments 1975," Subcom mittee on Health and the Environment of the Committee on Interstate and Foreign Commerce House of Representatives (1975), p. 1149.

> it is always assumed that ozone depletion alone is the serious problem and potential threat; the possible dangers of ozone *accretion* are in this context considered as irrelevant. An alternative view . . . comes from considering the possibility that the cycling of gases by the biosphere is not merely passive but represents an active process concerned with homeostasis. . . . This hypothesis [and] the large scale biosynthesis of methyl chloride and nitrous oxide . . . suggests a *natural process* for ozone depletion. Could it be that the biosynthesis of these compounds responds to some function of stratospheric ozone density and acts as a regulator?[33]

And so, in the year 1975, Gaia was formally vaulted to the status of corporate PR strategy. The natural-sources argument immediately became part of Dupont's official company line, with Dupont's director of research Ray McCarthy stating as much during his congressional testimony ("we know . . . that chlorine in the stratosphere comes from many other compounds besides fluorocarbons; it comes from natural sources"),[34] and the possibility of the existence of "natural mechanisms for maintaining ozone" consistently raised in the editorials of aerosol trade publications.[35] Dupont and other aerosol companies pursued the theory in earnest, furnishing Lovelock and other scientists with funds to research the question, and investing in a study of a volcano near Alaska whose eruption promised to extrude enormous quantities of chlorides from the sea into the upper reaches of the atmosphere (thereby affording an opportunity to observe "an ability of the ozone layer to resist factors working toward its depletion" in real time).[36]

Given his highly unorthodox ideas about pollution, perhaps it comes as no surprise to learn that Lovelock had by this time fashioned himself as

33. Lovelock, "Natural Halocarbons in the Air and in the Sea," *Nature*, 17 July 1975, p. 194; my emphases.

34. Raymond L. McCarthy, "Prepared Statement, Clean Air Act Amendments 1975," Subcommittee on Health and the Environment of the Committee on Interstate and Foreign Commerce House of Representatives (1975), p. 1121.

35. "Ozone/Fluorocarbons: Gaining a Perspective," *Aerosol Age* 20 (Aug. 1975): 21. See also Tom Alexander, "What We Know and Don't Know About the Ozone Shield," *Fortune*, 1 Aug. 1975, pp. 184 94, and "Fluorocarbons: Clearly Safe or Banned by '78?," supplement, *Aerosol Age* (June 1975): 14a 14b.

36. Walter Sullivan, "Volcano May Be Test of Theories on Ozone," *New York Times*, 1 Oct. 1975, p. 48. Their efforts were ultimately for naught. Sales of consumer products containing CFCs declined precipitously over the course of the 1970s; in 1977 the US banned their use in aerosol spray cans. An international CFC phaseout was officially put into place in 1987 with the enactment of the Montreal Protocol; see Edward A. Parson, *Protecting the Ozone Layer: Science and Strategy* (New York, 2003). On the CFC industry's deceptions during the so called ozone wars, see Oreskes and Erik M. Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming* (New York, 2010).

something of a contrarian scientist, openly disdainful of the hysterical Cassandras of the environmental movement. In one respect, the contempt was deeply personal. Lovelock believed that his invention of the exquisitely sensitive electron capture device all those years ago was a root cause of the activism, having made it possible for the first time to detect—and, therefore, problematize—the presence of trace amounts of synthetic chemicals in the atmosphere. He later explained:

> I had a strong sort of feeling that Barry [Commoner, an American biologist and prominent alarmist about the environmental dangers of synthetic chemicals] or somebody like him would immediately say, 'Look! this chlorine compound's in the atmosphere we're all breathing, we're all under threat of cancer. Dreadful.' This kind of nonsense. And the Greens were too good at that. And they would take the numbers I had produced as evidence that everybody was under threat. And people are innumerate, I'm afraid this is the awful trouble, and they cannot see the difference between, if you can detect something, then it's there, and it's a danger. They don't take into account the fact that a part per trillion may be an utterly insignificant toxic hazard, even of a toxic compound, and the CFCs weren't even toxic. ["O," pp. 179–80]

His identification of supposedly natural sources of these very chemicals only reinforced his suspicion of those who instinctively conflated detection with danger.

The Nine Lives of Gaia

Concurrent to his very public defense of CFCs, Lovelock turned his attention to the biological implications of Gaia. It was in this context that Gaia migrated from its origins as a vehicle of corporate skepticism to assume new meaning as a new goad to inquiry in the life sciences. Beginning around 1972, Lovelock embarked on a series of collaborations with American microbiologist Lynn Margulis, then of Boston University, to identify the biological techniques by which environmental conditions might be maintained—the "sensors, information storage, amplifiers, and feedback mechanisms" of Gaia.[37] They were especially intrigued by phenomena in the microbial world. The capacity of algae communities to modify their surface properties—from light and reflective one season to almost completely black in the next, for instance—could be interpreted as a mechanism for regulating

37. Lynn Margulis and Lovelock, "Biological Modulation of the Earth's Atmosphere," *Icarus* 21 (Apr. 1974): 474.

the albedo (solar reflectivity) of the Earth. Similarly, the metabolic activities of microorganisms in the Earth's soils—their ability to produce ammonia, carbon dioxide, and nitrate—might well play a central role in regulating the greenhouse gas effect.[38]

Such theories diverged profoundly from mainstream thinking in evolutionary biology. Far from entertaining notions of coevolutionary interplay between organisms and their environments, evolutionary biologists circa the mid 1970s were preoccupied with increasingly reductionist theories of evolution, with E. O. Wilson's theory of sociobiology and Richard Dawkins's "selfish gene" both appearing in print during these years.[39] These were biological theories that reinterpreted the entire spectrum of animal behaviors as self-interested actions meant to maximize an organism and its offspring's benefit. The Gaian premise that organisms were working toward an outcome that had little, if any, benefit for the individual was antithetical to this line of thought. "No serious student of evolution," carped W. Ford Doolittle, "would suggest that natural selection could favor the development in one species of a behavior pattern which is beneficial to another with which it does not interbreed."[40] Privately, Margulis and Lovelock anticipated such critiques: "What is in it for the algae in the middle of the ocean making volatile iodine, sulphur, and other compounds for the benefit of us and giraffes etc???"[41] But in print, the two made no apologies for infusing purpose into biological thought.[42]

38. See ibid. See also Lovelock and Margulis, "Atmospheric Homeostasis by and for the Biosphere: The Gaia Hypothesis," *Tellus* 26, nos. 1 2 (1974): 2 10 and "The Biota as Ancient and Modern Modulator of the Earth's Atmosphere," *Pure and Applied Geophysics* 116, no. 2 (1978): 239 43. Margulis was something of a contrarian in her own right. She first came into scientific acclaim in the 1970s for her highly controversial but eventually accepted theory of evolution by symbiogenesis: the idea that certain life forms evolved not through the slow, Darwinian style accumulation of genetic mutations over time, but through the wholesale incorporation of one freestanding organism into another to form a new, single organism. In the early 2000s she gained notoriety for suggesting that AIDS was caused not by HIV but syphilis. Her taste for controversy later took a turn to the conspiratorial when she became an outspoken proponent of 11 September false flag theories.

39. See Richard Dawkins, *The Selfish Gene* (New York, 2006).

40. W. Ford Doolittle, "Is Nature Really Motherly?" *CoEvolution Quarterly* 29 (Spring 1981): 60 61. For more, see Michael Ruse, *The Gaia Hypothesis: Science on a Pagan Planet* (Chicago, 2013).

41. Lovelock, letter to Margulis, 18 July 1973, box 31, folder 516, G. Evelyn Hutchinson Papers (MS 649), Manuscripts and Archives, Yale University Library, New Haven, Conn.

42. The two found a more receptive audience during these years in the readers of *CoEvolution Quarterly*, the reincarnation of countercultural icon Stewart Brand's *Whole Earth Catalog*. Brand had long viewed cybernetics, with its conceptual vocabulary of feedback loops and self regulating systems, as a promising model for a nonhierarchical social order; as the naturalization of cybernetics, Gaia made intuitive sense to Brand and his acolytes. Lovelock and Margulis coauthored multiple articles for *CoEvolution Quarterly* in the 1970s, including a cover story in summer 1975.

In the 1980s, Gaia captured the attention of the atmospheric chemistry community. Stephen Schneider, a preeminent American climatologist, found Gaia intriguing for the very reason evolutionary biologists found it objectionable: it constituted a dramatic departure from how scientists had previously construed the directionality of ecological change. Unconvinced by Gaia's appeals to teleology, Schneider nevertheless believed at least one dimension of the theory—the idea of "a coupled biophysical living system"—warranted further inquiry; he arranged for the 1988 Chapman conference of the American Geophysical Union (AGU) to be dedicated to the theory.[43] The meeting convened biologists, oceanographers, Earth scientists, climatologists, and philosophers. Not everyone was a convert. Paul Ehrlich (of *The Population Bomb* fame) took to the dais to proclaim that he found it "very hard to believe that the physical Earth . . . is evolving to make life comfortable for the organisms on it."[44] University of California, Berkeley Earth-scientist James Kirchner took aim at the inconsistencies in Lovelock's definitions of Gaia over the years, noting that "the Gaia hypothesis" had, at various points, referred to a claim about life commanding a "substantial influence" over certain environmental conditions; a claim about life acting to stabilize conditions; and a claim about life acting to "create biologically optimal conditions."[45] But by and large, the meeting provided a measure of just how far the idea of a climate affected—if not controlled—by life had permeated scientific research agendas. Glenn Shaw, a geophysicist at the University of Alaska, presented his work on a possible biological mechanism for stabilizing the climate that involved algae and cloud formation. Drawing on the ecological theory of community succession, Lee Klinger of the National Center for Atmospheric Research suggested that a landscape's long-durée progression from woodland bog to peatland bog might be understood as its own kind of Gaian temperature control mechanism. Daniel Lashof of the Natural Resources Defense Council offered a survey of the various biological feedbacks that might amplify the effects of anthropogenic climate change. The meeting was considered productive enough that the AGU sponsored a follow-up conference in 2000.

In his own research, Lovelock continued to pursue the biological phenomena that might double as techniques of climate control. In 1984, during

43. Stephen H. Schneider, *Science as a Contact Sport: Inside the Battle to Save Earth's Climate* (Washington, D.C., 2009), p. 66.

44. Paul Ehrlich, "Coevolution and Its Applicability to the Gaia Hypothesis," in *Scientists on Gaia*, ed. Schneider and Penelope J. Boston (Cambridge, Mass., 1991), p. 21.

45. James W. Kirchner, "The Gaia Hypotheses: Are They Testable? Are They Useful?" in *Scientists on Gaia*, pp. 38 39.

a visiting professorship at the University of Washington, Lovelock met Robert Charlson, an atmospheric chemist who specialized in the science of clouds. The two collaborated on a project that combined Lovelock's earlier work on dimethyl sulfide-emitting algae with Charlson's research on cloud formation to posit a relationship between sulfur gas, cloud formation, and climate. Whereas Lovelock's earlier research on dimethyl sulfide and climate centered on the gas's status as a possible source of atmospheric turbidity, here the proposed mechanism of climate control hinged on cloud albedo. In brief, the scientists suggested that the sulfate particles in the atmosphere that result from algae's dimethyl sulfide emissions might form a site on which clouds droplets form. An increase in the number of these clouds would increase the amount of solar radiation reflected back into space, which, by extension, would reduce the overall temperature (fig. 2). Such a system could be said to be driven by algae because changes in temperature would lead to changes in algae population numbers, which in turn would lead to changes in the number of clouds, which in turn would change the atmospheric temperature. Or, in more overtly Gaian terms: "the link between the biota and climate in . . . these processes of cloud formation could be a mechanism for climate control."[46] The work spurred something of a cottage industry of scientific studies on the relationship between algae and climate, and in 1988, Lovelock and his coworkers received the World Meteorological Association's inaugural Norbert Gerbier Prize, an award intended to recognize groundbreaking research on the relationship between meteorology and the natural sciences.[47]

In the 1970s, the Gaian approach to the world was one of naturalizing pollution. And in reducing life to its biochemical processes, the Gaian biological cybernetic system proposed an astonishing outlook for the future: that the climate, faced with pollutants on an increasingly vast scale in the service of capital, might simply restore itself all on its own. Remarkably, by the late 1980s, Gaia had evolved from this doctrine of biochemical relativism into a vantage from which to scientifically investigate biological mechanisms of climate change. Indeed, a climate influenced by life was *the* fundamental presumption about the climate to emerge from Gaia, giving rise to new research programs aimed at discerning how, biologically speaking, this influence was exerted.

In the meantime, climate science had grown increasingly preoccupied with anthropogenic climate change. Despite several headline-capturing studies in

46. Robert J. Charlson et al., "Oceanic Phytoplankton, Atmospheric Sulphur, Cloud Albedo and Climate," *Nature*, 22 Apr. 1987, pp. 660 61.

47. On the algae climate studies, see Tony Slingo, "Can Plankton Control Climate?" *Nature*, 1 Dec. 1988, p. 421.

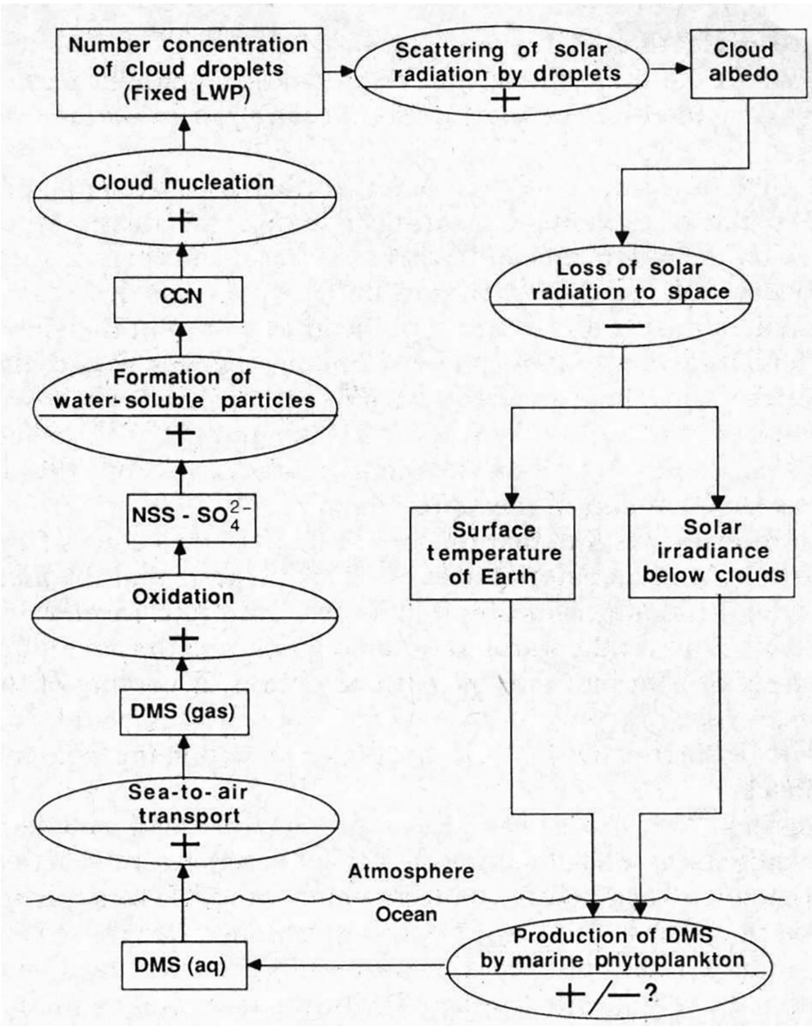

FIGURE 2. A diagram of Lovelock and colleagues' proposed algae climate feedback loop. Marine phytoplankton emit dimethyl sulfide ("DMS" in the diagram). DMS oxidizes in the air to form a sulfate ion ("NSS SO_4^{2}"). These sulfate ions act as cloud condensation nuclei ("CCN") on which cloud droplets form. Changes in CCN concentration leads to changes in cloud droplet density ("Fixed LWP"), which in turn leads to changes in the amount of solar radiation reflected back to space by the cloud ("cloud albedo"). An increase in cloud density would lead to an increase in amount of solar radiation reflected back into space and hence would cool the climate. From Charlson et al., "Oceanic Phytoplankton, Atmospheric Sulphur, Cloud Albedo and Climate," *Nature*, 22 Apr. 1987, p. 659.

the early 1970s predicting that human activities might eventually "trigger an ice age," by the end of the decade, equipped with increasingly sophisticated computer models, climatologists had converged around the consensus that the greenhouse effect would outweigh any possible aerosol-related cooling of the climate.[48] By the late 1980s, global warming had become an issue of international policy concern, and the foundations of the climate change denialism machine—industry think tanks and task forces, lobbying campaigns, and scientific front groups—had been put into place.[49]

Gaia meanwhile continued to evolve in meaning. Perhaps incredibly, Lovelock in recent decades has retreated from his contention that the climate will restore itself in the face of anthropogenic pollutants. He accepts the idea that the climate is warming and that it will continue to warm, though he remains vague on the question of culprits, preferring to talk of humans in a species-level sense—"we are now so abusing the Earth that it may rise and move back to the hot state it was in fifty-five million years ago"—rather than take an anticapitalist or anti-fossil-fuel stance.[50] He construes climate change as evidence that Gaia is moving "irreversibly to a new hot state," one that will no longer be hospitable to human life.[51] In other words—and the irony will not be lost on you—once a device for naturalizing fossil fuel emissions, Gaia is now a symbol of the existential threat that global warming poses to humanity. The human in Gaia is now an endangered species.

What then do we do with a theory like Gaia?

Conclusion

Gaia has lately become something of a mascot for posthumanist approaches to environmental politics. It is not hard to see why. Gaia's pivotal moves—the elevation of the nonhuman to the status of autonomous agent, the refusal of narratives of human exceptionalism—are today pillars of posthumanist thought. They form the foundation of what Bruno Latour describes as the new climatic regime, in which the Earth's status as an active agent in human affairs can no longer be ignored. Gaia, he explains, makes plain that "every element that . . . would have [been] seen as part of the *background* of the majestic cycles of nature, against which human history had always stood out, becomes active and mobile thanks to the introduction of new invisible characters capable of reversing the order and the hierarchy of the

48. Quoted in Spencer R. Weart, *The Discovery of Global Warming* (Cambridge, Mass., 2008), p. 79.

49. See Riley E. Dunlap and Aaron M. McCright, "Organized Climate Change Denial," in *The Oxford Handbook of Climate Change and Society*, ed. John S. Dryzek, Richard B. Norgaard, and David Schlosberg (New York, 2011), pp. 144 60.

50. Lovelock, *The Revenge of Gaia: Earth's Climate Crisis and The Fate of Humanity* (New York, 2006), p. 1.

51. Ibid., p. 6. He has also rewritten Gaia's history as a theory born of his NASA exobiology research, omitting Shell from the narrative entirely. Compare, for example, the account of Gaia's origins that Lovelock offers in his 1979 book, *Gaia: A New Look at Life on Earth* with that of his 1998 book, *The Ages of Gaia: A Biography of Our Living Earth.*

agents." Or, more succinctly: in Gaia, the "capacity of humans to rearrange everything around themselves is a *general property of living things*."[52]

But as Gaia's own history bears out, such a statement is politically ambiguous at best. Gaia's posthumanism (*avant la lettre*) gained conceptual traction and material texture under the imprimatur of Royal Dutch Shell. It collapsed the human-nonhuman ontological divide to lend legibility to the notion of *biological* sources of pollution and ascribed a shared historicity to humans and algae to undermine efforts to link environmental problems with industrial operations. Simply put, Gaia created the conditions for a denialism that derived its power by denying the uniqueness of humans' capacity to permanently alter the Earth. However one might want to defend Gaia and the radically planetary view of life that it brings into focus, it is impossible to ignore its status equally as a corporate tool for forestalling the threat of anthropogenic change from becoming fact.

In other words, Gaia's brand of posthumanism is no longer a historically transcendent category that necessarily lends itself to a project of rearticulating questions of ecology as matters of politics. Rather, Gaia's history requires that we see posthumanism as itself a discourse that has historically served multiple political projects—from upending the nature/culture dualism of modernity to the insulation of a capitalist status quo.

52. Latour, *Facing Gaia*, pp. 92 3, 246.