Taking Technology Seriously: Introduction to the Special Issue on New Technologies and Global Environmental Politics

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Human beings are at once makers of and made by technology. The ability to wield tools was an essential ingredient in propelling an otherwise unremarkable ape to a position of dominance over ecological and even planetary affairs. This dominance has been attained through a remaking of the physical world and has produced a planet fundamentally altered. Technology, this is to say, has been central to history and human-induced environmental change. Our earliest significant environmental impacts appear to have been mass extinctions of megafauna, especially in North and South America, Australia, and the Pacific Islands, enabled by hunting and trapping tools and techniques. These were followed by large-scale land use changes from the rise of agriculture, another early set of technologies that were key to *Homo sapiens*' success (Boivin et al. 2016).

Technology presents a paradox. Existing, emerging, and anticipated technologies offer remarkable possibilities for human well-being and the environmental condition. Since 1900, global average life expectancy has more than doubled and continues to rise (Roser et al. 2013). Most people can access information and educational opportunities that in the not-too-distant past were restricted to a tiny elite. The growth of farmland—which may be the leading direct driver of change in nature (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services 2019)—has recently been reversed through agricultural intensification (World Bank, n.d.). Ozone-depleting substances have been largely replaced by synthetic substitutes. Preventing further anthropogenic climate change rides on lower-cost zero-carbon energy, electricity storage, and carbon dioxide removal. Evidence shows that technology-enabled economic security allows societies to invest in protecting natural areas, ecosystems, and species for their own sakes. And writing in the era of COVID-19, quarantines, and sheltering in place, one

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realizes that the only route to quickly returning to normalcy is through the development of a vaccine. Ultimately, political scientist Jonathan Symons asserts that "democratizing and accelerating the pace of technological change is an essential element of any effective response to Anthropocene challenges" (Symons 2019, 12).

At the same time, though, technologies are often implicated in the most pressing environmental problems of our age. The patterns of industry facilitated by modern technologies are responsible for massive environmental change, from localized pollution to ecological distress on a global scale. Irrigation salinizes soils, while online black markets enable continued illegal trade in endangered species and their products. The requisite energy to power the contemporary world is still derived mostly from fossil fuels, whose greenhouse gases are causing global climate change. And at the extreme, one of the markers of the post–World War II era is our technological capacity to destroy the bulk of life on Earth, whether by choice or error.

The importance of technology is especially highlighted as we continue our collective entry into and production of the Anthropocene, the proposed geological epoch in which our reshaping of the Earth is visible in the stratigraphic record due to industrialization, nuclear weapons testing, and more. Although humanity's impacts on Earth systems have thus far been largely unintentional, some emerging technologies would enable activities to alter basic planetary features intentionally. Large-scale interventions in Earth systems to remove carbon dioxide are now part of mainstream climate scenarios. Slightly reducing incoming sunlight through "solar geoengineering" in order to counteract climate change is steadily moving inward from the fringe of climate response discourses. New biotechnological innovations, such as CRISPR-powered gene drives, could allow the intentional local eradication of invasive species or disease vectors and possibly the reintroduction of extinct species. The powers of certain emerging technologies or of existing ones used at greater scales may facilitate more sustainable futures even as they present expanding and novel challenges.

These technologies will fundamentally change how humanity interacts with Earth systems and, by extension, how we see ourselves as human beings in relation to the nonhuman world. This raises numerous challenging questions. Who will benefit, and who might lose out? Who is included in decision-making, and who is presently absent? Will these technologies alter or reinforce existing power relations and distributions of resources? Do these technologies enhance or hinder democratic participation? What is the role of corporate power in governance and, if excessive, how can it be appropriately limited? Are new institutions, rules, and norms needed, or can we adapt extant ones to legitimately govern Anthropocenic technologies? To what extent can and should governance anticipate technological developments?

Questions of the role of institutions, norms, and power in shaping environmental outcomes are well-established areas of investigation for global environmental politics scholars. Yet technology has—perhaps surprisingly—been underexamined. As a field, we seem guilty, collectively, of what Langdon Winner (1986, 5–10) once termed "technological somnambulism"—a sleepwalking relationship with technology, based on insufficient attention to the roles that technology plays in political and social life. Furthermore, much of the environmental politics scholarship treats technology one-dimensionally, simply as a threat to sustainability.

This special issue looks squarely at the complex intersections between new technologies and global environmental politics. Its aims are to interrogate, across the range of technological forms outlined below, various methodologies, and differing normative priors, the places of technology in shaping environmental outcomes and to explore how emerging technologies might be directed toward the production of better environmental outcomes.

Technology is considered here in its broadest sense, as the artifacts that are created by human ingenuity, complemented by the social systems in which those artifacts are embedded. The importance of this expansive understanding is made clear via contributions to this special issue that show how biodiversity protection is being rethought and potentially remade by the ongoing development of gene drives and synthetic biology, how global food production is being reconfigured by a collection of technological developments and associated practices packaged as "precision agriculture," and how nascent investigations into solar geoengineering and carbon dioxide removal approaches are complementing established responses to climate change. The collection is more, though, than a survey of interesting technological developments. Taken together, the articles give form to the variety of ways in which technologies are political. We are given insight into ways that technology shapes the political world and, in turn, how political contestation as well as acts and omissions of governance shape technological development and utilization.

In this opening essay, we foreground what it means to give a political reading of technology. We then outline the various contributions to the special issue and draw together some of the collection's major themes.

Political Readings of Technology

The word *technology* is derived from the Greek *techton* (or *tektön*), referring to a carpenter or builder, and from *techne* (or *tekhnē*), meaning "art," "craft," or "skill." The term has its origins, then, not only as a description of the products of human ingenuity but also more broadly as a way to describe the application of ingenuity in the many different spheres that constitute human lives.

Given the ubiquity of technology in contemporary existence, it may be unsurprising that technology is often rhetorically imbued with autonomous qualities. That is, our technological direction can be taken as independent, moving forward on terms of its own logic, divorced from rational human control. This is the view of technology captured by Ralph Waldo Emerson (2006, 36) in his "Ode Inscribed to W. H. Channing": "Things are in the saddle, / and ride mankind." Yet such a view, though widespread, can be fatalistic. To adopt the position that technology is autonomous implies that humankind travels on a technologically determined trajectory.

The only options left us by such a view seem to be a wholehearted embrace or an utter dismissal of technology—that is, "take it or leave it" (Feenberg 1991, 8). For those optimistic about the direction of technological change, then, there appears little to worry about. But for those who criticize our technological society, the only option left by this autonomous view is rejection—hence the "back to the Pleistocene" cry of Earth First!ers, echoed by other revolutionary environmental groups and so-called Neo-Luddites. Either way, viewing technology as autonomous leaves little hope that humanity might willfully direct technology toward particular ends (presuming that willful direction is itself desirable).

However, to truly comprehend technology and the role that it plays in shaping human and planetary affairs requires seeing that technology is a product of, and embedded in, social, political, and material relations. From one perspective, actions clearly shape—if not determine—technological direction through research, innovation, and utilization. This suggests that human agency is central to technologies' courses. In turn, technologies influence how people understand themselves and others, their choices, and society more generally. Global communication, for example, has made a cosmopolitan worldview possible.

An implication of this viewpoint is that moving beyond description and properly comprehending a technology and its impacts requires considering not just its physical characteristics and its means of operation but also its place in the social and material worlds. This includes understanding artifacts, processes, and techniques as components of technosocial *systems*. The social world and technology can be considered mutually constitutive, in the sense that through their interaction, technology and societies shape and give rise to one another. Technologies are, said differently, part of the basic fabric of social life—"we live our lives," as Donald MacKenzie and Judy Wajcman (1999, xiv) have put it, "in a world of things that people have made."

This appreciation of the back-and-forth between technology and society gives rise to two senses in which technology can be considered *political*. First, particular technological artifacts or systems are not simply products of some unyielding march of technological progress. Rather, technological developments are also results of social contestation. As Andrew Feenberg has written:

> Technology is not a thing in the ordinary sense of the term, but an "ambivalent" process of development suspended between different possibilities. … On this view, technology is not a destiny but a scene of struggles. It is a social battlefield, or perhaps a better metaphor would be a *parliament of things* on which civilization's alternatives are debated and decided. (Feenberg 1991, 14, emphasis original)

Second, through their development and use, technologies can alter, challenge, or serve to entrench arrangements of social, economic, and political power. This is one implication of Sheila Jasanoff's (1999, 143) assertion that any given technology represents "a physically stabilized, congealed embodiment of an entire history of social assumptions, conventions, interests, and cultural practices." Particular technologies and technological configurations are products of their historical moments and shaped by associated concatenations of ideas and institutions.

Comprehending the forces driving technological developments, recognizing the full range of emerging technologies' effects, and learning how to more effectively steer them are among the most pressing intellectual challenges of the present age. The articles collected here show that technology is shaping human and environmental possibilities and, at the same time, that there are mechanisms of governance that can be applied to the shaping of technological developments. Understanding and influencing this complex interplay is at the heart of what it means to look at technology in relation to global environmental politics.

Articles in the Special Issue

The five research articles in this collection offer a diversity of perspectives, assumptions, conclusions, and technologies of concern.

Leslie Paul Thiele opens the collection with an examination of what he calls *ecological restoration technologies*. He focuses on the use of the emerging tools and techniques of synthetic biology and their potential application for assisted evolution and the "de-extinction" of species. The article assesses the enormous potential of synthetic biology to mitigate biodiversity loss. Importantly, it also poses a range of ethical and governance questions that should be addressed if synthetic biology or other ecological restoration technologies are deployed to alter the biosphere. Thiele makes the case that human beings are on the cusp of creating a new, managed nature—Nature 4.0—characterized by the use of sophisticated technologies to "rescue and resuscitate the natural world." We are racing headlong, he suggests, into the transformation of a planet that we are just beginning to understand.

One of us—Jesse Reynolds—next focuses on an emerging technology within Thiele's discussed domain of synthetic biology. *Gene drives* are genetic modifications that can rapidly propagate through a population via mechanisms of biased inheritance. Scientists are developing them for purposes that include both the conservation of biodiversity—by eliminating invasive alien species, protecting endangered species, and fostering adaptation to threats such as climate change—and human well-being via, for instance, eradicating disease vectors. Gene drives' potential outdoor testing and use are highly contentious due to environmental risks and social challenges. Given the importance of governance of these activities, Reynolds describes and analyzes the applicable international law and decisions of intergovernmental institutions, especially the Convention on Biological Diversity (CBD). He contrasts the governance and still-inchoate politics of gene drives with those of agricultural genetically modified organisms, considering in particular the roles of states, nonstate actors, precaution, and the relevant deliberative forums. Reynolds asserts that the governance of gene drives will be of increasing salience but that the CBD is a poor fit for formal governance activities in this case. He concludes that these discussions are part of larger debates regarding emerging technologies among those concerned about sustainability.

Jennifer Clapp and Sarah-Louise Ruder take us into the world of precision agriculture. Precision agriculture combines new digital technologies with new forms of genome editing. The vision is of autonomous farm equipment operating independently on farmland that is mapped and monitored by sophisticated surveillance hardware and software, overseeing the growth of seeds modified using cutting-edge tools for biotechnological manipulation. Clapp and Ruder outline all that is new with precision agriculture. They also show us all that is old by placing these technological developments in the context of prior technology-driven changes to agriculture. The article maps a vigorous debate. On one side are those focused on the potential sustainability benefits of precision agriculture. On the other are those who see precision agriculture as undermining sustainability by concentrating corporate power and entrenching destructive agricultural practices. Clapp and Ruder draw on insights from the broader literature on the political economy of technological change—including the concepts of technological lock-in, the double-edged nature of technology, and uneven power dynamics—to unpack the politics of this debate. Their analysis also points to a different possible outcome. This would entail the inclusion of elements of precision agriculture in more ecological and equitable models of agriculture, coupled with the political and economic conditions needed to distribute power to farmers.

The collection wraps up with a pair of articles on emerging technologies for climate change. Carbon dioxide removal (CDR) and solar geoengineering are sometimes lumped together as "geoengineering" (although this nomenclature has fallen out of favor). Edward Parson and Holly Buck consider the long-term use of the former. If CDR is indeed utilized at the scale implied by current scenarios that would likely keep global warming within 2°C, then an enormous multi-billion- or -trillion-dollar industry would arise. Accompanying this would be institutions, policies, industries, workforces, and political constituencies that establish, maintain, and benefit from these large financial flows. The CDR endeavor would need to end once atmospheric greenhouse gases are stabilized and perhaps lowered. However, akin to the contemporary challenge of ending fossil fuels, the associated interests are unlikely to go gently into the night but instead are expected to mount political resistance. Parson and Buck note that early decisions regarding which CDR methods and policies are to be dominant will make this phasing out more or less difficult. Their specific suggestion is to incentivize large-scale CDR via public procurement instead of putting a price on removed carbon or encouraging removed carbon's utilization.

Finally, Joshua Horton and Barbara Koremenos start not with technology but with theory. Transnational climate governance, they note, is a popular and influential framework for studying nonstate and substate actors in global environmental governance. However, Horton and Koremenos argue that the transnational climate governance framework too strongly emphasizes steering (i.e., direct governance) at the expense of influencing (or indirect governance) via informing, lobbying, and enabling. This lacuna is evident when considering the governance of researching solar geoengineering, a set of proposals to slightly block or reflect incoming sunlight in order to counter climate change. There, the active transnational nonstate actors are disseminating knowledge, building scientific capacity, and pressuring and persuading governments and intergovernmental institutions to adopt their favored policies. From this, the authors conclude that scholars' analyses of global environmental governance should incorporate emerging work synthesizing research on interest groups and nongovernmental advocacy organizations as well as existing research on epistemic communities and capacity development.

New, emerging, and anticipated technologies offer remarkable possibilities for human well-being and sustainability but, at the same time, present grave challenges. These challenges are not just physical and environmental but also social and political. Technology is implicated deeply in the ways in which we organize our individual and collective lives and how we comprehend ourselves and our place in the world. By unpacking the often complex interplay among technological development, human agency, and social and political context—rather than presenting technologies as resulting from the straightforward development of a technical response to a problem—this special issue points the way to deeper comprehension and a more effective steering of the technological future that awaits.

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Jesse Reynolds researches how society can develop norms, rules, procedures, and institutions to manage environmental opportunities and challenges, particularly those involving new technologies. He is the Emmett/Frankel Fellow in Environmental Law and Policy at the Emmett Institute on Climate Change and the Environment of the University of California, Los Angeles School of Law. Dr. Reynolds is also an associate researcher at the Utrecht Center for Water, Oceans, and Sustainability Law, Utrecht University, and a research affiliate at Harvard's Solar Geoengineering Research Program, Harvard University. His book *The Governance of Solar Geoengineering: Managing Climate Change in the Anthropocene* was published in 2019.

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