Geological Semantics and the Naming of the Anthropocene

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Clive Hamilton. *Defiant Earth: The Fate of Humans in the Anthropocene*. Cambridge, UK: Polity Press, 2017. xiv + 185 pp., index. ISBN 978-1-5095-1975-0. $19.95 (paper).

Bruno Latour. *Facing Gaia: Eight Lectures on the New Climatic Regime*, trans. by Catherine Porter. Cambridge UK: Polity Press, 2017. 327 pp., index. ISBN 978-0-7456-8434-5. $26.95 (paper).

Jamie Lorimer. *Wildlife in the Anthropocene: Conservation after Nature.* Minneapolis: University of Minnesota Press, 2015. 284 pp., illus., index. ISBN 978-0-8166-8108-2. $25 (paper).

J.R. McNeill and Peter Engelke. *The Great Acceleration: An Environmental History of the Anthropocene*. Cambridge, MA: Harvard University Press, 2015. 275 pp., illus., index. ISBN 978-0674545038. $19.95 (paper).

Jason W. Moore. *Capitalism in the Web of Life: Ecology and the Accumulation of Capital*. London: Verso, 2015. 316 pp., index. ISBN 978-1-7816-8902-8. $29.95 (paper).

Oswald J. Schmitz. *The New Ecology: Rethinking a Science for the Anthropocene*. Princeton: Princeton University Press, 2017. xiii + 236 pp., index. ISBN 978-0-6911-6056-6. $35 (hardcover).

Two stories beg a simple question.

First, in 1839, British geologist Charles Lyell was thoroughly dissatisfied with some terminology describing the geologic time scale. Only six years earlier, in *Principles of Geology*, he had laid out a master geochronology to delineate the Earth's deep past. Comparing the fossil record of forty thousand mollusks excavated from the Paris Basin to existing species, Lyell had divided the Post-Tertiary (Quaternary) era into four different phases: the Eocene held only 3.5 percent in common to the present; the Miocene, 17 percent; the Pliocene, 35 to 50 percent; and the Post-Pliocene, 90 to 95 percent. However, the designations confused fellow European naturalists, who repeatedly mixed up the Post-Tertiary *era* with the Post-Pliocene *epoch*. The latter name just didn't gain scientific traction.

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The Pleistocene did. Lyell introduced the term to replace Post-Pliocene, but he quickly withdrew it for he feared that its Greek-derived meaning of "most recent" would undermine his slow-moving gradualist interpretation of geological change. The Swiss naturalist Louis Agassiz had announced a past Ice Age based on his evidence of past glaciation, so for Lyell, the thought of rapid climatic warming seemed far-fetched. Edward Forbes revived the Pleistocene seven years later while Paul Gervais instead offered the term Holocene (from the Greek *holos* meaning "whole" and *kainos* meaning "new") in 1867. From there, the new epoch's boundaries took shape: its beginning would be defined by ice; its end would be defined by humanity, or in Lyell's words, "tenanted by man."[1]

And second, in 2000, Dutch atmospheric chemist Paul Crutzen was equally disgusted with the lack of scientific debate about the sheer magnitude of human-induced changes to the Earth System. In one of the meetings at the International Geosphere-Biosphere Programme Conference in Mexico, Crutzen interrupted the chairman's remarks on the Holocene by interjecting: "No, we are in the Anthropocene." Attendees were shocked by Crutzen's declaration as it suggested that a geological epoch could be defined by a single organism: *anthropos*, humans, us. The name appeared again that same year, authored for the first time in print by Crutzen and the original wordsmith, American biologist Eugene Stoermer, and it has confronted scientists and scholars ever since.[2]

Like the Pleistocene, the Anthropocene name stuck but its boundaries remained muddied. Climate scientist Will Steffen, along with Crutzen and others, spearheaded two potential starting

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[1] Lydia V. Pyne and Stephen J. Pyne, *The Last Lost World: Ice Ages, Human Origins, and the Invention of the Pleistocene* (New York: Penguin Books, 2012), 28-39; 173-74.

[2] Paul Crutzen, Interview by Christian Schwägerl, 2013, http://www.environmentandsociety.org/exhibitions/anthropocene/huge-variety-possibilities-interview-nobel-laureate-paul-crutzen-his-life (accessed 6 September 2017); Paul Crutzen and Eugene Stoermer, "The Anthropocene," *International Geosphere-Biosphere Programme Global Change Newsletter* 41 (May 2000): 17-18.

points: around 1800, when burning coal during the Industrial Revolution pushed atmospheric CO_2 conditions outside Holocene variability between 260 and 280 parts per million; and around 1945, with the exponential uptick in socio-economic markers—such as total human population, world gross domestic product, and trade intensification—and Earth System markers—like global deforestation, ocean acidification, and nitrogen deposition—that has come to be known as the "Great Acceleration."[3] While the International Commission on Stratigraphy has not formalized an official start date, a special working group recommended adopting the post-World War II chronology because of its stratigraphic "golden spike" as defined by radionuclides from atomic explosions and plastics accumulation.[4] Most scientific discourse indicates that the Anthropocene name is here to stay.

So, what's in a name? Both Lyell and Crutzen sought to redefine the geological past in order to better serve needs in the present. Whereas Lyell hoped to build a case for uniformitarianism as a counterweight to religiously-held beliefs in Noah's Flood, Crutzen resurrected neo-catastrophism as a wake-up call for industrial societies that have pushed the Earth's governing systems to the brink. For historians of science, recent scholarship on the Anthropocene reveals why naming a new geological epoch after humanity matters—and why it doesn't.[5]

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[3] Will Steffen, Jacques Grinevald, Paul Crutzen, and John McNeill, "The Anthropocene: conceptual and historical perspectives," *Philosophical Transactions of the Royal Society A* 369 (January 2011): 842-67; Will Steffen, Paul J. Crutzen, and John R. McNeill, "The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature?" *AMBIO: A Journal of the Human Environment* 36 (2007): 614-21.

[4] Jan Zalasiewicz et al., "When did the Anthropocene begin?: A mid-twentieth century boundary is stratigraphically optimal," *Quaternary International* 30 (January 2015): 196-203; "Working Group on the 'Anthropocene,'" Subcommission on Quaternary Stratigraphy, http://quaternary.stratigraphy.org/workinggroups/anthropocene/ (accessed 14 September 2017).

[5] For the conceptual framework for this review essay, see Patricia Nelson Limerick, "What's in a Name? Nichols Hall: A Report," Center for the American West, September 1987; and Mark Fiege "Of Sunburn, Sore Feet, and Hemorrhoids: Why Disciplinary Differences Matter—and Why They Don't," *Journal of Historical Geography* 43 (January 2014): 165-167.

Alternative names for the Anthropocene epoch render visible a series of contested ontologies, or how we scholars understand humankind's place within the larger cosmos. In *Capitalism in the Web of Life*, environmental historian Jason Moore argues that while historians have been able to analyze how capitalism itself acts upon nature, they lack the analytical vocabulary to examine how capitalism acts through nature. To break down this human-nature dualism, Moore offers the eco-Marxist ontological concept of *oikeios* as a means to discuss "the creative, historical, and dialectical relations between, and also always within, human and extra-human natures" (35). Over the long sixteenth century, capitalism not only developed ways to organize people into what social scientist Immanuel Wallerstein has called a "world-system" of cores and peripheries, but it also established ways to integrate human and extra-human natures into what Moore calls a "world-ecology."[6] Instead of the Anthropocene term, Moore contends that the "Capitalocene" better recognizes the inequalities and violence at the center of capitalist power- and production-in-nature.[7]

The Capitalocene epoch was based on maintaining what Moore labels the "Four Cheaps": labor-power, food, energy, and raw materials. He asserts that intense capital accumulation was less about *externalizing* costs onto either humans or nature and more about *internalizing* both as unpaid work. Moore points to some distressing calculations to back up this premise. A handful of economists have estimated that about seventy to eighty percent of the world's GDP today comes from the work of unpaid laborers—mostly women—while around seventy to two-hundred fifty percent of the world's GDP comes from unpaid ecosystem services. Moore gives historical

[6] For world-systems theory, see Immanuel Wallerstein, *World-Systems Analysis: An Introduction* (Durham: Duke University Press, 2004).

[7] For another Capitalocene recommendation, see Andreas Malm and Alf Hornborg, "A geology of mankind?: A critique of the Anthropocene narrative," *The Anthropocene Review* 1 (April 2014): 62-69.

examples where human and extra-human natures were organized into the world-ecology. Starting in the 1500s, for instance, European capitalists appropriated landscapes and enslaved peoples to cultivate sugar cane in the Americas just as they exploited working-class laborers at home by delivering cheap sucrose energy. For Moore, the web of life has been used and abused to generate wealth.

Moore asserts that the concept of the Industrial Revolution serves as a weak temporal marker for a new epoch because it reinforces dualistic narratives. He indicates that if we redefine industrialization as the processes of mechanization and standardization, industrial development occurred much earlier and happened for much longer. Stories move back from the moment that James Watt "invented" the coal-fired steam engine during the latter part of the eighteenth century (Crutzen's original Anthropocene argument) to the gradual accumulation of capital at places such as the sugar mills in Brazil and Barbados or the mast-building sites in Norway and North America. From this perspective, the Capitalocene began sometime during the sixteenth century with the environment-making shift of capitalism-in-nature. Geological semantics, or quarreling over names, thus possess real consequences. As Moore puts it, "how one answers these historical questions shapes one's analysis of—and response to—the crises of the present" (173).

Other scholars have offered their own alternative labels. Cultural anthropologist Alf Hornborg, for example, proposes the "Technocene." Hornborg asserts that the term better acknowledges how industrial technologies have been concentrated in the hands of the wealthy few who bear most of the responsibility for climate change.[8] Environmental historian Timothy LeCain suggests the "Carbocene." LeCain criticizes the Anthropocene for reinforcing

[8] Alf Hornborg, "The political ecology of the Technocene: uncovering ecologically unequal exchange in the world-system," in *The Anthropocene and the Global Environmental Crisis: Rethinking Modernity in a New Epoch*, eds. Clive Hamilton, Christophe Bonneuil, and François Gemenne (New York: Routledge, 2015), 57-69 (quote 60).

anthropocentrism and for downplaying the creative power of material things like coal and oil in bringing on a new epoch.[9] Feminist scholar Donna Haraway recommends the "Chthulucene." Haraway contends that the new label, adopted from writer H.P. Lovecraft's dark, Medusa-like, tentacle-laden character of Chthulhu, better represents the messy non-human assemblages that we humans must recognize as ecological kin if we want to persist into the future.[10] Historians Christophe Bonneuil and Jean-Baptiste Fressoz introduce a series of new terms: the "Thermocene," for the consequences of a warming planet; the "Thanatocene," for the ecocidal trends toward a sixth mass extinction event; and the "Phagocene," for the emergence of mass consumer society.[11] These scholars critique the Anthropocene narrative for its universalizing and homogenizing tendencies in order to bring out a more complex and contingent reading of this epochal shift.

In *Defiant Earth*, ethicist Clive Hamilton defends the Anthropocene designation on the grounds that "anthropocentrism" is less a philosophical position and more a scientific fact. For supporting evidence, Hamilton discusses the *weight*, literally, of the human footprint. Try this thought experiment on for size: what if we divided all terrestrial vertebrates on Earth into three categories—wild animals, domesticated animals, and humans—and calculated their collective biomass today? We would find some startling results. Wild animals comprise only three percent of the total biomass while domesticated animals encompass sixty-seven percent and humans consist of thirty percent. Human beings and their animal companions therefore make up a grand total of *ninety-seven percent* of the total terrestrial vertebrate biomass on Earth. Hamilton

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[9] Timothy James LeCain, "Against the Anthropocene: A Neo-Materialist Perspective," *International Journal for History, Culture, and Modernity* 3 (April 2015): 1-24.

[10] Donna Haraway, "Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin," *Environmental Humanities* 6 (2015): 159-65.

[11] Christophe Bonneuil and Jean-Baptiste Fressoz, *The Shock of the Anthropocene: The Earth, History and Us*. London: Verso, 2016.

maintains that the lack of societal response stems from the position that we humans are not anthropocentric enough—that is, we refuse to recognize that the fate of humanity has been inextricably linked with the fate of the Earth System.

Hamilton develops the ontological position of what he calls the "new anthropocentrism" and its premise of an embedded subject. Unlike posthumanism, where human agency emerges from a network of non-human forces, Hamilton asserts that the ability to shape the past—and potential futures—has been heightened for *both* human activities *and* biogeochemical processes. A more accurate reading of Earth System science, in Hamilton's "both/and" telling, gives us a picture of interacting feedback loops: humans release carbon dioxide into the air by burning coal and oil just as permafrost and glaciers release methane when ice melts. Both industrializing humans and natural systems contribute to rising levels of greenhouse gases as a sort of tit-for-tat phenomenon. Hamilton worries that by elevating non-human actors over human ones, and thus blurring any distinctions between the two, posthumanist scholars inadvertently deflect human responsibility for choices and decisions.

Hamilton also challenges eco-Marxist critiques of the Anthropocene narrative. To the criticism that the *anthropos* overlooks social inequalities by flattening all of the world's peoples into a single planetary humanity, Hamilton acknowledges culpability on behalf of developed countries in the global North but highlights the present-day rapacious expansion on part of the global South—particularly in China and India. While about sixty percent of all carbon emissions between 1850 and 1950 came from two nations, Britain and the United States, today's Chinese population discharges the same amount of CO_2 on a per capita basis as Europeans do. Moreover, India's 1.3 billion people (forty percent of the global populace) will likely match these figures in the near future as the developing nation pursues its own industrial path. The Eurocentric origins

of the Anthropocene quickly became a Euro-American problem, only to become an Indo-Sino-Americo-Eurocentric ordeal. Hamilton goes one step further by arguing that international agreements on climate change—taking lessons from Rio de Janeiro, Kyoto, Copenhagen, and Paris—will only be effective with global solidarity. Hamilton observes: "The pursuit of the American Dream has brought the Anthropocene nightmare" (84).

And the nightmare must be dealt with soon. In *The Great Acceleration*, historians J.R. McNeill and Peter Engelke discuss the dizzying rate after World War II during which human numbers and activities became a planetary geological force. According to McNeill and Engelke, the primary drivers of the "Great Acceleration" were rising human population and fossil-fuel consumption, as well as the pursuit of unending economic growth and military might. Take, for example, the pace of fossil-fuel depletion. Since coal, oil, and gas represent eons and eons of frozen sunshine—some 500 million years' worth of stored photosynthetic energy—over the last sixty years, humans have burned through about 50-150 million years of it. Or, take radioactive waste. On both sides of the Iron Curtain, nuclear weapons industries created sacrifice zones where thousands died from lethal cancers due to large radiation exposures. Some fissionable materials, like Plutonium-237, break down at a half-life of 24,000 years—leaving behind a geological signature that suggests the Cold War never really ended. Perhaps one of the most provocative question that McNeill and Engelke's study raises is whether our political, economic, and cultural institutions, which developed under the relative stability of Holocene conditions, can be flexible enough to adapt to the Anthropocene?

One potential adaptation that all of the above scholars are united against is geoengineering and the ecomodernist ontology. For ecomodernists, the Anthropocene signals that we humans have finally reached the culminating status as makers of the Earth System. As

such, they hold "the conviction that knowledge and technology, applied with wisdom, might allow for a good, or even great, Anthropocene."[12] They also possess a blind faith that human inventiveness will be capable of overcoming any obstacle—global warming, ocean acidification, or mass extinction. Stemming from this ontology, geoengineering involves taking human control of the global thermostat: from establishing a solar shield by spraying sulphate aerosols into the atmosphere to boosting natural carbon sinks by fertilizing the oceans with iron. These measures treat symptoms without addressing underlying causes. The ecomodernist narrative has received most of its backing from conservative politicians and corporate elites, since geoengineering a "great" Anthropocene supports a business-as-usual approach.[13]

To return to our question, what's in a name? Embedded in the Anthropocene name and the various alternatives are efforts to redefine the geological past in order to serve the epistemic needs of the present. That is to say, akin to Lyell and Crutzen's earlier declarations, we humans in some sense need to *name* the problem first before we can begin to *address* it. Above all, embedded in alternative names are attempts to create substitute ontologies to form a bulwark against hubristic ecomodernism and the status quo. As the Anthropocene debate makes evident, naming reflects values. Naming sets priorities. Naming points to possible solutions. And in this sense, naming matters.

Yet, in another sense, naming changes very little. Whatever name scientists add to the geologic calendar doesn't change the shared consequences of geophysical perturbations to the Earth System. It also doesn't change the need to reassess all areas of the human experience—our

[12] For eco-modernism ideology, see John Asafu-Adjaye et al., "An Ecomodernist Manifesto," April 2015, http://www.ecomodernism.org/.

[13] For a critique of geoengineering, see Clive Hamilton, *Earthmasters: The Dawn of the Age of Climate Engineering* (New Haven, Connecticut: Yale University Press, 2013).

political economy, our science, our ethics, and so on—in order to build a more livable future. Noticeable shifts in ecology and conservation demonstrate that a rethinking of scientific research and its practical applications is already happening.

In *The New Ecology*, ecologist Oswald Schmitz synthesizes fellow ecologists' attempts to bridge the human-nature divide by re-imagining both sides as interdependent systems. This false dichotomy was supported by the view of an ecosystem as a more or less self-contained unit where living things and non-living things interacted. This perspective explains why past scientists were fascinated with studying islands, from Alfred Russel Wallace on the Malay archipelago to E.O. Wilson on the Florida mangroves, as these places came to represent insular environments. Wallace and Wilson realized a general rule: the bigger the island, the larger its biodiversity.[14] As Schmitz discusses, however, new studies are challenging this older paradigm. For instance, ecologist Gary Polis and his team of researchers at the University of California-Davis noticed that, off the coast of Baja California, *smaller* islands actually contained *more* varieties of spiders than larger ones. They discovered that arthropods were supported by the inflow of nutrients from dead animal carcasses and other materials washing ashore. The smaller the island was, the higher its coastline-to-area ratio and therefore the larger its biodiversity was. One major implication of the "new ecology" is that "natural" ecosystems cannot be understood as isolated entities removed from human societies because they are embedded in complex processes that encompass them both.

Hence the recent application of what ecologists call "ecosystem services." Schmitz defines ecosystem services as placing value on the ways in which ecologies provide for human well-being. He divides them into four different types: provisioning, like soil formation and food

[14] For the theory of island biogeography, see David Quammen, *The Song of the Dodo: Island Biogeography in an Age of Extinctions* (New York: Scriber, 1996).

production; regulating, like climate stabilization and water purification; supporting, like nutrient cycling and crop pollination; and cultural, like aesthetic and spiritual inspiration. For example, scientists have calculated that the cost of water-treatment facilities for municipal governments in the United States is largely correlated with the percentage of forested watershed: cities with more than sixty percent tree cover on their local rivers paid about $300,000 per year for treating water, while cities of equal size with ten percent tree cover paid about $1 million per year. On one level, ecosystem services represent another commodification of non-human nature as we humans begin to place economic values on ecological processes for their utilitarian worth. But on another level, which Schmitz (and even Moore) underscores, they represent the possibility of integrating the human ecology with the unpaid work of nature's economy.

For Schmitz, the application of ecological thinking to urban-industrial society epitomizes this crucial insight. The field of industrial ecology strives to turn linear economic models of production, consumption, and waste into circular economies by returning all spent and unused materials back into an available pool of resources for future production. What does an industrial ecosystem look like? In Denmark, an electric utility company, a pharmaceutical manufacturer, a wallboard plant, and an oil refinery share and utilize a common set of steam, gas, cooling water, and gypsum residues. As Schmitz notes, "this innovation takes a lesson from nature where one organism's waste is another's resource" (174). The field of urban ecology traces material flows between cities and their hinterlands in order to guide infrastructure development. In Beijing, the municipal government gives financial incentives to farmers on the Miyun watershed to adopt agricultural practices that provision more freshwater resources—again, an ecosystem service—to urban residents. Ecological planning ensures systems integration. Schmitz reasons that both of

these disciplines "offer ideas about entwining humans and nature to achieve sustainability in ways that are respectful and ethical to both" (192).

In *Wildlife in the Anthropocene*, geographer Jamie Lorimer continues to break down the human-nature binary when analyzing recent conservation efforts. Like the concept of a walled-off ecosystem, older models of conservation were largely predicated on removing indigenous peoples from the landscape and erasing their subsistence practices. In a colonial setting, the U.S. National Park Service dispossessed Natives from ancestral homelands across the American West, such as outlawing Blackfeet Indians from hunting elk and deer within Glacier National Park. In a postcolonial context, the Tanzania government banished cattle herders from the Mkomazi Game Reserve in 1988 to appease international scientific NGOs, as well as their wealthy patrons from Europe and North America, in attempts to protect exotic "wilderness."[15] Diverging from these practices, Lorimer discusses how the recent mixing of the social and the natural into "hybrid" ecologies of community-based conservation can lead to protecting biological diversity without alienating local peoples. The densely-populated island of Sri Lanka offers a good illustration. In 2007, the Department of Wildlife Conservation negotiated with nearby farmers to allow African elephants to seasonally graze outside park boundaries in fields during the fallow period instead of building fences to separate animals and agriculturalists.

Lorimer also contends that conservationists are taking lessons from the disciplines of disturbance and restoration ecology in order to preserve wildlife in a human-built world. Take the example of the corncrake, a migratory bird species that travels every year from North Africa to Europe. Before World War I, corncrakes were found almost everywhere across the United

[15] For a darker side of conservation, see Mark David Spence, *Dispossessing the Wilderness: Indian Removal and the Making of the National Parks* (New York: Oxford University Press, 1999) and Dan Brockington, *Fortress Conservation: The Preservation of the Mkomazi Game Reserve, Tanzania* (Bloomington: University of Indiana Press, 2002).

Kingdom, but especially in Scotland, as the bird had co-evolved with the premodern agrarian system called "crofting" in which small cultivated plots created ideal breeding grounds. After World War I, farm mechanization and consolidation destroyed most corncrake habitats and, consequently, avian numbers precipitously declined. In reaction to its near extinction during the 1980s, scientists with the Royal Society for the Protection of Birds (RSPB) collaborated with Scottish crofters on the archipelago of Hebrides to see which particular farming practices the corncrakes responded to. They found that cutting fields later in the season, and from the inside out, meant more birds survived the mower. Beginning in 1992, RSPB redirected payments to farmers who adopted these measures and corncrake populations started to rebound. Lorimer discusses how the conservation group learned that wildlife thrived on a particular disturbance regime, a disturbance regime constructed by humans.

Lorimer offers "rewilding" as another promising conservation method. In the late 1960s, the Dutch government reclaimed a polder from the sea called Oostvaardersplassen (OVP) in the suburbs just north of Amsterdam, which was slated for industrial development. When these plans fell through in the 1980s, the Dutch Conservation Authority took over management of OVP as an open-ended restoration experiment. Paleoecologist Frans Vera and his research team introduced hardy varieties of cows and horses in order to mimic their extinct ancestors, the auroch and the tarpan, in hopes of creating a variegated landscape of pasture and forests. Rewilding does not deny human-constructed ecologies—in this case, water engineering and land reclamation—but it attempts to reestablish ecosystems to what they might have been like before wild animals were exterminated—in this case, the Pleistocene circa 10,000 B.C.E. Although the Netherlands benefits from the OVP's recognized ecosystem services of slowing floodwaters and sequestering carbon dioxide, some citizens have been less than enthused to see dying animals collapse on their

train rides to and from work. These complaints aside, Lorimer observes how rewilding is reworking popular conceptions of pristine ecosystems, stressing "untamed" over "unspoiled" in wilderness discourse, and retooling landscapes for nonlinear futures.

In sum, the disciplines of ecosystem science and conservation biology are trying to create alternative paradigms and practices in which coupled socio-ecological systems might be able to adapt to the Anthropocene—or whatever we call the brave new world we are entering. They also deliver a much humbler counterweight to the overconfidence of ecomodernists, recognizing that we humans are unwise to think we're in absolute control in the face of uncertain futures.

Why do geological semantics matter for historians of science? According to theorist Bruno Latour, the Anthropocene debate offers scholars the possibility of closing the modernist gap between humans and their material environments. In *Facing Gaia*, Latour gives eight lectures in which he argues that anthropogenic climate change "has made the framework on which Moderns tell history unstable" (3).

One pertinent illustration, for Latour, of bringing humans and nature together is James Lovelock's "Gaia hypothesis." As a NASA scientist during the 1960s, Lovelock pondered the question: why isn't the Earth's climate more hostile to life like Mars's is? Lovelock had been unimpressed with explanations about the "balance of nature" between metabolizing agents of carbon dioxide and oxygen, but he and Lynn Margulis believed that answers could be found in the "geophysiology" of the planet. At the microscopic level, bacteria and fungi break down organic matter, a process which stores carbon in the soil and thus regulates the climate. These decomposers led Lovelock and Margulis to a fundamental insight: living organisms don't just *adapt* to their environments in the strictest Darwinian sense; rather, they desire to *construct* their

environments in ways more conducive to their own survival. The biosphere, then, is really a self-regulating super-agent that Lovelock and Margulis called Gaia. "Since all living agents follow their own intentions all along, modifying their neighbor[ing environments] as much as possible" Latour argues, "there is no way to distinguish between the environment to which the organism is adapting and the point at which its own action begins" (100).

Gaia, however, presents historians of science with a problem that Latour calls "Atlas's curse." Like the Greek titan who carries the weight of the world on his shoulders, the balancing act becomes recognizing how scientific knowledge of ecological change is produced in particular places—such as offices, field stations, or laboratories—while still demonstrating that it can be connected to the Earth System. Or, to put this dilemma another way, the Anthropocene inverts the environmentalist mantra of "think globally, act locally" into the new phrase "act globally, think locally." In my own work on the earth-moving activities of humans, I've tried to narrate local networks of causality at the same time acknowledging how they are deeply imbedded in global patterns and processes with the concept of "geophysical agency."[16] Geophysicists, for example, not only estimate that today's aggregate pace of road building, mine quarrying, and industrial agriculture has altered more of the lithosphere than the erosive processes of wind, water, and ice, they also approximate that the global, post-World War II dam-building frenzy impounded enough water to speed up the rotational spin of the planet.[17] A single incident will bring ecological change, but when amassed, many episodes become a more consequential Earth

[16] Will Wright, "Geophysical Agency in the Anthropocene: Engineering a Road and River to Rocky Mountain National Park," *Environmental History* 22 (October 2017): 668-95.

[17] Bruce H. Wilkinson, "Humans as geological agents: A deep time perspective," *Geology* 33 (March 2005): 161-64; Roger LeB. Hooke, "On the history of humans as geomorphic agents," *Geology* 28 (September 2000): 843-46; P.K. Haff, "Hillslopes, rivers, plows, and trucks: mass transport of the Earth's surface by natural and technological processes," *Earth Surface Processes and Landforms* 35 (August 2010): 1157-66; Roger LeB. Hooke, "On the efficacy of humans as geomorphic agents," *GSA Today* 4 (September 1994): 224-25; Benjamin Fong Chao, "Anthropogenic impact on global geodynamics due to reservoir water impoundment," *Geophysical Research Letters* 22 (December 1995): 3529-32.

System transformation. Atlas's curse, in effect, stretches the physical dimensions of what constitutes space and nature.[18]

To collapse the human-nature divide on multiple scales, as these geological semantics indicate, one logical place to begin should be to further bring together the methodologies of the history of science and environmental history. Both fields share the intellectual commitment of seriously engaging the physical world as an actor. Both analyze steps taken by scientists within the resource management state. But challenges remain on how to place science as the contingent byproduct of human endeavors while at the same time using science to tell stories about large-scale biological, geological, and chemical realities, that is to say, on how we produce histories in which science is *both* socially constructed *and* materially evident.[19] At the very least, we scholars need to develop a vocabulary—what's in a name?—that will do the job.

[18] Diarmid A. Finnegan, "The Spatial Turn: Geographical Approaches in the History of Science," *Journal of the History of Biology* (Summer 2008): 369-88.

[19] For recent work on bringing the two fields together, see Conevery Bolton Valencius, *The Lost History of the New Madrid Earthquakes* (Chicago: University of Chicago Press, 2013); Gregg Mitman, *Breathing Space: How Allergies Shape Our Lives and Landscapes* (New Haven: CT: Yale University Press, 2007); and Paul S. Sutter, "Nature's Agents of Agents of Empire? Entomological Workers and Environmental Change during the Construction of the Panama Canal," *Isis* 98 (December 2007): 724-54.