

# INTRODUCTORY REMARKS: THE ANTHROPOCENE AND THE EIGHTEENTH CENTURY

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A specter is haunting academia—the specter of the Anthropocene. In recent years this ungainly neologism has risen from nowhere to become part of the vocabulary of natural scientists, social scientists, and humanists, not to mention journalists and lawyers. In the next few pages I will sketch the origin and rival meanings of the term and explore some of the controversies surrounding the concept, such as: Does the Anthropocene exist, and if so, when did it begin? Who gets to decide such things? And why should anyone bother? I will address these questions with special reference to the eighteenth century and its possible connections to the Anthropocene.

The term Anthropocene now increasingly serves as a shorthand way to signal that times have changed. Humankind now exerts—clumsily—great power over some of Earth's basic biogeochemical systems, over life on Earth, and upon the surface of Earth itself. Several chemical compounds and elements, including water, nitrogen, sulfur, and carbon, are constantly moving around our planet, cycling among living things, rock and sediments, the oceans, and the atmosphere—these are some of the biogeochemical cycles. They did this planetary cycling before humans existed, and they will likely do so after humans no longer exist. But for a few thousand years (just how many is a subject of debate), humans have affected these cycles. And in the last few decades, human actions have radically altered some of them. The crux of the original Anthropocene concept is just that: a new interval in Earth's history in which human actions have overshadowed the quiet persistence of microbes and the endless wobbles and eccentricities in Earth's orbit, and have

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therefore defined the age. That new age follows the Holocene epoch, which began 11,700 years ago.

Meanwhile, in addition to monkeying with biogeochemical cycles, humankind has also inaugurated what appears to be the sixth great mass extinction in the four-billion-year history of life on Earth. This we have achieved mainly by converting habitats in which millions of species have learned to live over millions of years into fields and pastures that help feed us.<sup>1</sup> And humans have been clawing, scratching, and scraping rock and soil to such an extent that we are now, by some measures, the most active geological agent on our planet, outstripping the earthmoving work of glaciers and rivers. We have even created new “rocks” that will survive for millions of years in the earth’s crust, including half a trillion tons of concrete—and more each year.<sup>2</sup>

To put the matter differently, in recent decades, human action has nudged Earth into a place it has never been during the Holocene. Greenhouse gas concentrations, the acidity of the oceans, and the proportion of biomass put to human use are all now outside the previous ranges of variation in the Holocene. The nitrogen and sulfur cycles are notably different from any prior incarnations at any time in Earth’s history. Global average temperatures and the share of the earth’s surface covered by ice will, in all probability, soon be outside the Holocene envelope as well. It is recognition of this torrent of anthropogenic environmental change that has inspired some geoscientists to claim that the Holocene is over and to recommend formally adding the Anthropocene to the official roster of epochs and eras in Earth’s history.

Since the middle of the nineteenth century, geologists have busied themselves dividing the history of Earth, and of life on Earth, into eons, eras, periods, epochs, and ages. Geological intervals, they now insist, are marked off by clear signatures in Earth’s fossil or rock record. Such a signature is known colloquially as a “Golden Spike” (and formally as a Global Boundary Stratotype Section and Point, or GSSP). Golden Spikes generally take the form of a difference in the fossils found above and below a transitional layer in the earth. They are something of an ideal for stratigraphers: only about two-thirds of the boundaries in the Geological Time Scale currently have one.

Geologists modify their scheme only after sober reflection and protracted consultation. It took about a century for geologists to agree on the use of the term Holocene, first proposed in the mid-nineteenth century. Since 1977 a body known as the International Commission on Stratigraphy—itsself a division of the International Union of the Geological Sciences, a venerable presence in existence since 1961—has claimed custody of the geological time scale. In 2016, if all goes according to schedule, the profession of geology will formally rule that the Anthropocene exists or does not exist.<sup>3</sup>

The contrast in the periodization procedures between geologists and humanists could scarcely be starker. If historians or scholars of literature want to christen a span of time as the Age of Jackson or the Age of Sensibility, no one tries to stop them. They might be ignored. But there is no formal process by which history or literature is sliced into eras and ages. The whole business is anarchic and full of contradiction. Moreover, it is fragmented both by discipline and by geography.

What is the Edwardian period in architectural history may be the Progressive Era in political and social history in the U.S. And what is the ancien régime in France might be the Georgian era in Britain, the mid-Qing in China, the colonial period in Latin America and the precolonial period in Africa. This chaos and inconsistency seems normal and natural to those trained in the humanities. Indeed, arguing about periodization schemes is one of our delights. We have argued about whether women had a Renaissance, for example. Now some of us are arguing, as the geologists are, about whether or not the Anthropocene exists; and if it does exist, what on earth is it? The geologists prefer a less anarchic approach, and their reports and recommendations will climax in a vote on the existence of the Anthropocene.

The stratigraphers and geologists, however, have already lost the custody battle over the Anthropocene. In 2011 both *National Geographic* (March) and *The Economist* (May 27) devoted major stories to it. An environmentalist magazine, *Earth Island Journal*, dedicated its spring 2013 issue to the Anthropocene. *The New Yorker* (23 December 2013) joined the fray too, and returned to the issue online in 2015 (March 11). The term appears often in the pages of *Le Monde* and *Der Spiegel*. Since 2013 three new scientific journals dedicated to the concept have begun publication. A Danish university, Aarhus, has opened a research program on the Anthropocene, which appears to have little to do with geology and less with stratigraphy.<sup>4</sup> The genie is out of the bottle, and the geologists will not be able to stuff it back in even if they formally pronounce that the Anthropocene does not exist. Scholars, scientists, and the lay public are adopting the term and concept, and increasingly concluding that we are now in a new period in the history of our planet.

#### INTELLECTUAL FOREBEARS OF THE ANTHROPOCENE

Countless scientists and other curious souls have long supposed that Earth might be ancient and its history might helpfully be sliced into manageable slivers. The earliest extant systematic attempt was that of Nicolas Steno (1638–86), a Danish convert to Catholicism and eventually a bishop. When not fighting the losing battles of the Counter-Reformation in northern Europe, Steno took comfort in thinking about deep time, and in effect laid down the foundations of what would become stratigraphy.<sup>5</sup> Followers refined this vision, gradually creating, and from time to time carefully modifying, the geological time scale familiar to most high school science students.<sup>6</sup>

The idea that human action might be so significant as to affect the history of the earth dates at least to Georges-Louis Leclerc, comte de Buffon (1707–88), the French naturalist and mathematician. He suggested that the latest age was one in which humankind played a subsidiary role in shaping the planet.<sup>7</sup> Antonio Stoppani (1824–91), an Italian priest, revolutionary, and geologist, took matters further and almost imagined the Anthropocene. He coined a term—*antropozoico* or anthropozoic—to suggest that the modern era constituted an age in the history of life dominated by humankind.<sup>8</sup> His neologism did not catch on.

Nor, at first, did that of the Russian and Soviet polymath Vladimir Vernadsky (1863–1945). He recognized that biological processes changed the surface of the earth, and that human action powerfully affected the distributions, populations, and indeed the existence (or extinction) of many forms of life. He adopted a

vocabulary of geosphere, biosphere, and—his neologism—noosphere to represent this vision. The noosphere referred to the realm of ideas and cognition that allowed humankind to exert an outsized impact on other forms of life. He came close to positing an equivalent to the Anthropocene, but in his formulation, unlike Stoppani's, human environmental impact, while real enough, did not constitute grounds for an era or epoch in Earth's history.<sup>9</sup>

Neither Steno, Buffon, nor Stoppani thought in terms of biogeochemical cycles and Earth systems. Vernadsky began to do so, but those concepts emerged only slowly in the course of the twentieth century. They truly caught on after the field of systems analysis developed and after the rise of scientific programs focusing on the atmosphere and the oceans, which happened mainly during the Cold War—after Vernadsky's death. If the Anthropocene is taken to mean fundamental restructuring of biogeochemical cycles, then not only did no one genuinely imagine it before the 1960s, but no one *could* have imagined it.<sup>10</sup> But that does not mean it did not exist. No one imagined Pluto before 1930, yet it existed. No one imagined the Miocene or the Cenozoic before 1850, but that does not mean the time periods we now designate with these terms did not exist.

According to Google Ngram, the word "Anthropocene" first appeared in 1958. It went extinct by 1962. It was briefly resurrected from the dead around 1980 before dying off yet again. Its sustained use dates from about 2000, when aquatic ecologist Eugene Stoermer and atmospheric chemist Paul Crutzen coauthored a piece about it.<sup>11</sup> Since that time, the term has colonized ever-larger swathes of intellectual terrain.

### ONE, TWO, A HUNDRED ANTHROPOCENES

The term and concept are both, to put it mildly, contested. The most conspicuous differences concern the birthday of the Anthropocene, for which at least six dates are jockeying for position. More contenders will surely emerge. Some authors argue for an Anthropocene beginning in the late Pleistocene. Their rationale is that the extinctions of megafauna occurring then were human handiwork (which is controversial) and brought large and lasting changes to life on Earth.<sup>12</sup> They claim that vast reductions in the numbers of herbivores allowed forest to overspread former grassland, in effect sucking carbon out of the atmosphere and into the biosphere, thereby weakening the greenhouse effect and cooling Earth. Confusingly, in this view the Anthropocene both precedes and succeeds the Holocene.

A second version of an "early Anthropocene" puts the onset around 5,000 BCE, when agriculturalists in southwest Asia, China, and a few other spots (allegedly) cut and burned enough forest to inject sufficient carbon dioxide into the atmosphere to enhance the greenhouse effect. Moreover, the early farmers in China—so goes the argument—carved out enough rice paddies to release enough methane into the atmosphere to strengthen the greenhouse effect. (Methane has roughly 25 times the greenhouse-effect strength of carbon dioxide.) In this view, the scale of the change in the carbon cycle effected by early farmers, with an assist from methane rising from rice paddies, was sufficient to stave off an otherwise expected renewal of Ice Age conditions.<sup>13</sup>

Less influential variants of the early Anthropocene argument abound. Two soil scientists maintain that the Anthropocene began 2,000 years ago on the evidence of abundant anthropogenic (human-made) soils.<sup>14</sup> Others argue for 1492, when sailors' voyages began to redistribute species among the continents, producing enduring changes in the biosphere. The migration of cattle, sheep, pigs, and goats to the Americas after 1492 left a durable signal in the fossil record, just the sort of thing stratigraphers like to see when trying to demarcate one geological interval from another. One variant of this position suggests 1610, citing not only the surge of biological exchange begun in 1492, but also a modest dip in atmospheric CO<sub>2</sub>, credited to spontaneous reforestation in the Americas.<sup>15</sup> All of these arguments offer early dates for the advent of the Anthropocene; however, early Anthropocene advocates—at present—are in the minority.

The most common view, and the one held by Stoermer and Crutzen, is that the Anthropocene began only with the advent of sustained fossil fuel use and is only as old as coal-fired industrialization; that is, the Anthropocene began in the late eighteenth century. Crutzen occasionally gave 1784 as the birth date of the Anthropocene, as it was the year of a notable advance in James Watt's tinkering with coal-powered steam engines.

Coal use on a global scale remained negligible until a temporary industrial revolution took place in north China. During the Song dynasty (960–1279), coal became an important fuel in a steel-and-iron complex that flourished for a century or more after 1020. Its windblown sulfurous residue turns up in polar ice. After the Chinese metallurgical boom withered, coal slipped into obscurity. It returned to the stage when it became a routine heating fuel in London in the sixteenth century. But the real departure came with increasingly effective steam engines, developed over the course of the eighteenth and nineteenth centuries. The most famous of these was James Watt's. It had many uses, none more important than pumping water out of coal mines, thereby preventing English industrialization from drowning in its infancy. Soon steam engines delivered mechanical power to looms and wheels as well as pumps. Steam engines could convert the chemical energy of coal first into heat energy and then—this was the revolutionary part—into kinetic energy, useful for making things and going places. As a result of these new uses for coal, British coal consumption more than doubled between 1750 and 1800 and then quintupled between 1800 and 1850. It peaked in 1913.<sup>16</sup>

In the Anthropocene debates, coal is important mainly because, when burned, it releases carbon dioxide into the atmosphere. Carbon dioxide is the most important, even if not the most powerful, of the greenhouse gases because of its quantity in the atmosphere. It helps regulate the temperature of Earth's surface and lower atmosphere—where we live—as well as the oceans. For the last 800,000 years—until very recently when fossil fuels entered the picture—carbon dioxide accounted for between 175 and 285 parts per million (ppm) of the atmosphere. The ups and downs help explain natural oscillations in temperature [figure 1].

The eighteenth-century Anthropocene, the view championed by Crutzen, privileges atmospheric chemistry above all other considerations. At the very end of the eighteenth century the carbon dioxide concentration in the atmosphere, as revealed in air bubbles trapped in polar ice, began to climb slowly. That slow climb

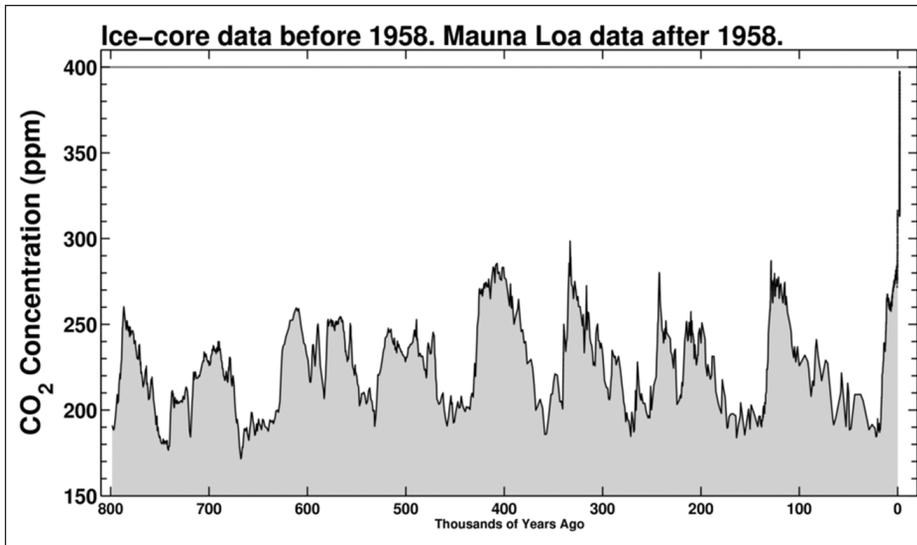


Figure 1. Concentrations of carbon dioxide in the atmosphere go as far back as the ice core records go, which is about 800,000 years. In that time, the range of fluctuation has been between 175 and 285 ppm until the last century. During the Holocene, or the last 11,700 years, the carbon dioxide concentration range has been unusually stable, between 260 and 280 ppm. Global average temperatures have also been remarkably stable. Scripps Institution of Oceanography, available at [https://scripps.ucsd.edu/programs/keelingcurve/wp-content/plugins/sio-blumoon/graphs/co2\\_800k.png](https://scripps.ucsd.edu/programs/keelingcurve/wp-content/plugins/sio-blumoon/graphs/co2_800k.png).

became the fast one that continues to this day, and has brought those concentrations from about 260–280 ppm, their range for the last 11,000 years, to a little more than 400 ppm today. This is the quickest rise in the past 800,000 years. It is probably the fastest in the history of the atmosphere.

Crutzen, the most consistent exponent of the eighteenth-century Anthropocene position, finds that this point of inflection on a long curve of greenhouse gas concentrations represents the decisive break with the past. That point of inflection is more conspicuously lodged in the eighteenth century in the case of methane than in the case of carbon dioxide [figure 2]. If the uptick in atmospheric CO<sub>2</sub>, which is slight before 1850, really derives from fossil fuel burning (as opposed, for example, to faster deforestation), and if one prefers atmospheric chemistry over other variables, then the case for an eighteenth-century onset of the Anthropocene is strong. If the uptick derives from something else (and it is very hard to tell), or if one considers the Anthropocene in a different light, with atmospheric chemistry and climate only two among many relevant variables, then the case for an eighteenth-century advent is weaker.<sup>17</sup>

My own view, for what it is worth, is that the better choice is an even later Anthropocene, beginning about 1950. Prior to 1800, while human action had many impacts on Earth and the biosphere, and might have had some effect on climate, the rate, scale, and scope of these impacts was modest compared to what came later. A new stage in the history of human impact came with industrialization in the late eighteenth century, although its consequences for atmospheric chemistry appeared only in the nineteenth. But a still more radical departure came in the mid-twentieth century with the advent of tremendous surges in fossil fuel energy use,

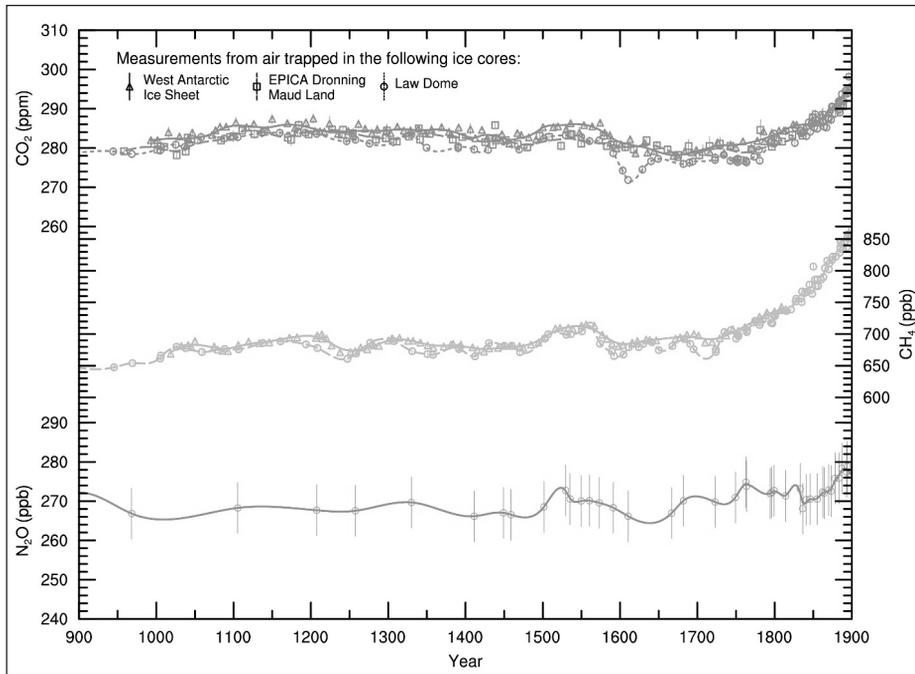


Figure 2. The evolution of the atmospheric concentrations of some greenhouse gases from 900 CE to 1900, as compiled from ice cores by the Intergovernmental Panel on Climate Change (IPCC) in its 2014 assessment. These data provide the strongest case available for an eighteenth-century beginning of the Anthropocene. Intergovernmental Panel on Climate Change, 2014 Assessment, available at <http://www.ipcc-wg2.gov/AR5/>.

population growth, urbanization, tropical deforestation, carbon dioxide emissions, sulfur dioxide emissions, stratospheric ozone depletion, freshwater use, irrigation, river regulation, wetlands drainage, aquifer depletion, fertilizer use, toxic chemical releases, species extinctions, fish landings, ocean acidification, and much else besides. So, as I now read the evidence, the Anthropocene began about 1950.<sup>18</sup>

For those geologists who require a Golden Spike for the birthday of the Anthropocene, I propose the bones and teeth of all those mammals born in the 1940s and 1950s. Unlike those born long before, their bones and teeth include a chemical signature from the aboveground testing of nuclear weapons. Those born after 1964, when a test-ban treaty went into effect, carry a far weaker signature of radionuclides in their bones and teeth. In the fullness of time, some of these bones and teeth will be lodged in sediments, creating a layer that distinguishes the mid-twentieth century from all that went before and all that came after. Some will last for several million years, like the bones and teeth of hominids in East Africa, which is long enough to satisfy most geologists.

When pondering geological time scales, choosing between 1800 and 1950 is not so much a choice between dates as a choice between understandings of what it is that makes the Anthropocene different from what came before. After all, no one knows or cares whether the Jurassic began 206,000,150 years ago or only 206,000,000 years ago. All that matters is that it had different fossils than what came before (the Triassic) and that the transition between them came roughly 206

million years ago. So the difference between an eighteenth-century and a twentieth-century Anthropocene is not really about 150 years. It is about what constitutes the Anthropocene. If the Anthropocene is defined by, for example, a slow acceleration of fossil fuel use and of human population growth, then the eighteenth century is the right choice. If, on the other hand, it is defined by screeching acceleration of both fossil fuel use and human population growth, plus burgeoning emissions, deforestation, biodiversity decline and all the rest, then the mid-twentieth century makes more sense.<sup>19</sup>

There is, perhaps, a way to reconcile the arguments for an eighteenth-century Anthropocene and a mid-twentieth-century one. It rests upon the concept of the “Great Acceleration.” In effect, the Anthropocene has stages. It may have begun about 1800, but the scale, scope, and pace of anthropogenic environmental change all grew enormously from the mid-twentieth century. That post-1945 or post-1950 period, then, is the Great Acceleration within the Anthropocene.<sup>20</sup> Ultimately, the distinction between an Anthropocene originating in the late eighteenth century and including within it the Great Acceleration and an Anthropocene beginning in the mid-twentieth century is a small one, although fiercely fought over at the moment.

The distinction between an early Anthropocene and a late one is much more meaningful. If the Anthropocene began 7,000 years ago, it is an artifact of agriculture and a necessary result of farming. If it began earlier still, with Pleistocene extinctions, it is intrinsic to human nature. The implication of early Anthropocenes is that there is nothing to be done about the outsized human impact upon Earth and its systems but to accept it, embrace it, and manage it as best we can.<sup>21</sup> But if the Anthropocene began with the advent of fossil fuels, or about 1950, the implications are different. The ecological and biogeochemical disruptions that we witness are not intrinsic to human nature, and not even necessary to farming. We can, at least theoretically, live on Earth without disrupting its basic systems—although to do so we would need to replace fossil fuels with something else.

An early Anthropocene also has the effect of demoting the eighteenth century—indeed, modernity in general. If the course of human relations with planet Earth entered their current phase thousands of years ago, then neither the eighteenth century nor the mid-twentieth century is in any major sense a turning point. The key transitions took place long ago, and can be studied only through the methods of archeology and natural sciences. No primary source texts can illuminate them, because no writing existed back then (so far as we know). So early Anthropocene hypotheses take the concept out of the realm of the humanities entirely. And matters such as industrialization, the turn to fossil fuels, the onset of rapid global population growth, and indeed anything else anchored in the eighteenth century, slip into the background.

#### THE ANTHROPOCENE AND ITS DISCONTENTS

The Anthropocene idea has attracted critics in its young career. Some critiques are scientific, some political, and some both. Some geologists, especially stratigraphers, accept the idea of the Anthropocene as a loose term to denote human impact on the environment, but believe it ought not be elevated to the status of a geological epoch or era. There is nothing durable (the objection runs) that shows

a transition from Holocene to Anthropocene. The radiation layer resulting from the use and testing of nuclear weapons between 1945 and 1964 will apparently linger for only about 100,000 years, and that is not permanent enough to serve as a boundary marker between geological periods. The ice core bubbles that record carbon dioxide levels in the atmosphere are also temporary: when the polar ice caps melt, which could happen within a mere few thousand years, that marker will be gone (although it is in the ice of Greenland that scientists found the Golden Spike marking the start of the Holocene, which was officially declared in 2009). This objection is fast disappearing as various suggestions pour forth about suitable Golden Spikes for the Anthropocene, ranging from fly ash layers to high-latitude lake sediments to ubiquitous accumulations of concrete, all of which should linger long in Earth's sediments to become hard rock. In any case, stratigraphers and geologists disagree about whether or not there really must be a Golden Spike in the earth marking off a new period.<sup>22</sup>

For other geologists, the term and concept of the Anthropocene are unwelcome for other reasons. All other epochs, eras, and periods had to prove themselves against the test of time. So, some cautious geologists argue, before we admit the Anthropocene into the club, it too must stand that test. In effect, runs this objection, we have to wait several thousand years to see whether or not the Anthropocene is legitimate. The impacts of humankind on Earth could be wiped away (well, most of them anyway) by routine geological events, such as a new round of glaciation, another flood of molten basalt, or a volley of bolides peppering the planet. Other geologists note that no other interval in Earth's history is named for any single species, and insist this noble tradition ought never to be discarded. So even should the Anthropocene be legitimate as a slice of time, it must go by another name. Naming an interval for ourselves is unseemly hubris.<sup>23</sup>

For some anthropologists, the term "Anthropocene" is also unfortunate, but for different reasons. It is, they claim, a misrepresentation of the modern ecological predicament and an impediment to useful political action. The problem, they believe, derives from the use of "anthropo," signifying humankind, when, as they see it, only a small subset of people is truly responsible for the ecological tumult of the industrial era (that subset being industrial capitalists). By confusing humankind with capitalists, the term blunts the possibility of urgently needed action to redress matters, deluding people into supposing that the Anthropocene results from some innate human qualities, rather than from choices that may be revisited.<sup>24</sup>

For some conservation biologists, the term is also unfortunate. Even if it has scientific merit, some say, it invites complacency, even despondency, when vigorous action is required to save species from extinction and ecosystems from undesirable transformation. If the biosphere is already transformed by human action, if the Anthropocene is here, what is the point of saving parts of it from further human action? Why bother to save white rhinos or Siberian tigers from extinction? If transforming the biosphere is an innate ambition of the human species, as the idea of an early Anthropocene implies, then what hope is there of resisting the human juggernaut? For some advocates of nature conservation, the term Anthropocene, while perhaps useful in drawing attention to the problem that concerns them, is also a threat because it might sap morale.<sup>25</sup>

### BIGGER PICTURES

Confining ourselves to planet Earth may yield too narrow a view of the Anthropocene. Since 1957 earthlings have launched a few thousand rockets into nearby precincts in space. The rockets have left landing pads on Mars, Venus, and the moon. They have put thousands of satellites in orbit. Millions of pieces of “space junk” now careen around Earth’s general neighborhood, ranging in size from paint flakes to rocket boosters. Two cameras, a glove, a toothbrush, and countless bits of metal (mainly aluminum) are zooming above Earth in low orbit, and will do so for centuries to come. (Sometimes space junk falls to Earth, as in 1997 when a piece of a US Air Force rocket fuel tank landed on the shoulder of Lottie Williams in Oklahoma. She was unhurt, and said it was roughly like being hit with a soda can.) In all about 6,000 tons of space junk is in Earth orbit, approximately equivalent to a fleet of 3,000 cars parked overhead. In any case, the Space Age on our planet is also an age of anthropogenic environmental change in our solar system, and the Anthropocene concept might deservedly apply beyond Earth itself.<sup>26</sup>

Indeed, it could be that ours is not the only Anthropocene—or, more strictly speaking, not the only Anthropocene-equivalent. If we accept that there are a lot of planets out there (lately astronomers suggest  $10^{27}$  would be a good guess), then the odds are that some, even if only a few billion, host life. If some host life, then a subset of those planets probably host intelligent life. If that is the case, one can plausibly suppose that some of that intelligent life is clever enough to have fundamentally altered its home, whether clumsily like us, or cautiously and prudently (as we might yet do). Thus the phenomenon of the Anthropocene, or at least Anthropocene-equivalent, might be part of the history of multiple planets. That, however, takes us rather far from the eighteenth century.

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#### NOTES

1. By “learned” I mean: became adapted over many generations via evolution by natural selection. Only a very few species “learn” anything in the human sense. In this article I will at times avoid the precise and technical language used in the relevant sciences in favor of what I hope will be prose more agreeable to readers.

2. See, e.g., the several papers in the *Philosophical Transactions: Mathematical, Physical and Engineering Sciences* 369, no. 1938 (2011); B. H. Wilkinson, “Humans as Geologic Agents: A Deep-time Perspective,” *Geology* 33 (2015): 161–64.

3. The Sub-Commission on Quaternary Stratigraphy now houses the Anthropocene Working Group, an ad hoc collection of geoscientists, a few archeologists, soil scientists, one lawyer, and, improbably, two historians (myself included). The AWG will make a recommendation to the SQS, which will make one to the ICS, which in turn will report to the IUGS, and in 2016 a vote will determine whether the Anthropocene will be formally adopted or rejected by the geoscience community.

4. “AURA: Aarhus University Research on the Anthropocene,” last modified September 1, 2015, accessed September 4, 2015, <http://anthropocene.au.dk/>.

5. Nicolas Steno, *De solido intra solidum naturaliter contento dissertationis prodromus* (Florence, 1669).

6. For an example, see “Geologic Time Scale,” University of California Museum of Paleontology, accessed September 14, 2015, <http://www.ucmp.berkeley.edu/help/timeform.php>.

7. Georges-Louis Leclerc, comte de Buffon, *Les Époques de la Nature*, Supplément, Tome V, *Histoire naturelle, générale et particulière* (Paris: Imprimerie royale, 1778).

8. Antonio Stoppani, *Corso di Geologia*, (Milan, 1873), 2:741–85.
9. Vladimir Vernadsky, *Essays on Geochemistry & the Biosphere*, trans. Olga Barash (Santa Fe, NM: Synergistic Press, 2006). For a discussion of how Vernadsky's thought prefigured the Anthropocene, see Bertrand Guillaume, "Vernadsky's Philosophical Legacy: A Perspective from the Anthropocene," *Anthropocene Review* 1 (2014): 137–46.
10. For an interesting discussion, although a trifle overdrawn in my opinion, see Clive Hamilton and Jacques Grinevald, "Was the Anthropocene Anticipated?," *The Anthropocene Review* 2 (2015): 59–72.
11. P. J. Crutzen and E. G. Stoermer, "The Anthropocene," *IGBP Newsletter* 41 (2000): 12.
12. The Pleistocene Epoch: roughly 2.6 million years ago to 11,700 years ago. One voice suggests using the first evidence of human use of fire, at least 1.8 million years ago, as the start date for the Anthropocene. Andrew Glikson, "Fire and Human Evolution: The Deep-time Blueprints of the Anthropocene," *Anthropocene* 3 (2013): 89–92. A recent overview is A. J. Stuart, "Late Quaternary Megafauna Extinctions on the Continents: A Short Review," *Geological Journal* 50, no. 3 (2015): 338–63. Roughly 65% of the genera of large mammals were swept into the dustbin of natural history between 50,000 and 12,000 years ago, mainly in the Americas and Australia.
13. W. F. Ruddiman, "The Anthropocene," *Annual Reviews of Earth and Planetary Sciences*, 41 (2013): 4–24. Specialists disagree about whether the rhythm of glacial advances and retreats is precise enough to allow one to say a new ice age would have come at such-and-such a time.
14. Giacomo Certini and Riccardo Scalenghe, "Anthropogenic Soils Are the Golden Spikes for the Anthropocene," *The Holocene* 21 (2011): 1269–74.
15. Simon Lewis and Mark Maslin, "Defining the Anthropocene," *Nature*, March 12, 2015, 171–80. That spontaneous reforestation in the Americas was anthropogenic in that newly introduced diseases, violence, and dispossession reduced the population of the Americas by perhaps 90%. These drastic changes forced abandonment of farmed land and permitted the return of forests, which absorbed carbon from the atmosphere as they grew. Various objections to this argument appear in Jan Zalasiewicz et al., "Colonization of the Americas, 'Little Ice Age' Climate, and Bomb-produced Carbon: Their Role in Defining the Anthropocene," *The Anthropocene Review* 2, no. 2 (2015): 117–27.
16. Data on the quantitative history of coal in Britain are scattered throughout volumes 2 and 3 of *The History of the British Coal Industry* (Oxford: Oxford Univ. Press, 1983–87), written by Michael Flinn and Roy Church respectively.
17. One attempt to calculate the relative contributions of land use changes and fossil fuel burning to greenhouse gas buildup since 1800 concludes that land use changes outstripped fossil fuel combustion until 1900 or 1920. Mike Raupach, "Have We Reached Peak CO<sub>2</sub>?," International Geosphere-Biosphere Programme, accessed September 14, 2015, <http://www.igbp.net/news/features/features/havewereachedpeakco2.5.1b8ae20512db692f2a680003465.html>.
18. A detailed argument to this effect appears in J. R. McNeill and Peter Engelke, *Into the Anthropocene* (Cambridge, MA: Harvard Univ. Press, 2016).
19. In the eighteenth century global population rose by about 25%; in the twentieth century it rose by about 400%.
20. This term, intended to echo Karl Polanyi's "Great Transformation," which took a holistic view about the origins of modernity, made its debut (so far as I know) at a workshop in Dahlem, a Berlin suburb, in 2005. The proceedings of that workshop are available in Robert Costanza, Lisa Graumlich, and Will Steffen, eds., *Sustainability or Collapse: An Integrated History and Future of People on Earth* (Cambridge, MA: MIT Press, 2007); for an explicit presentation of stages of the Anthropocene, see Will Steffen, Paul Crutzen, and J. R. McNeill, "The Anthropocene: Are Humans Now Overwhelming the Great Forces of Nature?," *Ambio* 36, no. 8 (2007): 614–21.
21. Erle Ellis is an important voice advocating this position, e.g. in Ellis et al., "Used Planet: A Global History," *Proceedings of the National Academy of Sciences* 110 (2013): 7978–85.
22. Among several objections from geologists, see John Lewis and Mark Macklin, "Marking Time in Geomorphology: Should We Try to Formalize an Anthropocene Definition?," *Earth Surface Processes*

and *Landforms* 39 (2014): 133–37; and P. L. Gibbard and M. J. C. Walker, “The term ‘Anthropocene’ in the Context of Formal Geological Classification,” *Geological Society of London Special Publications* 395 (2014): 29–37.

23. The unhappiest geologist might be Guido Visconti, who cites most of the prominent, and more measured, published objections in his “Anthropocene: Another Academic Invention?,” *Rendiconti Lincei* 25 (2014): 381–92.

24. Andreas Malm and Alf Hornborg, “The Geology of Mankind? A Critique of the Anthropocene Narrative,” *Anthropocene Review* 1 (2014): 62–69.

25. Tim Caro et al., “Conservation in the Anthropocene,” *Conservation Biology* 26 (2012): 185–88. A helpful review of the issues from the conservation biology viewpoint is Richard T. Corlett, “The Anthropocene Concept in Ecology and Conservation,” *Trends in Ecology and Evolution* 30, no. 1 (2015): 36–41. See also the impassioned essays in George Wuerthner, Eileen Crist, and Tom Butler, eds., *Keeping the Wild: Against the Domestication of the Earth* (Washington, DC: Island Press, 2014).

26. Alice Gorman, “The Anthropocene in the Solar System,” *Journal of Contemporary Archaeology* 1 (2014): 87–91.