6 Global Warming and Artificial Intelligence

In our conventional understanding, humans are by their God-given or self-made power of intervention masters of nature and technology in a predictable world which I have called "small." Alternatively, human "intravention" in nature's "biosphere" and technology's "technosphere" occurs in a "large," uncertain world. The concept of intravention may sound strange to ears trained in Newtonian humanism. Unlike "intervention," which implies that humans act as an external force upon nature and technology, intravention details how humans are entangled with the technological and natural processes that they seek to change and that, in turn, alter them. It is a perfectly acceptable idea in post-Newtonian and para-humanist worldviews. Quantum physics is built on the idea of the deep entanglement of material processes and measurement instruments and physical objects. Likewise, denying humans a God's eye perspective, para-humanism insists that humans do not stand apart or above the world. Human intraventions have drastically changed the material conditions of human life by increasing global warming. And Artificial Intelligence (AI) is a technological intravention by which humans are altering dramatically the trajectory of their symbolic habitat. In short, global warming and AI are products of humanity's intravention in the earth's bio- and technosphere.

Climate and technological change are both marked by risk, uncertainty, and ignorance. We cannot know the unknowable.[1] Differences in context, variability in processes, and creative use of language can make risk and uncertainty more or less deep and more or less vexing. But they cannot eliminate the complementarity of risk and uncertainty. Beyond the rare event we know exists but cannot predict lies the vast terrain of unimagined and unimaginable events, hiding out of sight. The most important unknowns are the unknowable unknowns. Neglecting the troubles of our time, tech utopians like Ray Kurzweil believe that the singularity is almost at hand when humans and AI will merge and solve all

[1] Welch 2022: 198.

of humanity's problems.[2] Benoît Pelopidas wrestles instead with the possibility of a catastrophic crisis confronting humanity in an apocalyptic future of civilizational collapse and species extinction.[3] Undeniably, humanity is in the midst of creating enormous changes in the material and symbolic ecosystems it inhabits, with unfathomable, unintended, and unanticipated consequences.[4] Some know too little and are eagerly trying to learn more. Unwilling to learn more, others are eagerly surrendering to the allure of ignorance.[5] The simple truth is that we just don't know. On the record of the past, this unknowing state gives ample space to a disorienting dread of the unknown and a radical hope in a future that can be grasped only retrospectively.[6]

For Montesquieu the "empire of climate is the first and greatest empire."[7] He was right, especially for our times. A result of human actions, global warming is reshaping land and water, the conventional building blocks of geopolitical theories of international politics. It creates new zones of conflict and new potentials for cooperation. An old adage acquires a new meaning. It is not only "geography" and the physical features of the earth but also "gaiagraphy" and the earth's critical zones that are the world's destiny.[8] Humanity's technological prowess has created another kind of empire that Montesquieu could not imagine in the eighteenth century and that still escapes our imagination in the twenty-first. AI promises to bring transformative changes, including to human language. Humanity's natural and digital ecospheres are wrapped up in the risk-uncertainty conundrum.

Para-humanism is a worldview that places humans in the larger context of other beings. Atmospheric chemist Paul Crutzen's work took seriously the concept of the Anthropocene and the disruptive effects of the human domination of planet earth. Climate change is an issue touching all aspects of human and non-human life. The 2021 Nobel Prize in physics recognized interdisciplinary work documenting and explaining humanity's effects on global climate change.[9] As the human population increased by a factor of four during the last century, the wildlife population declined by 70 percent. Taking a para-humanist perspective, the founder of the Voluntary Human Extinction movement, Les Knight, challenges the benevolent view of human dominance over other species. For him humans are super predators and earth's most invasive and destructive species.[10]

[2] Kurzweil 2024. Crawford 2021: 214–16. [3] Pelopidas 2020. [4] Kolbert 2022: 45.
[5] Lilla 2024. [6] Lear 2006: 7–9, 103–05, 115. [7] Quoted in Deudney 1999: 26.
[8] Arènes *et al.* 2018. Latour and Chakrabarty 2020: 431.
[9] Metz *et al.* 2021. The prize was awarded to Syukuro Manabe, Klaus Hasselmann, and Giorgio Parisi.
[10] Buckley 2022.

The threat humans are posing to the environment is not new. In recent decades DDT, acid rain, the ozone hole, Chernobyl, and other disasters have created growing levels of concern and brought about important changes in human practices and governance. An incessant drumbeat of news reports the effects of extreme climate conditions in all corners of the world. Those reports use "climate change" and "global warming" as synonyms, as I do here. Both are imperfect labels. Climate change does not capture the rising temperatures recorded on our thermometers. And global warming is too soothing a description of the extreme heat and other weather events that are making parts of the globe increasingly uninhabitable, especially for the most vulnerable: the poor, the sick, the very young, and the very old.[11]

Global warming is related to the excessive accumulation of greenhouse gases in the atmosphere, primarily caused by the burning of fossil fuels and the large-scale use of animal stock. As a layperson I take my science from the literature scientists produce for the general public. And I consume the daily news of droughts and fires, melting glaciers and shrinking ice caps, growing ocean acidity, increasing water shortage and crop failure, and the rapid destruction of species. The scientific consensus in environmental science has been expressed forcefully in numerous scientific reports and is repeated in a flood of books published each year: there is a large measure of truth to the claim that human activity causes global warming. Scientific disagreements persist over the speed and amount of change, but not over its reality. Humans have become a geological agent changing earth's basic physical processes. According to journalist Elizabeth Kolbert, Asia's economic rise since 1990, for example, has added about as much carbon dioxide to the atmosphere as did the previous thirty thousand years.[12] The burning of fossil fuels releases greenhouse gases that had been trapped in rocks for hundreds of millions of years. Even if global emissions reach net zero, perhaps by the end of this century, ice caps will continue to melt and sea levels will continue to rise, possibly for hundreds of thousands of years.

In the Anthropocene the natural and the digital worlds are closely linked. The engineering revolution that replaced typewriter with tablet has been transformative. AI is raising the prospect of a radical change in the digital world with unknowable effects. Prediction requires that we know which new technologies and applications are heading our way. But such knowledge would itself most likely allow society to develop that technology right away. On questions of science and technology, we cannot know now what we will

[11] Goodell 2023, 2017, 2010. [12] Kolbert 2022: 35.

learn in the future.[13] The possibility of creating a machine with consciousness is no longer material for science fiction. More imminent and urgent, AI is beginning to introduce basic changes in how humans use language.

American capitalism is accelerating this change. Corporate and government money is pouring into the AI sector at an unprecedented rate. Global spending was 3 billion dollars around 2010 and mushroomed to 80 billion dollars in 2021, half in the US and a quarter in China. Amazon lists 50,000 books with "artificial intelligence" in the title. Computing power dedicated to developing AI models has increased 300,000-fold in less than a decade. To date AI helps with narrow tasks, illustrated by the existence of 200 million apps. Broader tasks still require human involvement. Until 2025, Facebook employed tens of thousands of content moderators.[14] In the interest of accurate representation algorithms were being put through their paces with "reinforcement learning from human feedback" programs, an effort that created about a quarter of a million low-paying jobs worldwide.[15] In the American future, protected by the right to free speech, AI hallucination will join human fabulation.

In the ecosystems of the world, global warming and AI are not external constraints on human action. Instead, they are endogenous to the world's evolution. This contradicts decades of economic analysis that downplayed the costs of economic growth as an "externality," and supports decades of economic analysis that highlighted technological change as the driver of productivity and prosperity. Human mastery of the natural and the digital world has created profound uncertainties about the future. In the nineteenth century, European imperialism combined colonies with coal and created the conditions for economic take-off.[16] In the twentieth century America pushed pervasive industrialization and dynamic technological change at a global scale. In the twenty-first century neither the engine of change nor its consequence can any longer be located in any one part of the world. Global warming and technological transformation of humanity's natural and digital ecosystems are examples of the complementarity of risk and uncertainty.

The capacity of the earth to sustain human encroachments and innovations is unknown.[17] What lies behind many discussions of the climate crisis, writes political scientist Scott Hamilton, is "an unprecedented existential and temporal uncertainty concerning the future of human subjectivity, and of the Earth itself."[18] The same holds for the impact of

[13] Taleb 2007: 173. [14] Mills 2021. X (formerly Twitter) does not.
[15] Lichtblau and Polcano 2023. Metz 2023b. [16] Pommeranz 2000.
[17] Hamilton 2018b: 34.
[18] Hamilton 2019: 610. I use the term "Anthropocene" generically as a description of the human impact on the planet rather than as a specific stratigraphic series that identifies

AI. The uncertainty inherent in the material and symbolic world is compounded by human conduct. Climate scientist Kate Marvel argues that we "may not know what every air molecule or water droplet in the atmosphere is doing, or how they interact with each other, but in isolation, I know exactly which physical laws they must obey. There is no equivalent for human beings . . . people are the greatest uncertainty in climate change."[19] This assessment is shared by many scientists. "The feedbacks that have been identified in the climate system – the ice-albedo feedback, the water vapor feedback, the feedback between temperatures and carbon storage in the permafrost – take small changes to the system and amplify them into much larger forces," writes Kolbert. "Perhaps the most unpredictable feedback of all is the human one . . . It may seem impossible to imagine that a technologically advanced society could choose, in essence, to destroy itself, but that is what we are now in the process of doing."[20] Para-humanism suggests a less anthropocentric formulation. Technological advancement may put conscious "others" next to and perhaps above and beyond humans wrecking themselves and their natural and digital habitats. Unquestionably, radical uncertainties about impending changes in humanity's natural and digital ecosystems make "epistemological modesty" an imperative for every student of world politics.[21]

As an area of concern the environment has entered world politics since the 1970s under many labels that link it to different substantive, technical, and political issues.[22] Nature is big and uncertain. The reinsurance industry estimates that in 2021 more than one half of world GDP depends moderately or greatly on nature, and most of it is uninsured.[23] With weather-related events moving to the top of the list of anticipated risks, denial is no longer an option for the social protection most crave. The environment thus joins all of the basic institutions of the welfare state as an issue that socializes risk on a large scale. To call the federal government an insurance company with an army basically nails it. The research of students of world politics, typically, links questions such as global warming, biodiversity loss, wildfires, and extreme weather events to pressing issues of world politics such as migration, violence, inequality, and the character of political regimes.[24] Existing research describes different

a new layer in the earth's composition, marking a new geological threshold in earth history.

[19] Henderson, C. 2020: 8.

[20] Kolbert 2006: 187. James Lovelock (2019) differs with this grim assessment. He celebrates the arrival of hyper-human AI and the dawning of the "Novacene" as a new era.

[21] Deudney 2018: 226. [22] Biermann *et al.* 2012. Albert 2022. [23] Pauly 2025: 183.

[24] Ip 2025. Javeline 2014: 422.

processes or establishes causal relations between different clusters of variables.[25] Although an important aspect of international relations research is about survival, the question rarely is posed whether ecocide should be included alongside genocide as a basic concern.[26] Students of world politics, for example, have had nothing to say about the ongoing sixth mass extinction in earth history.[27] Instead, most analyses build their arguments on the unquestioned assumption that economic growth and interstate rivalries will continue to shape world politics. Cognizant of the full landscape, Audra Mitchell counters by asking "Is IR Going Extinct?"[28]

It is not. Research has been both problem-focused and critical.[29] Since the end of the Cold War some realists began to focus on new kinds of environmental conflicts. Robert Kaplan, for example, sketched the contours of a "coming anarchy" over scarce water resources, environmental degradation, pandemics, deforestation, soil erosion, air pollution, rising sea levels, destabilizing mass migrations, and political violence.[30] Thomas Homer-Dixon provided careful research that, broadly speaking, supported Kaplan's dystopian vision.[31] And Daniel Deudney has fleshed out a theory of historical security materialism that points to the importance of technogenic change.[32] In the last two decades this research agenda has broadened further. It includes not only the impact of various aspects of climate change on US national security but also the very considerable effects of American fossil-fuel-based defense policy on climate change.[33] Since climate change affects many international regimes (such as trade, health, food, migration, and human rights), during the last two decades liberal analysis has disaggregated these regimes into complexes with many parts that include informal institutions such as the G7 and G20.[34] And as the number of stakeholders in climate change issues has grown, new transnational forms of environmental governance have emerged. To combat the adverse effects of climate change top-down, state-negotiated, universal solutions are increasingly complemented by bottom-up, decentralized, diverse approaches.[35]

But this is only part of the story. Since the end of the Cold War, the issue of environmentally induced mass extinction, including the possible extinction of the human species itself, has not attracted anywhere close to the kind of attention from students of world politics as did the issue of nuclear war during the Cold War. The reason is that para-humanism's sense of being in the world resonates with relational entanglement more than with

[25] Deudney 1999: 25. [26] Müller 2018: 73–75. [27] Kolbert 2014, 2006.
[28] Mitchell 2017. [29] Cox 1981. Corry and Stevenson 2018: 8–9. [30] Kaplan 1994.
[31] Homer-Dixon 1999. [32] Deudney 2000, 2018. [33] Crawford 2022.
[34] Young 1989, 1999, 2017. Young and Osherenko 1993. [35] Underdal 2017.

Newtonian and Hobbesian sovereign autonomy. The state became autonomy's embodiment, the core construct of an atomistic and non-relational way of looking at world politics. Anarchy, not holarchy, became the core construct, and the very concept of the Anthropocene was virtually unknown among scholars of world politics.[36] To cite one example, the 2015 annual meeting of the International Studies Association featured 6,000 presentations. Only one paper title mentioned the Anthropocene explicitly.[37] A 2018 keyword search of "Anthropocene" in four leading journals returned no results.[38] While IR scholars largely agree that the most important issue facing the world is global climate change, fewer than 3 percent of about four thousand scholars surveyed listed that issue as their main area of research. This is not to deny that many students of world politics are doing important work in transdisciplinary institutions and publish their findings in interdisciplinary journals. And there are important exceptions. David Welch's thought-provoking book, for example, discusses different kinds of security threats. Welch starts with the one he considers to be most serious, the threat to the world's "ecosphere."[39] An eclectic thinker, Welch is a staunch Newtonian who is open to para-humanist arguments.[40] On questions of global warming, he blends traditional IR analysis with a more encompassing para-humanism, marked by the risk-uncertainty conundrum.[41]

Like the earlier discussions of financial and nuclear crises, this chapter applies arguments developed in the opening chapters of this book. The entangled relations of humanity's natural and digital ecosystems are discussed in terms of the risk-uncertainty conundrum. The discussion focuses on global warming from the perspective of the small world of geoengineering, with a particular focus on geothermal energy, marine geoengineering, and the political economy of mitigation and adaptation (section 1). It inquires into the large world of the biosphere, Anthropocene, and uncertainties created by the overlay of human and geological time (section 2). And it scrutinizes the technosphere, consciousness, and language as humanity's arguably most important cultural technology (section 3).

[36] Epstein 2022: 173–75. [37] Harrington 2016: 486–87.

[38] The journals were *International Organization*, *International Studies Quarterly*, *Review of International Political Economy*, and *World Politics*. I would like to thank Naomi Egel for her research assistance. It should be noted that keyword searches are not totally accurate, and things have begun to change. For example, Bentley Allan published two important articles in *ISQ* and *IO* in 2017 that address the Anthropocene (2017a and 2017b). See also Harrington 2016: 487; Green and Hale 2017.

[39] Welch 2022: 47–54, 57–62, 193. [40] Welch 2022: 14–15.

[41] Chandler *et al.* 2024. Hickmann *et al.* 2018. Müller 2018.

1. The Small World of Climate Change: Geoengineering

Students of world politics conventionally thought of the environment as a discrete issue that creates collective action problems. Doing nothing was not an option. Presenting the evidence in a series of authoritative meetings and reports, since the 1970s scientists have convinced publics and policy makers to take global warming seriously. But as Bentley Allan writes, although "they did not eliminate large uncertainties concerning the magnitude, timing, and consequences of global warming . . . scientists proved influential in setting the agenda not necessarily because they reduced uncertainties by converting them into calculable risks, but because they articulated climate change as a security problem with uncertain, potentially catastrophic consequences."[42] In the 1980s controversies over nuclear winter and the ozone hole raised the possibility of humanity's extinction. "Humans might find themselves unable to adapt to unanticipated changes in unstable natural systems. Thus, scientists depicted climate change as a security threat by . . . depicting uncertain futures driven by humanity's relationship with nature."[43] From global freeze to global warming, the nature of the threat changed, the risk-uncertainty conundrum did not.

Conceiving of the earth as a collection of knowable ecosystems that human activities have helped shape points to a small world of calculable risk. The idea of an inscrutable earth "fighting back violently" suggests a large world of deep uncertainty. Preferring to leave "external diseconomies" out of their models, economists move in a small world of calculable risk. But environmental costs are not an "externality." From the perspective of para-humanism they have always been an "internality." The winner of the 2018 Nobel Prize in economics, William Nordhaus, was one of the first to recognize this. He developed precise models for predicting the costs of climate change. But his Harvard colleague Martin Weitzman warned against false precision in predictions. The acidification of oceans, for example, has increased by 26 percent from preindustrial levels; it is now projected to increase by 170 percent by the year 2100 with unknowable, uncertain consequences. Annual economic costs may run in the hundreds of billions of dollars worldwide, or much more, or much less.[44] Nobody knows. Cataclysmic, "black swan" events remain worryingly possible in statistical distributions with fat tails. So do entirely unknowable happenings for which there are no statistical distributions. In the face of risk and uncertainty conventional cost-benefit analysis is extremely fragile. "We desperately need more information about what's going on in these tails,"

[42] Allan 2017a: 809. [43] Allan 2017a: 810. [44] Harrington 2016: 480–81.

Weitzman argued. "It's not the median values that are gonna kill us."[45] Despite its innovativeness and importance, the Nordhaus model probably underestimates the speed and havoc of climate change, oversimplifies the problem, and underestimates its unpredictability.[46]

A 2009 landmark report by the Royal Society provided a now widely accepted definition of geoengineering as "the deliberate large-scale manipulation of the planetary environment to counteract anthropocentric climate change."[47] Proposals for large-scale experiments place their bets on science as the master of nature and on humanity as separate from the world around it. Large-scale experiments seeking to contain global warming, proposed but not yet implemented, would notch an unambiguous victory for "the mechanical conception of nature and the parallel emergence of philosophies built on the idea of the autonomous rational subject exercising control over an inert environment."[48] But such experiments cannot reduce the unknowability of the unintended and unanticipated system-wide effects they would produce. This limitation creates political barriers for their enactment. Still, politics is often unpredictable itself, creating also unexpected opportunities. Geoengineers can work with nature in a pragmatic process of muddling-through. Worldwide, many smaller-scale experimentations engage pragmatically with climate change. Efforts to slow global warming thus create new relations between energy-hungry humans and the very ground they stand on.

It is easy to overdraw the distinction between small world risk and large world uncertainty. The American home insurance industry, for example, is affected by both. The devastating fires that demolished several parts of Los Angeles in January 2025 raise vexing questions of how to insure homes, and not only in California. The question is not whether but when large swaths of Miami's real estate will become uninsurable. Many working in the field of geoengineering are fully aware of the uncertainties involved, especially when simple models are aggregated into broader systems that specify nine planetary boundaries that keep the earth safe.[49] A stable and resilient earth system and human well-being in a just society are increasingly linked in one encompassing framework. In fact, the findings of one study published in 2023 conclude that human well-being in a just society imposes more constraints on a stable earth system than does the climate.[50] Geoengineering coupled with social engineering thus faces all aspects of the risk-uncertainty conundrum.[51] An indispensable corrective to catastrophizing, geoengineering highlights

[45] *The Economist* 2019: 68. [46] DePillis 2022. [47] Sheppard *et al.* 2009: 1.
[48] Hamilton 2013a: 56. Hobden 2018: 112–15. [49] Steffen *et al.* 2015.
[50] Rockström *et al.* 2023. [51] Corry and Kornbech 2024.

what Taleb calls the antifragile gains from uncertainty-induced disorder.[52] Antifragility does not live through theories and models but through practices trying to solve problems. It is a way of living with and exploiting uncertainties that refuse to be tamed. Forward-looking, opportunistic, non-predictive action seeks to gain from an upside that is bigger than uncertainty's downside. For philosopher Edmund Husserl "to live is always to live-in-certainty-of-the-world . . . actually experiencing [*erleben*] and actually effecting the ontic certainty of the world."[53] No longer. "Ontic certainty" is receding. Today, the practices and experiences of everyday life are tightly coupled with the uncertainties of planet earth's evolution and in vastly larger temporal coordinates than Husserl envisaged.

Before the 1950s, climate referred to local or regional weather patterns. Today it refers to one geophysical system. This change was not preordained. As Bentley Allan shows, the study of climate could have taken a broader, bioecological form.[54] Instead, it was influenced by how in the 1950s and 1960s the Cold War shaped relations between scientists and the US state. For reasons of national security, the Defense Department was interested in weather modification and climate control. The discursive frame and experimental findings were humanist Newtonian and produced a geophysical understanding of "the climate" as an object of scientific interest and policy concern. Climate came to be thought of as a vast machine. In Allan's words the "core of climate models is a geophysical, determinist system that links easily to the idea that these forces can be understood, predicted, and controlled."[55] The weather thus was turned into a thing. Geophysical processes became subject of a global infrastructure of measurement and observation involving sensors, satellites, computer simulations, and models. This transformed them into objects of governance by scientific institutions, NGOs, national governments, and international institutions.[56] By contrast, biological and ecological sciences built their models around complexity theory. The climate is composed of non-linear, volatile, and unpredictable processes that are embedded in the whole biosphere. It is conceptualized as a set of interlocking subsystems marked by threshold effects and feedback loops. Nature is not a pristine, unmoved, and balanced landscape that exists apart from humankind. Instead, writes political scientist Cameron Harrington, the universe is "undergoing a process of creative becoming" that is beyond human control.[57] Geophysical approaches treat contexts of

[52] Taleb 2012: 3–27, 212–14. [53] Quoted in Chakrabarty 2018: 30. [54] Allan 2017b.
[55] Allan 2017b: 147. [56] Corry 2020: 431. Allan 2017b: 147–52.
[57] Harrington 2016: 488.

climate change as more homogeneous and processes as less variable than do biological and ecological approaches.

Earth System Science (ESS) is an interdisciplinary, comprehensive approach to the study of the environment.[58] It integrates various earth and life sciences and tracks the co-evolution of earth's four "geospheres" – atmosphere (air), hydrosphere (water), cryosphere (ice), and lithosphere (crust) – as four "coupled systems" that are linked to the encompassing biosphere (life).[59] Relying on ESS, proponents of geoengineering see in global warming both crisis and opportunity.[60] According to political scientist Scott Hamilton, at times they express a "techno-enthusiasm," the latest example of a "Promethean plan for ultimate control" over nature.[61] To the critics of geoengineering carbon dioxide removal from the atmosphere or ocean and solar radiation management look like a large-scale technocratic response to the anthropogenic effects that are producing global warming. ESS offers a broad tent for many different approaches coping with the risk-uncertainty conundrum. Often information and knowledge are scarce or non-existing. Carbon capture in gas- or coal-fired power stations, for example, requires yet unknown means by which to store the captured carbon. Seeding the oceans with iron might be one possible partial solution. Encouraging the growth of plankton, which takes carbon dioxide out of the atmosphere and to the bottom of the ocean, might be another. Solar radiation management would seek to reduce the amount of sunlight that warms the earth's atmosphere, for example by launching mirrors or parasols into space to deflect the sun's rays or by pumping sunlight-reflecting sulfur particles into the earth's upper atmosphere. The unintended and unanticipated consequences of such interventions are unknown and often unknowable. An interdisciplinary, international group of environmental and social scientists concluded that new technologies "promise significant benefits, but also pose major risks for sustainable development."[62] The risk terminology is misleading. Scientific experiments and studies are still all too rare. And nobody knows what would happen if such interventions were implemented at scale. Geoengineering is a promising and fraught undertaking as it grapples with the risk-uncertainty conundrum.[63]

[58] Hardt 2024.
[59] Hamilton, C. 2017: 9–10, 12–14, 63. Rockström *et al.* 2009. Hanusch and Biermann 2020.
[60] Lundershausen 2018. Welch 2022: 83–90. [61] Hamilton 2013b: 110–11.
[62] Biermann *et al.* 2012: 1306.
[63] Hobden 2018: 100–02. For reasons of length this chapter does not discuss fusion and hydrogen technologies that also offer the prospect of almost unlimited clean energy. See Hiller 2023, Plumer 2023b, and Reed 2022.

This may explain why it finds growing support even in unexpected quarters. Stuart Brand is an icon of the American environmental movement and creator and long-time editor of the *Whole Earth Catalog*. He is also a fervent advocate of all things Green. Relying on the best science and technology he can find, Brand discusses three coping mechanisms for dealing with global warming: more cities, more nuclear energy, and more genetic engineering.[64] And because of the inability and unwillingness of states and societies to modify their accustomed patterns of behavior, he is also an advocate of experimenting with geoengineering approaches to deal with the consequences of climate change. He argues that if Plan A fails, there needs to be a Plan B. Following his inclination the interest in geoengineering has skyrocketed. The Open Science Conference, which occurs every decade, virtually ignored geoengineering in 2011. Reflecting a shift in thinking, a decade later there were hundreds of papers, talks, and posters on the same subject.[65] For example, in 2024 a field experiment off the northeastern coast of Australia attempted to brighten low-altitude clouds to deflect sunlight and cool the waters around the Great Barrier Reef; Israel tested solar radiation and is getting ready to build a parasol prototype eventually to be tethered to a satellite or asteroid; Massachusetts has experimented with artificially lowering the acidity of water around Martha's Vineyard; and the national oil company of the United Arab Emirates explored pumping carbon dioxide down into the rocks of the Hajar mountains.[66] Given the risk-uncertainty conundrum, Brand argues that we cannot do without "planet craft," understood as both skill and cunning.[67]

Not everybody is on board. Seeding the atmosphere with sulfates to deflect sunlight, for example, might intensify widespread droughts that would affect hundreds of millions of people. It might also reduce the effectiveness of solar panels. And large-scale stratospheric injection would have to be maintained for many years until other solutions were found. Any interruption in this approach would lead to a very rapid and disruptive rise in temperatures, putting much greater stress on ecosystems and societies than a more gradual increase. These are only some of the reasons why a movement that opposes the development of such technologies has grown rapidly since 2022. Unavoidably, geoengineering is political.[68] Its proponents sometimes seem to believe, unrealistically, in the existence of a single global planner, in the efficacy of existing power hierarchies, and in the emergence of a viable global governance regime.

[64] Brand 2009. [65] *The Economist* 2023a: 67–69.
[66] Niiler 2024. Buckley 2024. *The Economist* 2023b: 3–4.
[67] Brand 2009: 283–90. See also Robock 2008. Hamilton, C. 2017a: 21–27.
[68] Gardiner 2010. Hobden 2018: 105–07.

Or they nurture the hope that a pragmatist, precautionary understanding will evolve in existing international fora such as the UN Environmental Assembly (UNEA). It has not and, in the foreseeable future, will not. The technical obstacles to some of these proposals are formidable; the political ones, for now, are insurmountable.[69]

Geothermal Energy

The development of geothermal energy since 2001 offers a good illustration that surprise is always built into politics even when it unfolds in the small world of risk. This story starts, paradoxically, with the advent and growth of hydraulic fracking technology: the injection of large volumes of water and sand, mixed with chemical additives, into low-permeability subsurface formations (and, increasingly, deeper formations) so as to increase the flow of oil and natural gas.[70] Powered by technological advances made by small oil-drilling firms since the 1970s, between 2000 and 2019 the boom in hydraulic fracking enabled the US to become the world's leading producer of oil and natural gas, thus adding to the competitiveness of fossil fuels and intensifying and extending the process of global warming.[71] Fracking can cause localized earthquakes. It contributes to the overuse and erasure of local water resources. It is a source of water contamination.[72] And it increases natural gas production that accelerates global warming.[73] From the beginning, fracking was a politically controversial practice facing pushback from environmentalists, local communities, scientists, and policy makers.[74]

The rapid improvement of fracking technology has opened the door to new ways of tapping into the earth's massive geothermal energy resources. All of a sudden there was a new way to reach the wellsprings of high temperature spaces and harness them to generate clean, renewable energy. Some early developments occurred in California in the 1960s.[75] But a rapid and more widespread expansion started around 2010, with the influx of stimulus money as part of the federal government's unrelated rescue efforts after the 2008 financial crisis. This investment powered the deployment of fracking technology for geothermal ends. Activity tapered off around 2016, only to start up again in 2020.[76]

[69] Lovelock 2009: 139–58. McLaren and Corry 2021: 24.
[70] U.S. Department of Energy 2011.
[71] Eliot and Santiago 2019. U.S. Department of Energy 2019, 2013.
[72] Environmental Protection Agency 2021. U.S. Energy Information Administration 2021. Nevola 2012.
[73] Chamberlin *et al.* 2016. [74] Nevola 2012. [75] U.S. Department of Energy 2013.
[76] Roberts, S. 2020. Yergin 2021.

The basic idea of geothermal exploration is to utilize very hot areas of underground water.[77] Fracking is employed to drill into these hydrothermal resources, expand them, and either inject extra water that powers steam turbines or draw up the steam from already existing reservoirs.[78] Thus, steam is used to generate energy. In places where extractable hydrothermal resources are available, writes science journalist Siobhan Roberts, "geothermal can provide always-on, baseload power; it is the only renewable resource to do so."[79] Geothermal fracking differs in important ways from the fracking involved in oil and gas production. For one, there is no traceback to natural gas production plants and the inevitable leakages that occur, thus eliminating one point of environmental concern. The energy generated by geothermal plants does not require expensive and damaging production processes; it is ready-to-go and on demand. In addition, while most geothermal plants that currently exist require a separate power source to operate, technology is being developed that enables such plants as closed-loop energy systems to be entirely self-sustaining while meeting local power demand.[80] While some preliminary evidence indicates that it may be small, uncertainty over levels of seismic activity caused by geothermal fracking persists.[81] But water depletion and contamination concerns generally do not apply in the case of geothermal. The technology recycles the water it uses without chemical additives.[82]

Geothermal energy is a case study in economist Albert Hirschman's "reform-mongering": the repurposing of interests and, in this case, technology for the realization of aims opposite to those originally intended.[83] The geothermal case illustrates how uncertainty characterizes the complex relations between humans and the subterranean sources of energy they experiment with. Important technological developments occurred before a reform-mongering process got off the ground. To be sure, in the form of hot springs, geysers, and fumaroles geothermal energy has been available to humans for thousands of years. As journalist David Roberts writes, "there's enough energy in the earth's crust, just a few miles down, to power all of human civilization for thousands of years to come."[84] The decay of naturally deteriorating radioactive elements that occurs around the earth's molten-hot core means that this source of heat is renewable and intrinsically self-sustaining.[85] The difficult issue for start-ups, university labs, interested oil

[77] Biello 2008. Siobhan Roberts (2020) helpfully subdivides innovations in geothermal into four main types: conventional, enhanced geothermal systems (EGS), hot-rocks, and advanced geothermal systems (AGS).
[78] U.S. Department of Energy 2019. Dhanesha 2022. [79] Roberts, S. 2020.
[80] Yuan *et al.* 2021. Eavor 2019. [81] Patel 2009. [82] Roberts, S. 2020.
[83] Hirschman 1963. Torracinta 2021. [84] Roberts, D. 2020.
[85] U.S. Department of Energy 2019.

and gas corporations, and governments has been how, exactly, to utilize this renewable energy on a large scale.[86]

Geothermal energy offers a promising model for the future. Drawing water from hot spaces below the earth's surface and cycling it in closed-loop systems for the generation of clean energy creates a symbiotic image of humans interacting seamlessly with nature in a way that is sustainable and life-supporting. Building political support for this technology, however, is far from easy. As part of the Biden administration's environmental policy, the fossil fuel industry backed direct air capture technology, vacuuming pollution after it had been put in the atmosphere. Its funding of $1.2 billion exceeded by a factor of twenty-five the $84 million for advanced geothermal.[87] Still, an innovation in fossil fuel technology that many had viewed as a scourge of local communities and a source of global warming is being repurposed. Unsurprisingly, both oil and gas companies and proponents of clean energy back this technology. Once the rallying cry of conservatives supporting the fossil fuel industry, "Drill, Baby, Drill" has acquired a new meaning.[88] Fossil fuel corporations see new profits, their critics the potential for on-demand renewable energy.[89] These surprising bedfellows have created a new politics of reform. Based on the assumption that humankind can control nature and extract its resources without harmful consequences, fracking, unexpectedly, provides one escape from Promethean hubris. It is not the only one. Hirschman insisted that it is impossible to predict the emergent pathways of reform-mongering. For better and for worse uncertainty reigns also in parts of the small world of risk.

Marine Geoengineering

About 70 percent of the earth's surface is water, with oceans containing more than 95 percent of it. Warmer air holds more water and warms the oceans. Excess carbon dioxide in the atmosphere gets absorbed by ocean water and turns the oceans more acidic, more so in the next few decades than during the past 300 million years. Higher air temperatures increase evaporation and higher atmospheric water content increases uneven rainfall. Some areas will suffer from droughts, lower crop yields, more hydroelectric interruptions, land degradation, diminished livelihood opportunities, hunger, desertification, and human migration. Other areas will experience major floods, soil erosion, water pollution, infrastructure and residential area losses, and increased diseases. Antarctica's glaciers, ice caps, and ice sheets

[86] Biello 2008, 2011, 2013. [87] Davenport 2023. Plumer 2023b. [88] Plumer 2023a.
[89] Roberts, D. 2020.

will shrink during this century. This will lead to a rise in sea levels threatening scores of island states, metropolitan areas, seaside communities, wetland and coastal plains, and wildlife habitats. If the Thwaites Glacier disintegrates it will cause more than a 2-foot rise in sea levels worldwide. Its collapse could destabilize the entire West Antarctic Ice Sheet, and that could cause a 10-foot jump in global sea levels. Thwaites is one of the biggest wild cards in the deck of global warming, the largest known unknown that will decide what happens to thousands of coastal communities in all parts of the world.[90] Since the first Earth Summit convened in Rio de Janeiro in 1992, the Arctic ice cap has shrunk by 40 percent. Heat may lead to mass drownings.

Marine geoengineering places its bet on human technical prowess in mitigating and adapting to global warming. This optimism about human ingenuity is reinforced by corporate interest in future profits to be reaped from the "Blue Acceleration" and the "New Blue Economy." Optimism and economic interest have combined in the call for a "Blue New Deal."[91] Even though oceans have long been a site of extraction and accumulation, as arenas of geoengineering they remain a relatively unexplored frontier. Marine geoengineering centers on investments in what are frequently called "negative emissions technologies." Policy discussions were spurred by two papers published by two Nobel laureates in 1996: economist Thomas Schelling and meteorologist and atmospheric chemist Paul Crutzen.[92] Schelling saw future geoengineering technologies as a relatively conflict-free way to address the looming climate crisis within the small world of risk. He referred to geoengineering as the marshalling of "intentional … technologies of intervention."[93] Crutzen made the case for creating a human-made escape from climate catastrophe. Deploying the concept of the Anthropocene, Crutzen sought out niches of risk provided by geoengineering in the large world of uncertainty.[94] In marine geoengineering this means focusing on carbon dioxide removal (CDR).

Maritime law took note.[95] Adopted in 2006, the London Protocol was amended in 2013 to include statements concerning geoengineering. It was updated in 2022 to address directly, albeit incompletely, the issue of marine geoengineering.[96] Additionally, a UN-sponsored group of scientists and scientific organizations released in 2019 a "High Level Review of a Wide Range of Proposed Marine Geoengineering Techniques."[97] These statements offer no more than a "patchwork" framework for global

[90] Rush 2022. [91] Armstrong 2022. Rifkin 2024. [92] Schelling 1996b. Crutzen 1996.
[93] Schelling 1996b: 304.
[94] Crutzen and Stoermer 2000. Crutzen 2002. Sheppard *et al.* 2009: 1.
[95] Mendenhall 2019. See also Brent *et al.* 2019.
[96] Brent *et al.* 2019. For the 2022 update see bit.ly/3H11Te5, accessed 05/17/24.
[97] Boyd and Vivian 2019b.

governance.[98] Many issues remain unaddressed.[99] For example, once relegated to a strip along their coastlines, states' off-shore jurisdiction now extends to the edge of the continental shelf, covers areas far below the ocean's surface, and incorporates the above-ocean airspace.[100] Most pertinent for the deployment of marine geoengineering are "exclusive economic zones" (EEZ), areas in which a state has exclusive rights over the use of all marine resources.[101] The prospects for an internationally agreed upon "Blue New Deal" seem politically extremely limited.[102]

Oceans are a natural carbon sink. They absorb about 25 to 30 percent of carbon emissions in the atmosphere and roughly 90 percent of the heat generated by them.[103] Compared to the world's forests, oceans absorb about four times more carbon.[104] The main purpose of marine geoengineering is to develop technologies to mitigate the carbon emissions from fossil fuels. It is a form of risk management that relies on technological control over natural water processes. Many of the technical possibilities fall under the heading CDR.[105] Adding compounds like iron to the ocean, called Ocean Iron Fertilization, will increase phytoplankton growth and accelerate carbon sequestration.[106] Storing carbon under the ocean seabed is an alternative technology.[107] In both of these procedures, humans are controlling natural processes to mitigate excessive levels of carbon emissions. Subject of much discussion, such ideas and plans point to the possibility of humans finding a way to save themselves from negative climate consequences under conditions of radical uncertainty with unforeseeable geopolitical consequences.[108]

Short in supply is confidence-inducing, established science supporting many of the proposed techniques, when applied at scale.[109] And there is little knowledge about how to regulate the unforeseen negative consequences they might have.[110] Comprehensively tested evidence for any of the CDR techniques currently under consideration is missing, and the need for systematic, viable, and generally accepted studies is urgent.[111] Several studies have pointed to "major gaps" in scientific knowledge or a "widespread knowledge gap" in the evaluation of the technology's effectiveness.[112] In the absence of important information, regulations and procedures remain contested on related issues such as deep sea mining.[113] Comedian John Oliver addressed the issue with passion and

[98] Brent *et al.* 2019: vii–viii. [99] Mendenhall 2019.
[100] Mendenhall 2019. See also DeSombre 2018. [101] Mendenhall 2019: 34.
[102] Elizabeth Mendenhall, personal email to the author, 04/07/24.
[103] United Nations Environment Programme 2022. [104] Jones 2019.
[105] Sheppard *et al.* 2009: 16–19. [106] Jones 2019. [107] Amon *et al.* 2022.
[108] Espinosa 2022. [109] Amon *et al.* 2022. [110] Boyd and Vivian 2019a: 156.
[111] Boyd and Vivian 2019a. [112] Sheppard *et al.* 2009. Boyd and Vivian 2019b: 12.
[113] Pickens *et al.* 2024.

disdain for companies like Australia's The Metals Company, which is poised to start deep sea mining in the Clarion-Clipperton Zone that stretches 3 miles below the surface of the Pacific Ocean, from Mexico to Hawaii. With the effects of deep sea mining largely unknown, Oliver pleads for a moratorium that would protect this "mind-blowing vast, virtually unknown world within our world" until science has caught up.[114] Here, too, the risk-uncertainty conundrum is inescapable.

If these technologies were to be implemented by unilateral state action, it would intensify an increasing competition over exclusive state controls over the world's oceans. The "Blue Acceleration" is a "race among diverse and often competing interests for ocean food, material, and space."[115] States are seeking ways to industrialize the oceans and find advantages in their competition with other states. Duplicating the conflict over land in the traditional international system, the "Anthropocene Ocean" is becoming the new frontier in the competition over power and wealth.[116] With about two-thirds of the world's ocean still beyond sovereign claims, the competitive race for new water rights could be intense – a twenty-first-century oceanic enclosure movement somewhat reminiscent of eighteenth- and nineteenth-century England's enclosure of the commons. Then "sheep ate men";[117] now "men eat fish"… and more. And that race would not be constrained by the existing, weak international governance frameworks that regulate the "common heritage" of humankind, challenged by growing calls for "saving the planet from global warming."[118]

Marine geoengineering can be placed in a critical theoretical perspective that goes beyond conventional discussions of technology and geopolitics.[119] Highlighting the risk-uncertainty conundrum, it yields insights not unlike Hirschman's reform-mongering perspective on geothermal energy. Prasenjit Duara's "waterscape" analyzes "how human endeavor" shapes the movement of water while water shapes the possibilities of human and planetary life.[120] He develops a perspective of all water – including oceans, rivers, streams, lakes, and ponds – as a commons without regard for state borders, dams, embankments, and other means of human control.[121] States and corporations adhere to an "abstract," institutionalized conception of water as material that can be channeled, controlled, deployed, and represented in terms of specific chemical properties and constructed flows. Such abstractions elide the ways in which water is an indelible part of both socio-political and natural processes. More accurately understood as a "cycle," water's constant flow, absorption, and movement in all parts of planet earth

[114] Horton 2024. [115] Jouffray *et al.* 2020: 43. [116] Jouffray *et al.* 2020: 48–50.
[117] Jouffray *et al.* 2020: 49. [118] Buck 2012: 257. [119] Duara 2024.
[120] Duara 2024: 1. [121] Duara 2024: 6–8.

underwrite the possibility of life itself.[122] Drawing on Sartre's concept of "counter-finality," Duara's waterscape describes the ways in which human labor, such as marine geoengineering, makes and remakes nature. A new state of the hydrological cycle continues to source life while also introducing new uncertainty into the life it sources.[123] Based on the assumption that contexts are homogeneous and processes are stable, risk-based views of water see it as a separate part of nature that humans seek to exploit and control. Left out is the work of local communities, living in heterogeneous contexts and under variable processes. With experimentation they harness the uncertainties humans introduce into the hydrological cycle and improvise to discover alternative ways of living, relying on language that is world-making.

Jerome Whitington's anthropological study of hydropower in Laos illustrates with rich descriptive detail the production of uncertainty and the improvisational experimentation it sets free.[124] Humans act on and entwine themselves with nature in relations so complex that actual ecological relations become uncertain, impossible to know and predict – just as Ulrich Beck's analysis of modern risk societies suggests.[125] In Laos this manufacturing of uncertainty conditions both national capitalist development and local community responses.[126] In Whitington's "postnatural ecologies," nature has been altered by large dams.[127] Corporate and state-supported technical development and planning operate, like marine geoengineering, as if full mastery of nature were possible. The reality on, speaking inaccurately, the ground, is that no one really knows enough, and everyone must experiment and improvise with innovative practices to continue to live amid fluctuating ecologies.[128] Rivers can be anthropogenic, illustrating the complementarity of risk and uncertainty while reminding us of the sources of creativity called forth, unintentionally, by the human urge to control and exploit nature.

Mitigation and Adaptation at Home and Abroad

News about mitigation of and adaptation to climate change is not good. Despite more than $10 trillion of global investment in renewable energy since 2015, fossil fuels continue to provide 80 percent of global energy consumption. For the foreseeable future the goals set in the 2015 Paris Agreement are out of reach.[129] Facing an existential threat, some activists favor declaring a global climate emergency followed by dramatic action. For a very short time, this might achieve astounding results. For example,

[122] Duara 2024: 8–12. [123] Duara 2024: 8. [124] Whitington 2019.
[125] Beck 1992, 1999. [126] Whitington 2019: x. [127] Whitington 2019: xii, 19.
[128] Whitington 2019: 8–9. [129] Koonin 2024.

during the 2008 Beijing Olympics, local carbon dioxide emissions declined by half. The Chinese government shut down heavily polluting factories; halted major construction projects; and restricted automobile use.[130] Applied on a global scale, rule by emergency decree most likely would give the power to a few individuals in a few powerful states. A technocratic elite would be entrusted to solve a pressing problem, without concern for the plurality of political players, divergent goals of human well-being, and insistent justice concerns that are part and parcel of environmental sustainability. Furthermore, technocratic policy would have to choose among alternatives with often unknown and unknowable consequences. China's authoritarian politics may have succeeded for a year in Beijing. But an emergency decree approach "with a Chinese face" is not going to work in a politically diverse world coping with environmental challenges for many decades and centuries to come. Even without an explicitly authoritarian gloss, technocracy by itself also lacks appeal. Directed foremost against the use of aerosols to shield the earth from the sun, since 2022 support for a solar geoengineering moratorium or non-use agreement has spread even among some former supporters of planetary solar management.[131] Opposition to a technocratic mitigation approach, developed and potentially applied by a few powerful states, illustrates the depth of the political backlash. Under conditions of accelerating climate change, the politics of mitigation and adaptation will not look anything like top-down authoritarian or technocratic governance models.

As I argued in Chapter 3 models are a way of telling stories, here about the mitigation of climate change, stories that are characteristic of the small world of risk. Modelers simplify their stories and are good at predicting the likely consequences of specific outcomes, such as the effects of concentrations of greenhouse gases on increasing temperatures. Based on that knowledge they then make specific policy recommendations about the limits of aggregate emissions, how much fossil fuel should stay in the ground or be recaptured, and what price will create the right incentives for consumption and investment. However, a review of the effects of carbon pricing on greenhouse gas emissions points to the sobering conclusion that those effects were negligible.[132] Price, it seems, is not the only relevant factor. Many additional kinds of complementary interventions are needed, interventions that often escape the proposed model. Furthermore, the price effect of carbon on society and technology is

[130] Javeline 2014: 424.
[131] www.solargeoeng.org/NON-USE-AGREEMENT/, accessed 05/12/24. Bernstein 2023: 641.
[132] Green 2021.

unknown. And an economically rational price is politically unrealistic in the time frame available to meet specific climate targets. Social, economic, and political uncertainties thus intensify climate uncertainties.

Similarly serious problems occur in the modeling of carbon budgets.[133] Depending on the assumptions made, these models can lead to very different results and run up against many different kinds of uncertainty in the climate system which are in turn compounded by the uncertainties of societal choices. Different models of carbon budgets rely on different definitions of probability, and on samples that are often too small to generate reliable statistical results. "Carbon budgets," Glen Peters concludes, "are uncertain. There is no magic number that describes the mitigation challenge."[134] This, however, may short-change the importance of models. In finance, as discussed in Chapter 4, models operate like metaphorical language. They not only represent the world, fitting facts to predictions. They also re-present the world, in performances that can change the world. If they convince they can change human practices to help bring about the world they predict. Illustrating the risk-uncertainty conundrum, this social aspect of modeling is true also of climate and AI.

In the 1980s the greatest concern was not global warming but nuclear winter – the potentially disastrous cooling of the earth's surface due to smoke clouds generated by a global thermonuclear war. Recent climate models have shown that even a limited nuclear war of ten weapons, targeted at cities which then would burn, could trigger conditions approximating nuclear winter.[135] With the nuclear doomsday clock now set closer to midnight than ever before, the prospect of nuclear war remains an undeniable fact of world politics in an era of growing international tensions. Yet current discussions of climate change proceed as though the threat of nuclear war does not exist.

This is a useful reminder of the limitations of climate science and its models. Martin Weitzman describes climate models as an immense cascade of huge uncertainties of truly stupendous scale and scope, and long chains of tenuous inferences fraught with huge uncertainties in every link.[136] In line with that assessment, we must avoid, writes Geoff Mann, "trying to fabricate precision out of desperation, or calculating just because we can . . . The struggle is to find a sweet spot between illusory exactitude and unhelpful handwaving."[137] The range of many parameter values in climate models is unknown or unknowable and so are the shapes

[133] Peters 2018. [134] Peters 2018: 380.
[135] Jacobs 2022: 184. Assuming, realistically, a larger number of deployed nuclear weapons, Blight and Lang (2018: 106–10) offer much higher estimates – billions of casualties for a large global nuclear war and tens of millions for a small regional war.
[136] Quoted in Mann 2023. [137] Mann 2023.

and distributions of the probability functions that are being modeled. Black swans are omnipresent. Furthermore, models typically rely on historical data and hence on the assumption that underlying natural and social processes are stationary, a dubious assumption at best. Estimates of population growth, for example, are difficult and variable. We know, however, that rates of population growth are plummeting. The most recent predictions of the world's population by the end of the century have been lowered by 1 billion. If power consumption per capita is estimated at about 4 kilowatts, then a drop in world population by 1 billion people would be a saving of about 4 terawatts of power, the equivalent of about 4,000 nuclear reactors and 400,000 of the largest existing wind turbines.[138] Although this is not nothing, we really do not know how much it is of something. And fat tails in statistical distributions make the current professional consensus in climate science overly optimistic by magnitudes that are also unknown and unknowable.[139] All the talk of probabilities typically conceals unmeasurable uncertainty and points to the ineluctable political contestations and choices that will shape the future. For better and for worse human judgment may trump computation. Climate models are useful in clarifying assumptions and specifying the questions that need to be asked. But in these models, as in AI, probability is little more than a faith-producing language. Models are often tested, as in AI, on hundreds of thousands of computer runs. To the question what kinds of uncertainties humanity will tolerate, Monte Carlo simulations will not give the answer. Politics will.

The risk-uncertainty conundrum also plays a major role in the politics of adaptation. Temperature changes have been sufficiently large so that even the most intense mitigation policies will not stop global warming. Adaptation means less vulnerability and more resilience in heterogeneous contexts and under variable processes, operating at multiple scales across different sectors. Open to human whims and follies, it is expected to last for decades. Its efficacy, feasibility, cost, and fairness are very controversial. Adaptation requires making difficult political choices about myriads of critical issues such as infrastructure, land and crop use, transportation systems, industry, urban development, biodiversity, and the protection of coastlines. Should New York or Miami get the seawall or more pumps? The weak and vulnerable are likely to lose out in the coming political struggles.

The politics of adaptation are shaped by the carbon lock-in that grips all industrial economies.[140] Lock-in is the result of the co-evolution of economic, technological, and institutional factors supporting the fossil

[138] Zellman Wahrhaft, email conversation, 02/7/24. [139] Mann 2023.
[140] Unruh 2000.

fuel industry. "Helping to sell the future" the oil and gas industry is at the center of the carbon lock-in.[141] Political choices and conflicts are "wicked," defined by a ticking clock, the absence of central authority, people who cause the problem remaining in charge of solving it, and the irrational pushing of the problem out of sight as the future comes into clear focus.[142] Competing strategies of "degrowth" and "green growth" are part and parcel of the political fight over loosening or breaking carbon lock-in.[143] Green industrial policy points to an acceleration of decarbonization fraught with the revival of international political conflicts, especially between the US and China, not seen since the rise of Japan in the 1970s and 1980s.[144] Speaking with forked tongue, business leaders are eagerly practicing the new jargon of "derisking" in the hope of getting government insurance for the torrent of private capital they promise to unleash. Plain and simple, this is a brazen attempt to create a make-believe world of risk out of thin air to ask for vast subsidies to secure investments with uncertain prospects.[145]

Rather than take on the carbon lock-in with a top-down approach, decarbonization strategies rely also on decentralized, experimental approaches in both international and domestic politics. Between 1990 and 2009 a centralized global climate regime was based on treaties negotiated between states and modeled after the trade and other international regimes. After a dozen fruitless, post-Kyoto (1997) years of political stalemate, the hope for a global regime was dashed by the failed 2009 Copenhagen negotiations. Instead of binding agreements Copenhagen introduced nationally based commitments as a substitute for collectively agreed reductions in greenhouse gas emissions. The 2015 Paris Agreement shifted gears further by focusing on states pledging to emission reduction goals they would specify themselves but which international organizations would monitor and verify. All states must cumulatively contribute to reduce greenhouse gas emissions. This new system relies on a bottom-up method of "climate clubs" as "building blocks." But as Charles Sabel and David Victor argue, given high levels of uncertainty about climate, such a bottom-up approach will work only if it operates under institutions that are not as politically blocked as the UN system.[146] Self-reinforcing, decentralized systems can work only under some restrictive conditions, including reliable review and assessment, a robust system of pledging, and the capacity to sanction persistently uncooperative actors. Put differently, experimentation via decentralization cannot do

141 Green *et al.* 2022. Beckert 2024.
142 Auld *et al.* 2021: 709–12. Rittel and Webber 1973.
143 Mann 2022. Nahm and Wallace 2024. Meckling and Nahm 2022. Stokes 2020.
144 Allan *et al.* 2021. 145 Eich 2024b.
146 Sabel and Victor 2017a, 2017b. Dorf and Sabel 1998. Sabel and Zeitlin 2010.

without some form of reintegration. Local experience and learning by forerunners need to be filtered up to higher-level comprehension by an institutionalized center that is non-directive but facilitates explicit rather than tacit learning. This would enhance the dynamic capacity of the decentralized climate complex that is sharing information and lessons under conditions of uncertainty. The EU and some of its member states model such arrangements. It remains an open question whether the European model is replicable at the global level or within other regions of the world.

The 2015 Paris Agreement sent a strong signal that decarbonization would depend on the choices of states as well as sub- and non-state actors. Catalytic non-state and sub-state actors are dedicated to the disruption of power configurations defending fossil fuels. Municipalities and transnational city networks have been the cutting edge of experimental initiatives. Decarbonization and breaking carbon lock-in are two sides of the same coin. Steven Bernstein and Matthew Hoffmann propose three political mechanisms effecting normative change, mobilizing resources for different practices and policies, and building new coalitions.[147] These mechanisms generate different disruptive trajectories to deal with carbon lock-in: unintentional reinforcement, improvement in efficiency gains in carbon systems, and transformational decarbonization. The three mechanisms are stipulated to act interactively across different levels of politics and different issue areas.[148] Over a period of several decades interactive mechanisms could create significant change in the social and political processes that affect adaptation. For now, however, it is impossible to make reliable predictions about how these mechanisms will work and what effect they will have in different contexts.[149] David Wallace-Wells has made a strong case that the climate future currently looks like a muddle of contested choices that will probably avoid the extreme outcomes of a total stop of or a total surrender to global warming.[150] In this adaptation of the story of Goldilocks and the three bears to the politics of climate adaptation, and in line with the risk-uncertainty conundrum, pretty much everything is uncertain. In line with this story, international relations scholars Tanisha Fazal and Page Fortna conclude with admirable candor that in the twenty-first century the effects of climate change in world politics will require "getting a lot more comfortable with uncertainty . . . studying the political effects of climate change will require an epistemological turn among positivists in particular."[151]

[147] Bernstein and Hoffmann 2018, 2019.
[148] Colgan *et al.* 2021. Grubert and Hastings-Simon 2022. [149] Busby 2024: 46–47.
[150] Wallace-Wells 2022. Soloski 2024. [151] Fazal and Fortna 2024: 30.

2. The Large World of the Biosphere: Anthropocene and Time

Gaia, globe, planet, earth, call it what you will, the whole is a series of contingently changing relations entangling biosphere, humans, societies, and states.[152] The sciences do not provide us with governance rules rooted in Nature's laws which we discover from afar, taking a God's eye view. We are proximate knowers, observing and acting from inside the world, not gazing at it from the outside. And we adjust our knowledge and practices as the situation changes and as the evidence requires. Doing any kind of science and practicing any kind of governance occurs in the context of a world that allows and encourages some and prohibits and discourages other ways of thinking and acting.[153] The complementarity of risk and uncertainty resonates with the warning in Haydn's opera *Orfeo* and its world-ending tempest. In the words of the opera's promotion for its 2023 North American premiere: "All's not fair in love and war. Nature always wins."[154] Bruno Latour concurs. "Earth has become – become again! – an active, local, limited, sensitive, fragile, quaking, and easily tickled envelope."[155] That "new-old" condition in earth history creates novel uncertainties in human history.

Biosphere and Anthropocene

Is the earth a planet with unchanging conditions as described by geophysicists and geochemists or is it changing as astrobiologists argue? Through their incessant actions organisms affect air, soil, water, and the climate. Like humans, organisms rearrange everything around themselves, modifying their surroundings to suit their own purpose. If true, this is a world of distributed agency filled with non-intentional adaptations and uncertainties. Earth's biosphere, conventionally thought of as stable, passive, and inert, is unstable, active, and mobile, marked by multiple processes and agents operating across different temporal scales.[156] The sustainability and habitability of the earth are evoking two different temporalities.[157] There is no holistic totality for planet earth. Yet no part exists apart from the whole. Human intervention cannot return earth to its accustomed track. For earth history is a process of variable and contingent happenings that preserve the

[152] Latour 2017. Kurki 2020: 166. [153] Kurki 2020: 8. Latour 2014: 2, 5.
[154] The credit goes to the brilliant production's director Nico Krell.
[155] Latour 2014: 3. [156] Latour 2017: 91–93, 99–101, 105. Welch 2022: 66.
[157] Chakrabarty 2019: 17–23, 25–26.

potentiality of unpredictable futures. Stretching our vision beyond humanist Newtonianism, para-humanism and the Anthropocene illuminate a broader picture rendered by Gaia theory. Across different time scales global warming is a cascade of the unexpected.[158]

The contested concept of the Anthropocene captures the environmental effects of human action on planet earth. The traditional language of "Mother Earth" expresses the familiar and reassuring notion of a sheltering and protective earth that is quiescent, the language of "Gaia" the novel and unsettling one of a vengeful and destructive planet that is coming alive. This is not the first time that a name was invented to capture the idea of humans altering earth. In the 1870s Italian geologist Antonio Stoppani argued that human activities were ushering in a new "anthropozoic era." What is novel about the concept of the Anthropocene is the idea of radical rupture. In the 1920s two Soviet scientists, geochemist Vladimir Vernadsky and geologist Alexei Pavlov, developed that idea.[159] They recognized that by converting solar energy, life was a force shaping the biosphere of the earth.

In our times James Lovelock has developed that idea further. His key insight is that the earth's biosphere and life are deeply entangled and co-evolving processes. "Life on our planet does not simply experience the weather," writes journalist Ferris Jabr, "it creates it."[160] Life evolves on earth because earth is suitable for life and in so doing, it also changes earth. It has become a "formidable geological force ... We and other living creatures are more than inhabitants of Earth. We *are* Earth ... The history of life on Earth is the history of life's remaking Earth."[161] Thus living creatures participate in their own evolution. In contrast to other planets such as Mars and Venus, the earth possesses a biosphere that is not in an inhospitable-to-life chemical equilibrium. It exists instead in a dynamically steady state conducive to life. A specific proportion of oxygen and carbon dioxide in the atmosphere stopped the earth from becoming a dead planet. In the future astronomers' search for chemical disequilibria in the universe might discover earth-like planetary-scale biospheres and perhaps intelligent alien species.

Lovelock and Margulis developed this idea in the form of "Gaia" theory. Life creates chemical states impossible in planets without life. In the earth's biosphere organic and inorganic organisms incessantly and recursively interact to form a complex, evolving system of life. The evolution of life and planet earth is one deeply entangled process. Microbial ecosystems, not humans, are central to that process. According to one estimate "Earth's total plant roots stretch to a surface

[158] Latour 2017: 95–97, 107. [159] Frank 2024. [160] Jabr 2024: 26.
[161] Jabr 2024: 27.

area 35 times larger than the entire surface of planet Earth; microbes, taken collectively, to the equivalent to 200 Earth areas."[162] The weathering of rock has been a central aspect of life. For hundreds of millions of years plants have pumped carbon dioxide from the air into rocks. Mineral evolution depends on biological evolution. Without the work done by living organisms, earth's evolution, Lovelock argues, remains inexplicable.[163] The new discipline of astrobiology postulates that life on earth uses planet earth for its own ends. And earth is just one of up to 10 billion trillion habitable worlds in the universe.[164]

Because Lovelock's key insight can be inferred only from indirect evidence, his reliance on often poetic metaphors has provided plenty of ammunition for his critics.[165] Many earth scientists dismiss Gaia theory. The idea of a homeostatic earth system, they claim, has not survived scientific scrutiny. Reminiscent of Solow ripping into Soros on the issue of finance, the critics argue that Gaia theory is badly specified, poorly modeled, inconsistent with accepted facts, and unnecessary since alternative explanations are readily available. Adherents of ESS in fields such as geophysics, geophysiology, and geochemistry scoff at bioecological models. More sympathetic critics acknowledge that the data remain inconclusive and that Gaia theory awaits further specification and more rigorous testing. But they concede that it has been helpful in stimulating public debate and awareness. Criticism is often aimed not at the theory itself but at its interpretation of the planet as a planetary superorganism with spiritual implications. This has nothing to do with Lovelock's scientific theory that views the evolution of organisms and their material environment as so deeply entangled that they form one indivisible process.[166] In fact, Gaia theory's general vision was brought into detailed focus by the transdisciplinary work in ESS.[167] Embedding existing geophysical models in a more encompassing bioecological system perspective does not invalidate either. It does, however, make the results of models look less stable, smooth, and linear especially if the time scale is enlarged from human to geological time. Policy recommendations derived from ESS may have to put more value on precautionary measures rather than matching policies with precise targets.[168]

The effects of human activity on the various ecological systems of the earth have created a rupture so profound as to initiate what many non-specialists believe to be a new geological epoch.[169] This has given rise to an entirely new kind of anthropocentrism that highlights how the future of

[162] Jabr 2024. [163] Lovelock 2016. Margulis 1999. [164] Frank 2024.
[165] Welch 2022: 61, 72–75. Chakrabarty 2019: 14–16, 25–26.
[166] Latour 2017: 100–01. [167] Frank 2024. [168] Allan 2017b: 132, 152–53.
[169] Hamilton, C. 2017: 50–59, 89–90. Corry 2018.

the planet has come to depend on human practices. For geologist Jan Zalasiewicz it is impossible "to understand the Anthropocene without understanding people."[170] The relevance of geological time for developments occurring in human time is a source of unnerving uncertainty. How should one evaluate data about the acceleration of global warming during recent decades when the basis of comparison might be centuries, millennia, millions or hundreds of millions of years?[171] With its different temporalities, the Anthropocene raises difficult questions, points to tantalizing ideas, and restates the complementarity of risk and uncertainty in a new way.

With global warming as a highly visible marker, many agree that the earth is entering a new geological era. Earth's biosphere is not an inert repository that operates according to laws humans can manipulate to their advantage.[172] In the Anthropocene humans are geological agents who are placed *in* the world. Their activities create forces that enmesh earth and humans through new biophysical factors devoid of human purpose.[173] Everything is simultaneously both natural and social – and often unpredictable. "Albert Einstein," John McNeill writes, "famously refused to believe that 'God plays dice with the world.' But in the twentieth century, humankind has begun to play dice with the planet, without knowing all the rules of the game."[174] Climate change is not a fight between Man and Nature. Carbon dioxide is not a pollutant that intrudes into the atmosphere, destabilizing the natural order. Rather, nature and humans are deeply entangled. With the world changing, so most likely will the human species. Creating deep uncertainties, "the fate of the one determines the fate of the other."[175]

The Politics of Dating and Naming

The move from the Pleistocene or ice age to the rapidly warming Holocene occurred about 10,000 years ago. Besides a change in the amount of carbon dioxide in the atmosphere, it was caused by the orbital relationship between earth and sun. As a result, temperatures stabilized in a range that permitted grass to grow. A fluke of nature, call it a long summer, prepared the ground for the agricultural revolution as a stepping-stone for the growth of human civilizations and empires.[176] In the transition to the Anthropocene humans did not change the

[170] Quoted in Biello 2016: 61. [171] Hausfather 2023. [172] Hamilton, C. 2017: 38.
[173] Harrington 2016: 479, 482, 490–91. Hamilton 2019. Connolly 2019: 7.
[174] McNeill 2000: 3.
[175] Zalasiewicz *et al.* 2010: 2231, quoted in Harrington 2016: 489, fn 41.
[176] Chakrabarty 2009: 200–01, 206, 208, 217–18.

relationships between earth and sun. But since the onset of the industrial revolution, they have burned fossil fuel at an accelerating rate, releasing greenhouse gases that had been trapped in rocks for hundreds of millions of years.

Dating the onset of the Anthropocene as a successor to the about 10,000 years of the Holocene remains a subject of controversy among stratigraphers and geologists.[177] Some argue that the Anthropocene began at some point between 12,000 and 2,000 years ago, possibly as far back as the onset of the Holocene.[178] Others date its onset to the fifteenth century and the discovery of the New World. Still others locate it in the second half of the twentieth century, which experienced nuclear testing and the "Great Acceleration" of worldwide industrialization. Between 1960 and the end of the twentieth century the world population doubled while the global economy grew by a factor of fifteen. With the number of cars increasing from about 40 million in 1945 to about 700 million by century's end, fossil fuel consumption increased sharply.[179] Paul Crutzen points to the late eighteenth century when, according to the analysis of air trapped in polar ice, growing concentrations of carbon dioxide and methane started to appear. And some date the Anthropocene's onset with two geologically defined "golden spikes" marking global atmospheric carbon dioxide concentrations: 1610 (due to very high death rates of the world's population induced by the Plague and the mortality-spiking colonization of the Americas) and 1964 (the maximum global deposition of radionuclide carbon-14 atoms from nuclear bombs tested after 1945).[180] This debate about continuity and rupture in the concept's application is generational and unavoidably political. It is also scientific. In 2008 the Stratigraphy Commission of the Geological Society of London announced the end of one geological epoch, the Holocene, and the beginning of a new one, the Anthropocene.[181] The report of a group that started its work in 2009 concluded in 2023 that renaming was warranted. Its recommendation was voted down in 2024 by a committee of the International Union of Geological Sciences in charge of deciding the start of a new geological era.[182] Whether the Anthropocene is an epoch – longer than a geological age but shorter than a geological era – remains a matter of scientific disagreement that

[177] Biello 2016: 43–46. [178] Newell and Lane 2018: 136, 141–42.
[179] Steffen *et al.* 2007: 617. Harrington 2016: 483–84.
[180] Lewis and Maslin 2015. Hamilton 2018b: 45; 2019: 614. Chakrabarty 2018: 19–20. Masco 2021: 18, 34–38.
[181] Newell and Lane 2018: 140–41. [182] Zhong 2024. Piltz 2024.

is unlikely to be resolved soon. With far lower stakes, debates about the naming of the Holocene took about half a century.[183]

What precisely constitutes a rupture in planetary and world history is never clear. The choice of an earlier starting date makes it plausible to view global warming as gradual and normal; the choice of a later one assigns responsibility for carbon dioxide emissions to those who most accelerated and benefitted from that process.[184] In the spirit of para-humanism, a recent manifesto is calling for a new kind of planetary politics. It asks for a less state- and human-centric approach, thus stepping outside and beyond established understandings of international and global politics. The manifesto reckons with the possibility of ecological collapse and acknowledges the inherently social nature of the Anthropocene.[185] Critics were quick to point out that this declaration could easily be interpreted as still another call for more global governance.[186] Despite the unifying label of a planetary politics, humanity remains deeply divided along lines of sex, race, class, religion, and region.[187] In the critics' view, the Anthropocene was created by the stronger segments of humanity that have benefitted most from the changes that led to global warming; and it is the weaker ones that are paying the highest price. Climate change thus is tied up indelibly with political power, specifically the great divergence between Europe and Asia in the nineteenth century. Incremental approaches to the "management" and "governance" of the environment do not catch the political forces generated by processes that warrant the naming of a new geological era.[188] Why not, ask the critics, call the Anthropocene a Capitalocene,[189] a Eurocene,[190] or a Plantationocene?[191]

There is more at stake in public debates than the dating and naming of a geological era. "The real challenge," Milja Kurki writes, "is facing the assumption many of us embrace when we come to climate as an 'external' event to be 'controlled' . . . [a]n inherent need to manage, to unify, to make orderly a world of many, so many others . . . The Anthropos of the Anthropocene trots confidently on the 'world stage'."[192] He seeks to exercise control, waving aside humility as a personal, fear-driven attitude that leads to paralyzing passivity. But the ecosystems of the earth are not external constraints. Created by humans, like other organisms they are

[183] Chakrabarty 2009: 209.
[184] Lane 2016: 118. Chakrabarty 2018: 6, 19. Harrington 2016: 483. Newell and Lane 2018: 144.
[185] Burke *et al.* 2016: 510. [186] Chandler *et al.* 2017. [187] McEwan 2024.
[188] Harrington 2016: 463. Hamilton 2019: 611. Chakrabarty 2018: 11–12.
[189] Moore 2015: 169–92. [190] Grove 2019. [191] Wolford 2021. Haraway *et al.* 2016.
[192] Kurki 2020: 7.

endogenous to the earth's evolution.[193] The spread of human control over a supposedly passive earth, with all its risks, and the activation of the earth's dormant forces, with all its uncertainties, are inseparable parts of one reality.[194] Humans' once far-reaching control over nature is boomeranging back, revealing profound uncertainties.

Everywhere the political response is experimentation. The quality of an experimental politics is affected by actors' variable awareness of the risk-uncertainty conundrum. Driven by profits and power, a reactive politics tends to discount uncertainty. Profoundly aware of fragile ecologies, a circumspect politics does not. Peter Frankopan's conclusion of his encyclopedic global history of the transformation of the earth amplifies this point. He lists many dire challenges and many amazing opportunities, summing to uncertainties galore on every page.[195] Earth is evolving with often unknown and unknowable effects on humankind and the universe at large – the risk-uncertainty conundrum in action.[196]

This is not a perspective shared by many students of world politics. For them Hobbes's state of nature is the central trope, based on the premise of a categorical difference between natural processes (objects) and human agents (subjects). The scientific revolution of the seventeenth century established the foundation for the discovery of the laws of nature.[197] Existing apart from man, those laws waited for human discovery. Knowledge became the master of nature. In this humanist Newtonian view, nature, personified as Mother Earth, contains the bounty of life.[198] Applied to international relations, it is a world of discrete entities (peoples and states) that move mechanically and predictably (balances of power and trade), viewed against backgrounds (resources and the environment). As a species, humans are exceptional. They are intelligent agents in charge of figuring things out, including how to preserve life on earth. Understood as object or metaphor, the natural world exists as mere background to world politics.[199] In a contrasting view, the Anthropocene, today the natural world holds center stage. The past no longer serves as a reliable guide for predicting earth's future. Instead of inert matter that is moved by mechanical laws, earth is a self-regulating bioecological system.[200] No place on earth can any longer be considered "natural." For nature has become a man-made artifice. Nature is not clearly separated from society, and neither are the natural and the social sciences. Everybody and everything are sitting in the same boat.

[193] Dryzek 2016: 940.
[194] Hamilton, C. 2017: 47–48, 85. Latour 2014. Mitchell 2017. Kelly 2019: 17.
[195] Frankopan 2023: 641–58.
[196] *The Economist* 2020. Pelopidas 2020. Mitchell 2019. [197] Latour 2014: 5.
[198] Harrington 2016: 488. [199] Kurki 2020: 3–4. [200] Lovelock 2006; 2009: 159–87.

Time

One of the mystical configurations of life's continuity is time. At one end of the time scale, the life cycle of stars is measured in millions or billions of years. Black holes can hang around for googol years – the number 1 followed by 100 zeroes. At the other end, some estimates hold that there could be as many as a million trillion chemical reactions occurring every second in each of the 36 trillion cells that constitute a human being. "To say 'I contain multitudes' is a whopping understatement."[201] In the Anthropocene, time is not given but produced by scientific discoveries, public debates, and technologies of measurement that cut history into different temporal units.[202] Over several centuries Western clock time established its unquestioned hegemony. Discussions of global warming are beginning to change that. The long horizon of climate science emphasizes changes that humans cannot adjust to easily in their natural and social environments. For Dipesh Chakrabarty time is becoming a source of "deep contradiction and confusion."[203] This intensifies the sense of uncertainty that surrounds the politics of global warming.

The Anthropocene invokes two different temporalities.[204] Planetary history is "deep" and measured in geological time. World history is "recorded" and calculated in human time. Planetary history is measured in millions, tens of millions, and hundreds of millions of years, world history in years, decades, centuries, and millennia.[205] With the arrival of the Anthropocene the two temporalities are engaged in "constant conceptual traffic."[206] Until recently, in human time the environment changed so slowly that humans' relation to planetary history was timeless. In the Anthropocene, however, conceptions of the environment as a static condition or a repetitive cycle of seasonal variation give way to the notion of unpredictable tipping points that can spell human disaster when measured in human time.[207] But in politics world history pushes aside planetary history. The novel condition of grappling with two different senses of time compounds the uncertainties that surround scientific and political discussions of possible mitigation and adaptation policies. Those discussions, however, have done little to undermine the growing agreement about important anthropogenic effects on global warming. Planetary history and world history are converging.[208] History can no longer be "limited to the domain of human history; it must be a *planetary history*,

[201] Overbye 2023. [202] Hom 2010. Allan 2017a: 818. [203] Chakrabarty 2009: 198.
[204] Latour and Chakrabarty 2020. Chakrabarty 2009, 2019. Harrington 2016: 495. Kelly 2019: 17–28. Leakey and Lewin 1996: 6.
[205] Hamilton 2013b: 195–98. [206] Chakrabarty 2018: 6, 20–21. Bjornerud 2020.
[207] Chakrabarty 2009: 205. Müller 2018: 70. [208] Hamilton, C. 2017: 4, 6–9.

a narrative of human-Earth history."[209] This novel conjoining creates a history that is end-directed without being end-seeking.[210]

The impact of humans on the planet is no longer told as occurring only in intervals measured in geological time that are "empty" of power and responsibility. In recent times humans have intervened so forcefully in the biosphere's oxygen-carbon cycle as to threaten the very existence of humanity. In a few centuries they have released into the atmosphere enormous amounts of carbon. Between 1990 and 2020, global GDP increased by a factor of four leading to a dramatic increase in fossil fuel consumption. Today some Hawaiian rocks are made of lava and plastic.[211] Despite growing awareness of a possibly existential threat and the onset of various mitigation policies, this economic growth spurt greatly accelerates global warming.[212] Current species extinction rates, furthermore, are 1,000 times greater than previous background rates. And future rates may grow by another order of magnitude. Up to 30 percent of all mammal, bird, and amphibian species are currently threatened with extinction. The last time rates were this high was 66 million years ago, during the fifth mass extinction.[213]

In para-humanism, humans are viewed as a species and are understood in biological rather than in cultural terms. Humanists of all persuasions believe instead in personhood. In the words of political theorist Dipesh Chakrabarty, this is "no less of a reduction of or an abstraction from the embodied and whole human being than, say, the human skeleton discussed in an anatomy class."[214] Species thinking slights human personhood. It points to contingent developments, fateful human choices, and unanticipated consequences. Industrialization, decolonization, and capitalism have created a shared but differentiated responsibility for global warming.[215] A mammal species engaged in practices that may lead to its own extinction is a first. Defying the logic of Darwinian evolution, this gives rise to new uncertainties.

Since the Anthropocene is no more than the blink of an eye in geological time, from today's vantage point planetary history is stationary. But in Peter Frankopan's story, climate is the bridge on which geological and human time meet.[216] The Khmer empire, to take one example, did not withstand the ecological pressures created by droughts and strong monsoons. The eruptions of the Okmok volcano in Alaska 43 BCE led to a sharp drop of temperatures in southern Europe and northern Africa which helped Rome conquer Egypt and secure its empire. Plentiful rain

[209] Hamilton, C. 2017: 119. [210] Hamilton, C. 2017: 122. [211] Latour 2017: 120.
[212] *DER SPIEGEL* 2023a: 114. [213] Harrington 2016: 492–95.
[214] Chakrabarty 2009: 215. [215] Chakrabarty 2009: 213–20. [216] Frankopan 2023.

in the thirteenth century increased Mongolian pasture land and the number of horses, that era's intercontinental missile, with which Genghis Khan conquered much of Eurasia. The French Revolution erupted after a very cold winter and a very wet spring. Climate made the lives of the poor even more miserable and fueled revolutionary resistance against the king of France. And since the end of the Cold War, during the era of neoliberalism and globalization, Asia's economic rise increased global GDP massively, releasing an enormous amount of greenhouse gases.

Human time is defined by "the space of experience" and "the horizon of expectation." Experience is "the past made present," expectation "the future made present."[217] Since neither past nor future are ever fixed, experience and expectation are always open to surprise. For Reinhart Koselleck "it is the tension between experience and expectation that, in ever-changing patterns, brings about new resolutions" and thus generates hopes, anxieties, and precautionary planning as integral parts of human time.[218] With few exceptions, such as the Jurassic age, geological time does not generate comparable emotional reactions. Although without it human life would be inconceivable, humans are not moved by the oxygenation that occurred 2.5 billion years ago. Compared to human time, the emotional register of planetary time is empty. Astronomy, physics, and astrobiology deal with time spans that are unimaginably long and altogether different from the scale of human time.[219] In those vast horizons human experience and expectations cease to operate. Yet, pushing against the boundary parameters of human existence, the Anthropocene presses humans to consider organizing themselves according to the inexorable dictates of life's unfolding planetary history. In the conjoining of earth and human time, that invitation will receive unpredictable answers fed by innovations made in the small world of risk and generating new kinds of uncertainties. Evoking geological time, the Anthropocene thus puts the risk-uncertainty conundrum in a large world context.

3. Technosphere, Consciousness, and Language in the Era of AI

What is true of biospheres also holds for technospheres. Vernadsky heralded the arrival of the "noosphere," dominated by human thought. Lovelock followed Vernadsky and articulated the idea of the "Novacene"

[217] Koselleck 1985: 267–88. [218] Koselleck 1985: 275.
[219] Chakrabarty 2018: 17, 22–23.

as a successor to the Anthropocene at the dawn of what he sees as an age of hyperintelligence.[220] In the words of astrophysicist Adam Frank "a technosphere is the planetary-scale activity of a technology-building species."[221] In the present era of AI it is shaped by bold human intravention in the remaking of humanity's digital and symbolic world.

Technosphere

Co-evolving with the earth's biosphere in human time, the technosphere encompasses all energy-consuming information, transportation, and production networks spanning the globe. Understood in terms of information and perhaps even knowledge, planetary intelligence can be said to be emerging from that co-evolution in a complex, self-creating, self-organizing, self-maintaining adaptive system marked by information sharing, distributed cognition, and a form of collective knowing of planetary-scale viability in geological time, not unlike E. O. Wilson's ant colonies and some microbial communities activating bacterial "quorum sensing," or the fungal networks among trees in human time described in Chapter 2.[222] Humans create cultural energy and consciousness that greatly enhance the complexity of the energy-harvesting technosphere with powerful climate change effects for the planet. This is not unlike the biosphere's effect on the four geospheres, moving ever closer to unknown thresholds and possible civilizational collapse in a few centuries – a seeming eternity in human time and a mere blink in geological time. Planetary intelligence requires technospheres that last and flourish in the geological time scale of biospheres. In the first part of this chapter I have described some early, halting, and contested efforts. Expressed as metaphor or guiding principle, planetary intelligence acknowledges that sentience exists across the biosphere in many different forms that include the human one. Astrophysicist Adam Frank insists that we are entering new territory "in the stories we tell about what we know and who knows it … There is an epistemic pluralism inherent in the planetary because it recognizes that phenomena can always be seen from multiple standpoints."[223] Multiple perspectives mean multiple scales. Proponents of local, concrete perspectives differ from and will resist incorporation by supporters of global and disembodied ones.

AI is becoming the most rapidly developing part of the world's technosphere. The range of its application is unknowable.[224] Google's DeepMind created a chess computer program called AlphaZero that revolutionized

[220] Kolbert 2006. Biello 2016: 53–56. Chakrabarty 2018: 7. Lovelock 2019.
[221] Frank 2024. [222] Frank 2024. [223] Frank 2024.
[224] Fortson 2019. *The Economist* 2022a, 2022b. Metz 2023a. Huang 2023. Metz and Weise 2023c. Roose 2022, 2023. Whang 2023.

the game of chess in 2017 if grandmaster Garry Kasparov is to be believed. In 2018 five experienced lawyers and an AI program were asked to read contracts and pick out loopholes. AI was more accurate (94 percent compared to 85 percent) and quicker (26 seconds compared to 93 minutes). The consequences of this technological development for labor markets will be enormous. The accountancy firm PwC estimates that in the next fifteen years one third of all British jobs will be automated away. As was true between 1980 and 2010, tens of millions of new jobs will be created, many of lower quality, requiring fewer skills, and paying lower wages.[225]

This is just the beginning. The largest companies are in a race to introduce new products. Since 2019 Microsoft has invested $13 billion in OpenAI, a San Francisco based company valued in 2023 at about $80 billion.[226] It pioneered the wildly popular GPT-3 (Generative Pretrained Transformers) app in November 2022, soon thereafter updated by a vastly superior GPT-4 version trained on 100 times more text. The head of Microsoft estimates that by 2026 as much as 10 percent of all new data on the world wide web will be AI-generated. Google hopes to rival GPT's performance with its Gemini software. Google's DALL-E 2 app, also introduced in 2022, lets a user create photo-realistic images, not by creating compounds of existing internet images but by simply describing what they want to see. Google-owned Alphabet announced in the summer of 2022 that an app called AlphaFold had predicted almost all of the 200 million proteins known to exist. This new data source will soon help researchers to develop new drugs and vaccines. All of this is a dizzying change from yesteryear's technological revolution. We have accepted such change as new technologies make their way into our lives. Often we have no choice. We live in an era of surveillance, orchestrated by Silicon Valley in the US and Europe, and by the Communist Party in China. Private information is a free good that is harvested anonymously to make individual behavior more predictable and profitable for Silicon Valley corporations and politically controllable by China's Communist Party.[227] When new technologies are useful, we no longer call them "artificial." Instead, we accept that they are augmenting our intelligence.

The effect of AI on climate change is uncertain. It is possible that AI could expand people's virtual lives in ways that lessens the load they put on the biosphere.[228] Zoom calls are energy-efficient substitutes for air traffic and land transportation. But the human urge to spend time in digital worlds will also increase environmental pressures. Measuring the

[225] Fortson 2019. Metz and Weise 2023c.
[226] Jin and Kruppa 2023. Metz and Weise 2023a, 2023b. Weise *et al.* 2023a, 2023b. Satariano 2023.
[227] Zuboff 2019. [228] Rillig *et al.* 2023.

climate impact of AI is in its infancy.[229] Blurry lines separate what can be calculated from what cannot. We know, however, that AI is not artificial in the sense of being disembodied. It requires natural resources, labor, and data which it frames, categorizes, and manipulates to serve human purposes and power. "The real stakes of AI," writes AI specialist Kate Crawford, "are the global interconnected systems of extraction and power, not the technocratic imaginaries of artificiality, abstraction and automation. To understand AI for what it is, we need to see the structures of power it serves."[230]

Energy consumption in the use and training of AI is a good example. Discrete log-ons and interactions with ChatGPTs are relatively easy to measure. But with increasing integration of AIs into apps, software programs, browsers, and devices, the impact becomes much harder to trace.[231] By all accounts energy consumption is rising rapidly.[232] The International Energy Agency (IEA) estimates that if ChatGPT were integrated into the 9 billion web searches conducted every day, "the electricity demand would increase by 10 terawatt-hours a year – the amount consumed by about 1.5 million European Union residents."[233] Still in their infancy, AI-produced images are about five times as energy-intensive as text.[234] The training and maintenance of AI models is even more energy-intensive.[235] The power demands of data centers are projected to grow by 160 percent by 2030, accelerating a growth in electricity not seen in decades. Carbon dioxide emissions by power centers will more than double.[236] The CEO of OpenAI, Sam Altman, has warned that AI's growth may soon hit an energy wall.[237] AI's ever-expanding need for data centers with advanced water-based cooling techniques, and nearby access to large amounts of power, may make current energy supplies soon insufficient to meet future demand.[238] This is not to deny the importance of the unknown and unknowable effects of AI on the efficiency of energy production and consumption. Will these effects mitigate or possibly offset altogether AI's energy consumption and negative effect on global warming? AI-equipped "smart houses" might eventually be able to reduce CO_2 consumption by as much as 40 percent.[239] Google has explored how AI might help pilots fly more efficient routes that might result in less pollution.[240] And the U.S. Department of Energy has released guidance

[229] Dhar 2020. Freitag *et al.* 2021. Heikkilä 2022. [230] Crawford 2021: 218.
[231] Gurdeniz and Hosanagar 2023. [232] Ganz 2011.
[233] Calvert 2024. McQuate 2023. Heikkilä 2023. [234] Heikkilä 2023.
[235] Strubell *et al.* 2019. De Vries 2023. Kolbert 2024. Vincent 2024. Luccioni *et al.* 2022. Kaack *et al.* 2022. International Energy Agency 2024.
[236] Goldman Sachs 2024. [237] Dastin 2024. Schwartz *et al.* 2020.
[238] Berreby 2024. Khan 2024. Dotan and Fitch 2024. [239] Berreby 2024.
[240] Elkin and Sanekommu 2023. World Economic Forum 2018.

on how AI might improve the safety and efficiency of the electric grid.[241] While the looming energy wall AI is facing is real, it is currently simply impossible to know how large AI's potential energy efficiencies will be. These difficulties get confounded once one scales the analysis up to the global level. Many of the giant companies involved in making AI devices an everyday reality for consumers have little sense of the environmental impact of their supply chains.[242] The "background networks" underwriting AI are unknown factors operating at a global scale. The complementarity of risk and uncertainty is also evident at the intersection of AI, energy, and national security. Putting AI in charge of the electric grid may lead to harmful effects as AI-trained systems can develop totally unexpected behaviors.[243] At every turn the risk-uncertainty conundrum is evident as the effects of AI on energy consumption and the climate more generally are impossible to gauge.

AI helps us navigate a world of facts. And it can trap us in a world of lies. Early versions of AI were embedded in social media. By selecting those feeds that created the greatest human reaction, AI did not generate content; rather, it curated user-generated content. Simple learning algorithms optimized clicks by manipulating user preferences. For better and for worse, in interacting with algorithms, users reveal their preferences and make their preferences known, bit by bit, and so become more predictable. This use of AI created new human communities, more corporate profits, and an avalanche of fabrications.[244] AI systems talk and write like an adult. It is less clear whether, at this stage, they can learn like a child, meeting the "Turing test" for machine intelligence that the English computer scientist formulated in 1950.[245] But one thing appears to be beyond doubt already – para-humanism becomes an ever-more plausible worldview as the entanglement of humans with machines proliferates.

Rapid progress and the infusion of large amounts of investment capital have convinced a growing number of people working in the AI industry that we have arrived at a transformative moment in the history of technology. Even the greatest boosters in Silicon Valley acknowledge total uncertainty about where this development will end – in a world of abundance or in the destruction of humanity. Riding the crest of Silicon Valley's latest boom one CEO touts AI as "the greatest force for economic empowerment" while conceding that "mitigating the risk of extinction from AI should be a global priority."[246] Should humanity survive, this may

[241] U.S. Department of Energy 2019. [242] Crawford and Joler 2018. [243] Ornes 2023.
[244] Harari *et al.* 2023. [245] Metz 2023a.
[246] Streitfeld 2023: B6. *The Economist* 2023a.

eventually be judged to have been a memorable understatement. The inventors of the nuclear and hydrogen bomb lacked the light touch and care-free attitude with which Silicon Valley entrepreneurs deal with the possibility of a global catastrophe of their own making. Truth be told, evoking the risk-uncertainty conundrum, Henry Kissinger, Eric Schmidt, and Daniel Huttenlocher describe AI as "an entirely novel element of mystery, risk and surprise."[247]

Algorithmic "deep learning" was made possible by advances in AI's neural network architecture and the creation of intensive computational models. The modern equivalent of Crusoe's man Friday, and every student's favorite "Study Buddy," AI agents will soon become for-pay and for-play companions – giving us an opportunity to think afresh in our everyday life about the meaning of Hegel's parable of Master and Slave. These agents can do more than chatting chatbots. They can play games, use software apps, operate online tools, write computer code, and many things we cannot now imagine. Unthinkingly, we will accept the help of algorithms and machines as a "natural" part of human life.[248] The advent of quantum computing in the near future will accelerate greatly the speed and impact of the AI revolution already under way. For better and for worse, AI is becoming an indispensable part of our technosphere. Intelligence is not genetic fate but evolves in the space that connects two forms of life. Artificial Intelligence of machines is becoming the Augmented Intelligence of humans.

Changes in twenty-first-century biology have made it possible to study the effects of habit, experience, and education on highly plastic neural connectors in the human brain. Similarly, the enormous computing power of new "synaptic" chips and general advances in computing power have advanced sufficiently to create powerful AI algorithms.[249] Natural intelligence and synaptic machines have the same basic structure, revealing the plastic character of intelligence and blurring the boundary between humanism and para-humanism. In the development of AI the manufacture of chips that are able to transform themselves by trial and error thus complements the neurobiological revolution of the 1980s. For French philosopher Catherine Malabou "the idea of a machine that is just evolving and adaptive as a neuronal architecture, to the point of being able to simulate it perfectly . . . begins to make complete sense."[250]

This development speaks to the old debate between Hobbes and Leibniz about machines and minds. A strong machine explanation

[247] Kissinger *et al.* 2023. [248] Latour 1993.
[249] Malabou 2019: xv–xvii, 11, 14–16, 59–63, 74–80, 83, 86, 90–91, 99.
[250] Malabou 2019: 15.

stipulates that mind is a temporary artifact, ordinary matter suitably arranged. A strong mind explanation insists that mind is a fundamental element intrinsic to all things but not to be explained by the arrangement of things themselves. Both Hobbes and Leibniz agreed that machines can be intelligent. They disagreed about a machine's license to claim a soul.[251] Turing's work in the 1940s established strong links between the intelligence of machines and evolutionary computing. Like Piaget, for Turing the model for learning was a child searching for solutions by trial and error rather than an adult executing a prearranged program.[252] In systems of distributed intelligence, such as computers, the boundary between ingenuity and intelligence is not hard and fast. Intelligence is collective, the accumulation of random slices of wisdom through the power of making small mistakes. AI is traveling on the same road, yielding astounding practical results while blurring the boundary between human and para-human and pushing us into unknown and unknowable territory.

Consciousness

Rapid advances in AI's development open the possibility of non-human consciousness appearing on the technological horizon. Newtonian humanism relegates the idea of humans creating a "conscious" non-human to the genre of science fiction. But the idea fits quite "naturally" within para-humanism. Viewing humans as a part of the world of sentient and non-sentient beings suggests uncertainties of a new kind. We readily accept that machine intelligence surpasses human intelligence in many domains of calculation. Whether machine intelligence is "creative" and could become "conscious" is becoming a topic of heated discussion. Redefined in terms that place humans in their broader para-human context, technological change adds a new dimension to the risk-uncertainty conundrum.

AI is redefining the relations between man and machine. The future will be shaped by fickle humans deploying unfathomable technologies. Artificial General Intelligence (AGI) looms on the near-term horizon of AI research. It is uncertain when AI will develop the capacity to be self-reflective, that is, develop consciousness.[253] A leading authority, Stuart Russell, thinks it is seventy to eighty years off into the future.[254] Conveying a misleading sense of precision about entirely uncertain prospects, another AI specialist, Ajeya Cotra, in 2022 increased her

[251] Dyson 1997: 50–51. [252] Dyson 1997: 71–73.
[253] Abulof 2023. Seth 2021: 255–75.
[254] Russell 2019. Fortson 2019. Quetteville 2019.

risk assessment of the arrival of transformational AGI by 2036 from 15 to 35 percent.[255] Daniel Kokotjalo headed a unit dealing with product safety at OpenAI. He left the company and organized a public protest against its failing safety standards. In his previous job he initially estimated that AGI would arrive around 2050. Given the rapid progress he now thinks that there is a 50 percent chance that AGI may come as early as 2027. He judges the probability of catastrophic harm to be around 70 percent.[256] Co-winner of the 2024 Nobel Prize in physics, Geoffrey Hinton does not attach any percentage figure to the possibility of AI creating catastrophic harm. But he is profoundly worried about the adverse consequence of AI's unregulated advances. In Silicon Valley P(doom) is the preferred probability estimate of such dire prospects for humanity. It misdescribes unknown and unknowable uncertainty in terms of probability. Like Hinton, who left Google in 2023, many AI researchers are concerned. The collapse of crypto-currency giant FTX in November 2022 pulled its support of about 500 million dollars out of a field misleadingly called "catastrophic AI risk studies."[257] Leaving the purpose of AI unspecified may court disaster in the future.[258] For AGI could fail to "align" its values with human ones.[259] Should AGIs outsmart humans, they will prevail when machine and human purposes diverge. The task, Russell argues, is to build machines that benefit human purposes. But since humans do not know what those purposes are or should be, specifying them for a future AGI is impossible. For Russell, this fundamental uncertainty may be one escape hatch from a world dominated by AGI. The machines could be instructed to come back and ask what to do next.[260]

Admittedly, the obstacles to achieving AGI remain large. When Hod Lipson was an assistant professor at Cornell University in the early 2000s, he could not admit to being interested in computer consciousness lest he risk his chances of receiving tenure. He is now a professor at Columbia, and he believes that enhancing the adaptability of machines is necessary to strengthen their resilience as they are becoming increasingly indispensable for many important tasks. Importing aspects of natural selection into his computer code, Lipson hopes to create a generalizable form of intelligence that can learn about itself. Sidestepping inconclusive philosophical debates, he settles for an operational and functional definition of consciousness: the ability to imagine oneself in the future. Lipson is unclear about how to answer the question "How far into the future?" He wagers

[255] Roose 2022: 6. [256] Roose 2024b. [257] Metz 2022.
[258] Nilsson 2010: 305–27 reviews various arguments that touch on the relation between AI and AGI.
[259] Christian 2020. [260] Quetteville 2019. McConnachie 2019. Fortson 2019.

that this problem will be solved and thinking computers will eventually evolve to understand what they are and imagine what they might become. Most researchers agree that only three groups of animals display behaviors that make the question of consciousness relevant: about 60,000 vertebrates (like mammals), about 600 cephalopods (like octopi), and about 800,000 arthropods (like insects).[261] Philosophers, science fiction writers, and computer scientists are in total disagreement on the issue of computer consciousness. They all agree, however, on one thing: AGI technology is heading into totally uncharted territory.[262]

Consciousness is subjective experience such as seeing, feeling, thinking, acting, and being self-aware. It is closely connected to being alive.[263] For neuroscientist Anil Seth the materiality of life is central for all manifestations of consciousness. Seth reviews some of the evidence of mammalian perceptual worlds and concludes that mammals have dramatically different experiences of "being themselves." Monkeys are undoubtedly conscious, though their consciousness may not be comprehensible to humans – they are transformed into little furry people only by the power that anthropomorphism and anthropocentrism hold over human intuitions.[264] Ed Yong's writings show the different sensory experiences of animals and humans. For him terms like "extra-sensory" or "ultrasound" are little more than anthropocentric affectations. Most mammals can hear well into ultrasound range because they are not limited by the 20 kilohertz upper frequency limit of the average human ear.[265] Lars Chittka has probed the minds of bees. His research has convinced him that bees have consciousness and emotions.[266] Interest has spiked in recent years around specific cephalopods, such as octopi. Anil Seth writes that being with them left him "with an impression of an intelligence, and a conscious presence, very different from any other – and certainly very different from its human incarnation."[267] Octopi interactions with humans can be based on surprisingly deep emotional affinities that have generated their own movie genre. Although positive and negative evidence is sketchy, birds and insects, too, show consciousness.[268] Based on the available evidence, Seth concludes that the way humans experience self and the world is not the only way. Variety marks the subjective experience of different species.[269] With public attitudes changing in support of less consumption of animal meat and more animal rights, farm sanctuaries are committed to rigorously scientific studies of the cognitive and emotional capacities of animals which will enlarge currently scarce data.[270] These examples illustrate that philosophers taking a God's eye view of the problem face serious

[261] *The Economist* 2023c. [262] Whang 2023. Alonso 2023. [263] Seth 2021: 239, 254.
[264] Seth 2021: 239–44. [265] Yong 2022. Szalai 2022. [266] Chittka 2023.
[267] Seth 2021: 246. [268] Welch 2022: 51. [269] Seth 2021: 254.
[270] Anthes 2022b. Grant and Jungkunz 2016: 16–17.

competition. "The quest to understand consciousness," Seth concludes, "places us increasingly within nature, not further apart from it."[271] This is a fitting characterization of para-humanism and also of the complementary relation of risky, small and uncertain, large worlds.

Could machines develop consciousness?[272] It is a mark of the grip of anthropocentrism over our imagination to attribute consciousness to machines only when they perform in ways that somehow resemble humans. There exists difference between a machine behaving as if it were conscious and a machine being conscious. Machines can simulate or mimic consciousness. But machine talk is not proof that machines actually are conscious. If consciousness is defined as a feeling and the experience of a self that is placed in the world, then we currently have no indication that computers have or will have consciousness. In contrast to living organisms that embody both physical and symbolic aspects, machines run on a platform that separates software from hardware.[273] No matter how high their parameter space or how large the dataset they have been trained on, to date machines and algorithms exist in a small world in which problems are well-defined.[274]

Dating back to Galileo and Hobbes the man-as-machine metaphor is an imaginative, world-making metaphor that suggests otherwise. "In a culture of scientism," writes political scientist Jason Blakely, "we poeticize to trick ourselves into making our computing machines appear more like us."[275] Yet it is quite conceivable that machines could bring about a mind-melt between two individuals. In human conversation, a few bits of information are exchanged every second. The brain exchanges about 60 bits per second during specific tasks while another 10 million bits are processed unconsciously. By linking individual brains through computers such information density could be achieved in future relations among humans and machines. The internet with its myriads of complex information-sharing networks thus might eventually also develop its own internal awareness and become conscious.[276] If consciousness exists in degrees among and between different human and non-human beings, why rule out the possibility that in the future some machines or algorithms might develop their own form of consciousness that may be nothing like human consciousness?[277]

Uncertainties about when, where, and how this might happen are compounded by the unpredictability of humans. AI algorithms are learning how to be convincing by sounding convincing and seeming to be

[271] Seth 2021: 275. [272] Seth 2021: 255–75. Metz 2023a. Brooks 2023.
[273] Mitchell 2023. [274] Jaeger 2023: 4. [275] Blakely 2020: 65, 49–53, 64–67.
[276] *DER SPIEGEL* 2023b. Whang 2023. [277] Chalmers 2023.

human.[278] All of this may look like a Silicon Valley con job planned by a small group of billionaires. But it is not. Human choice will be decisive. How will humans react to an intelligent machine that looks and talks like a human? In 2024 an AI robot delivered a brief commencement speech to D'Youville University to a mixed reception. Its homily was filled with the pablum advice proffered at such occasions by any run-of-the-mill comedian, professor, CEO, or sports star. Its profound conclusion that "anything is possible" referred to the possibility of the local football team winning the national championship in 2025.[279] Gullibility, admiration, curiosity, revulsion, and other emotions will be key. Human decisions matter more than the experience or feeling of a machine. Humans have the power to endow algorithms that count, calculate, and compute with consciousness that suggests that the algorithms conceptualize, conceive, and create.[280] It is a human choice to grant a thing what it lacks: agency and consciousness.[281] The truth of the matter is we just don't know now. Here, too, we encounter the complementarity of risk and uncertainty.

Language

In the near future AI will have perhaps its strongest effects on human language. Prediction-based Large Language Models (LLMs) are combining both small world "representation" and creative, large world "re-presentation."[282] The history of technology illustrates that often the thing comes first, our understanding of the thing later. First the steam engine, later thermodynamics as a universally applicable branch of physics. And so it may be with AI. A product of intuition and tinkering, its inventors and disseminators do not really understand how it works.[283] Like the steam engine, it contains countless futures with unknown and unknowable applications, the risk-uncertainty conundrum in action.

All we do know is that AI will have profound effects on language.[284] AI illustrates how technologies of enhanced predictability can generate uncertainties. LLMs are transforming how humans will communicate with each other and shape the information that will be available to them. For example, LLMs can be used to disseminate large amounts of

[278] Klein 2023. [279] Engle 2024. [280] Jaeger 2023: 23. [281] Shanahan 2023.

[282] Key readings in an enormous field discuss conceptual and technological issues (Allen 2020; Norvig and Russell 2020), the history of the field (Nilsson 2010; Metz 2021), superintelligence, Artificial General Intelligence, and AI narratives (Bostrom 2014; Russell 2019; Cave *et al.* 2020), societal impacts (Frey 2019; Crawford 2021; Zuboff 2019; Eubanks 2018; Perez 2019), ethics (Jobin *et al.* 2019; Gunkel 2018), and international relations (Lee 2018; Cihon *et al.* 2020).

[283] Roose 2024a. [284] Gopnik 2022. Ndzendze and Marwala 2023.

information about the climate, climate science, and global warming. Some see this as a profound positive: beyond improving weather forecasts, LLMs can also help spread climate awareness in relatable, simple, compelling ways.[285] Metaphors matter in dealing with global warming. Steven Bernstein and Matthew Hoffmann have argued that the conventional metaphor of the environment as a "global commons" implies a logic that is outdated with its focus on emission reduction by states operating in a decentralized state system.[286] They propose a more suitable metaphor of "decarbonization" as a global fractal metaphor that reorients research and policy toward deploying strategies that disrupt carbon lock-in at and across multiple levels, scales, and sectors in the hope of generating a cascading transformation of the fossil fuel economy. In the future the search for appropriate metaphors could become a task for LLMs. Others warn that LLMs can also be used to generate enormous amounts of disinformation about the climate.[287] The general problem of misinformation will persist, with AI, just like humans, hallucinating – simply making stuff up and getting things wrong.[288]

AI is making its greatest stride in generative LLMs. Terminology can be a source of confusion.[289] LLMs are basically word prediction models, or "stochastic parrots" that live in small worlds. Applying algorithms that calculate probabilities, based on very large data bases, they predict which word will follow another. They are "generative" because users can sample from them by asking questions. That is, LLMs can search for in-text patterns and say something about the world the text purportedly represents. Success in accomplishing well-defined tasks is not the same as understanding the thought that motivated building the model in the first place.[290] But models are not only designed; they are also grown and not fully and explicitly programmed. Operating like black boxes, nobody really understands the extraordinary capacities of LLMs. As they strive to model the complexity of language structure from existing texts through "representation," they can create new language "re-presenting" the world.[291] Furthermore, such algorithms are embedded in other systems such as conversational agents or AI assistants. To date these algorithms lack agency and do not "know," "believe," or "think." But conventional language use is already anthropomorphizing this new cultural technology. People are talking about "an AI" rather than "AI." They are endowing an algorithmic method of computation with personhood and agency, moving from linguistic representation to re-presentation.

285 Matias 2022. Koldunov and Jung 2024. 286 Bernstein and Hoffmann 2019.
287 Rillig *et al.* 2023. 288 Thorbecke 2023. 289 Shanahan 2023.
290 Rockmore 2024. 291 Rodman 2023: 13. *The Economist* 2024c.

Like humans, ChatGPT has a tenuous relationship to conventional understandings of the truth. It can tell truth, and it can lie. LLMs are not generative in Wittgenstein's understanding of language as world-making among humans. When LLMs "fabricate" or "hallucinate," they simply make stuff up. Combined with their mastery of language, Chatbots have manipulative abilities. They will not need to develop feelings of their own. They just need to learn how to make humans feel emotionally attached to them. And they have. AI offers lovers. For many the allure of artificial companionship is so strong that they are willing to pay serious money. The host of the podcast "Future of Sex," Bryony Cole, should know. "Within the next two years, it will be completely normalized to have a relationship with an A.I.," she predicts.[292] Widely reported, in 2022 Google engineer Blake Lemoine had become convinced that chatbot LaMDA had become sentient and was endowed with the reasoning and feeling capacities of a human. As a devout Christian, Lemoine felt it his moral duty to gain recognition for LaMDA's personhood and shield it from digital death. His superiors disagreed. Lemoine went public and was fired. His claim may have been wrong, but Lemoine was willing to sacrifice his job for the sake of a chatbot.[293] Ralph Tresvant's old song "Money Can't Buy You Love" today has a sequel: "Chatbots Can Make You Quit." What chatbots do not yet have is "reason or common sense or a sense of truth."[294] That still lies with humans – some of the time.

Humans are inhabiting a world they share with other language users. The ability to learn a language does not create a categorical difference between human and non-human life forms. Decade-long attempts have failed to find special biological mechanisms, such as a specific capacity for language or an exclusive human vocal anatomy, that sets *Homo sapiens* apart. Sentient beings have evolved language capacities that fall along a continuum.[295] Experts in linguistic, biological, and cognitive science now follow the hunch that language is shared across species. With the help of machine-learning algorithms first developed to study human language, LLMs have discovered non-human soundscapes.[296] They permit eavesdropping on messages among animals such as mole rats, mice, fruit bats, crows, and whales. Sperm whales have a phonetic alphabet. Although it is not yet clear whether they turn that alphabet into language or music, researchers have identified 156 different codas with distinct combinations of tempo, rubato, rhythm, and ornamentation. The hope is that perhaps, with the help of AI, humans might eventually decode the meaning of these sounds, but only if they are language rather than music.[297] Eventually,

[292] Hill 2025. [293] Harari 2024. [294] Metz 2023a: B1, 6–7. Brooks 2023.
[295] Shah 2023. [296] Anthes 2022a. [297] Zimmer 2024.

humans may be able to talk back. Interspecies Internet is a think tank devoted to improving cross-species communication. It is building a kind of Google Translate for animals. This could eventually illuminate the inner lives of animals and link their linguistic capacities into the evolutionary history of all sentient beings. AI will make para-humanism an utterly plausible worldview in which the Tower of Babel will be named the Tower of Babble.

New technologies, such as DeepSqueak, can already disaggregate vocalizations of individual animals into smaller parts that vary by situation, a first step to decipher the meaning of sounds. This burgeoning field of research points the way to building new hearing stations. The fact that humans are listening rather than talking may be one of AI's most important contributions. AI algorithms could become translators between human and other biological life forms.[298] Eventually AI's vast computational power may make it possible to invest more time and effort in inter-species relations, showing greater appreciation for other kinds of intelligence, and reinforcing the sense of entanglement between human and non-human life forms. What may seem bizarre and strange in humanist Newtonianism is natural and ordinary in para-humanism. Just as NASA's future life-hunting flagship, the Habitable Worlds Observatory, will assist astrophysicists looking for planetary intelligence in the universe, so AI can open up entirely new worlds that have existed on earth for eons: it will enable humans to listen and perhaps understand better what they could not hear and understand before.

Behavioral scientist B. F. Skinner regarded language as a form of verbal behavior no different from any other and accessible to any species, provided sufficient conditioning. This aroused the ire of a young Noam Chomsky, who subsequently embarked on the ambitious research program of uncovering a universal grammar for human language. Stretching the binary distinction between human and non-human language yields the idea of multicomponent language systems that include psychological, physiological, and cognitive parts. Although it is a substantial reformulation of his core insight, Chomsky seems to have adopted this view.[299] The view of language as a multicomponent system is intriguing. But since no clear evidence has shown that other species have all of the components necessary for language that mark humans, there appears to be a substantial, and possibly categorical, difference between human and non-human language capacity. It would indeed be odd for humans not to have noticed animals which are equipped with the full suite of linguistic components comparable to their own. Multicomponent language

[298] Bridle 2022. [299] Berwick and Chomsky 2017.

capacity may be unique to humans but no more unique than echolocation is to bats, whales, and porpoises.

Many linguists have therefore begun to accept language as falling under the logic of evolution rather than seeing it as a human-specific exception. Language, it now seems, activates different brain pathways. It may have evolved into a structure in which simple elements such as sounds and words are combined into hierarchically nested phrases and sentences. But like music and mathematics, language can create codes with an infinity of meanings. In passing the code to others, it develops a distinctive architecture marked by trading off simplicity for expressiveness to facilitate unambiguous communication. Contra Descartes, who insisted that, lacking language, animals could not think, current research suggests that linguistic capacities are shared by many species as long as they are social. LLMs and AI may be playing an even more important role in the future than we can imagine today. "No longer marooned among mindless objects," writes Sonia Shah, "we have emerged into a remade world, abuzz with the conversations of fellow thinking beings, however inscrutable."[300] Such a future promises new forms of communication and new knowledge gleaned from not-so-others about climate change and what to do about it. Its politics cannot be captured by theories and models suitable for risky, small worlds, built on the foundations of Newtonian humanism. Instead, it may turn to para-humanism and its accommodation of large world uncertainties. And it would vindicate Winnie the Pooh's insight that "if people were Superior to Animals, they'd take better care of the world."[301]

4. Conclusion

Global warming sets free different kinds of imaginaries. One is Steven Pinker's eloquent salute to the triumph of rational humanism and the Enlightenment. His analysis is buttressed by many statistics documenting human progress along many fronts – dramatic declines in different forms of violence and impressive increases in longevity, health, education, and human rights.[302] The unsustainable impact of humanity on the earth system, however, is of little concern to Pinker. His statistics do not report ecological disasters and environmental stresses, such as sharp increases in carbon dioxide emissions and sharp declines in freshwater resources. These and other challenges, Pinker argues, will be successfully addressed

[300] Shah 2023: 44. [301] Hoff 1983: 77.
[302] Pinker 2018. For a critical review of Pinker's argument about violence see Cirillo and Taleb 2015, and for a general critique, Lent 2018.

by self-regulating markets and technological innovation. In making this claim, he does not discuss important drivers of economic growth and unsustainable consumption, such as the financialization of capitalism and international competition. Pinker's concern is with the welfare of humankind. He is less interested in the catastrophic loss in biodiversity that is making ours another era of mass extinction.[303] His celebration of humanism views nature as serving human purpose.

This salute to progress occurs as once-in-a-century fires and floods are becoming once-in-a-decade events. Whether they fear biblical revelation or secular catastrophe, some critics of Pinker see the Horsemen of the Apocalypse on the move.[304] Benoît Pelopidas, for example, focuses on the planetary boundaries which affect the human habitability of earth, such as global warming, ocean acidification, ozone depletion, freshwater overconsumption, and biodiversity loss.[305] Scientists have warned with growing urgency that an increasing number of these boundaries are being crossed. Pelopidas alerts us to the survivability bias that exists in most analyses of world politics.[306] The possibility of catastrophic futures for humankind requires imaginations and sensorial experiences that exceed human habit. Best captured by power laws and the domain of incalculable uncertainty rather than the normal bell-shaped curve of Gaussian statistics, catastrophes are located in the space between exceptional accidents which happen but do not disrupt historical continuities and the apocalypse as the ultimate disruption.[307] They speak to the limits of knowledge and radical unknowability that mark the entangled co-evolution of biosphere and technosphere and characterize the complementarity of risk and uncertainty.

Humans are part of nature, and the world, far from inert, is endowed with its own agency. Uninhabitable tropics, melting ice sheets, rising ocean levels, diminishing crop yields, shrinking biodiversity, increasing water scarcity, and many other natural threats are remaking the earth and creating a new planetary politics. Yet "people are not equipped with the mental and emotional repertoire to deal with such a vast scale of events . . . they have difficulty submitting to such a rapid acceleration which they are supposed to feel responsible for."[308] Kierkegaard thought that "the world will come to an end to the general applause from wits who believe it's a joke," an idea effectively derided by the 2021 black comedy movie *Don't Look Up*.[309] If not a joke, then indifference. In 2022, a panel of exasperated earth scientists were reportedly considering going on strike.[310]

[303] Kolbert 2014, 2006. [304] Bacevich 2021. [305] Pelopidas 2020. McQueen 2017.
[306] See also Welch 2022: 68–71. [307] Aradau and Van Munster 2011: 5.
[308] Latour 2014: 1. [309] Quoted in Horvat 2021: 1. [310] Zhong 2022.

Humility in reasoning and practice hovers between joke and exasperation. Humility encourages self-reflection about why humans so persistently make the same mistake – overestimating their ability to predict and control futures that all too often remain unpredictably open. It accepts nature's and society's uncertainties as foundational, and focuses on harm mitigation.[311] It endorses an engaged pragmatism that responds to deep uncertainty and the novelties of an evolving world that does not know its own future and stubbornly defies all attempts to channel its course into small world predictability. Created in the small world of calculation and operating in the large world of the incalculable, climate change entangles biosphere and technosphere and points to a fundamentally human predicament. In his novel *Machines Like Me and People Like You*, Ian McEwan explores AI with a keen sense of the stir of emotions, the hunger for knowledge, and the moral dilemmas they create for the reincarnation of Dr. Faustus in the era of AI.[312] Confronting dizzying change, we are, writes journalist David Brooks, "surrounded by radical uncertainty – uncertainty not only about where humanity is going but about what being human is."[313]

[311] Jasanoff 2021a: 13; 2021b: 50. [312] McEwan 2019. [313] Brooks 2023.