Introduction

Growth, Punctuation, and Human Well-Being

This book is a venture into history on a grand scale, a contribution to what is coming to be known variously as "big history," "deep history," and "evolutionary history."[1] I begin with a foundational question: How has the history of the earth system shaped the history of the human condition? The most cursory consideration of these histories suggests the basic outline of the story. Over the very long term, the history of a volatile and changing earth has driven biological and human evolution: it has been a rough journey, and we are products of that journey. During long epochs of organic hunter-gatherer systems and agrarian economies, humanity was fundamentally subject to natural forces of an evolving earth system; our sudden transition into fossil-fueled industrial modernity has made us an increasingly active and determining agent in that earth system.[2] Occasionally, too, hurricanes, earthquakes, or volcanic eruptions remind us that the earth is a very volatile platform for our finely balanced societies and economies.

This book, then, explores the role of nature – more precisely *natural history* – in human history. Doing so challenges a fundamental if rarely spoken tenet of my profession. We historians are extremely uncomfortable

[1] For key works in "big history," see David Christian, *Maps of Time: An Introduction to Big History* (Berkeley, 2004); Jared Diamond, *Collapse: How Societies Choose to Fail or Succeed* (New York, 2004); John R. McNeill and William H. McNeill, *The Human Web: A Bird's Eye View of World History* (New York, 2003); Fred Spier, *The Structure of Big History: From the Big Bang until Today* (Amsterdam, 1996); and Spier, *Big History and the Future of Humanity* (Malden, MA, 2010). For important new approaches that will reshape attitudes toward history on the grandest scale, see Daniel Lord Smail, *On Deep History and the Brain* (Berkeley, 2008); Andrew Shryock and Daniel Lord Smail et al., *Deep History: The Architecture of Past and Present* (Berkeley, 2011); and Edmund Russell, *Evolutionary History: Uniting History and Biology to Understand Life on Earth* (New York, 2011), and Daniel Lord Smail and Shryock Andrew, "History and the 'Pre," *AHR* 118 (2013), 709–737.

[2] Historians should be aware from the outset that the earth system of geological, atmospheric, and biological domains should not be confused with the "world system" theorized by Fernand Braudel, Andre Gunder Frank, and Immanuel Wallerstein.

with the idea that natural forces in some way circumscribe human agency. Fearful of being labeled "environmental determinists," we opt for a model of change in which all of the significant causal agents in historical processes are internal – or endogenous – to human culture, society, and economy. Given that most historians work on the past three to four centuries at most, this is not a completely unreasonable posture, because natural systems typically operate over much longer time frames.

But three considerations require that we set aside our avoidance of nature.[3] First, a holistic, long view of the human past, starting with evolutionary time, requires an understanding of the natural forces operating over centuries, millennia, and millions of years. Second, the short time scale of the past three to four centuries has seen both the global recovery from the Little Ice Age and the onset of rapid anthropogenic (human-induced) climate change. Third, a revolution has occurred in climate science, driven since the 1960s by an emerging understanding of the role of fossil fuel technology in altering global climate. Forty years ago, historians of another generation had no truly systematic evidence for climate history at hand, and here prudence did indeed require restraint.[4] But over the past generation the careful scientific study of chemical signatures in ice layers, lake beds, and marine sediments has established a remarkably detailed history of global environments reaching back billions of years, and of remarkable texture and resolution in the relatively recent past. One of the central purposes of this book is to introduce historians to the findings of this new global climate science. Despite recent politically driven "controversies," a massive body of incontrovertible evidence exists for the history of climate and for human-induced climate change, as this book reports in some detail.

If climate history is a central problem in this book, it shares the stage with a series of other critical questions. A big question running through my story is the shifting conditions of human well-being, as roughly measured by changes in both the size and health of populations, over the very long term of human history. Here the systematic analysis of archaeological and genetic data is beginning to radically sharpen our picture of human health in past time and to extend a chronologically shallow documentary record; I offer a tentative sketch of the ways the health evidence may suggest trends in overall societal prosperity and poverty. These involve the conditions of routine health and those of the crises of epidemics, both in their emergence and operation during the premodern agrarian epoch and their control in what is known as the epidemiological transition of the past several hundred years.

[3] Here see the pointed suggestions in Dipesh Chakrapbarty, "The Climate of History: Four Theses," *Critical Inquiry* 35 (2009), 197–222.

[4] For an early assessment of a pioneering climate historian, see Emanuel Le Roy Ladurie, "History without People: The Climate as a New Province of Research," in *The Territory of the Historian*, trans. Sian Reynolds and Ben Reynolds (Chicago, IL, 1979), 287–319.

Here I see a fundamentally dynamic causal interaction between disease and human agency. In the book's final section, I argue that, in addition to global empire building, an emergent understanding and practice of public health, grounded in the efforts of increasingly effective early modern nation-states, drove a declining mortality and a surge of population growth that was a critical force in the spiraling development of economic modernity.

Thus human agency itself is another central problem in this book, perhaps the central problem. If natural forces of climate, environment, and disease are indeed so powerful, how has humanity managed to arrive at its current condition of modernity? Here I take the very long view of the growth of human capacities, considering a continuum of adaptive change running from biological evolution to technological innovation and economic growth. And as this problem of human agency develops in this book, I have had to try to suppress the impulse to write a political history, but questions of the role and efficiency of the state inevitably become essential problems in this account.

If it is to examine these foundational questions, a big history necessarily must address grand theory – our inheritance from the founders of the modern social and biological sciences who established our understandings of the evolution and history of biological and human life. They were the big historians of their day, and their reach has been long and powerful.

We might well start with Benjamin Franklin, whose writings on land and population in the 1750s were powerfully influential on Adam Smith and Thomas Malthus, who in turn shaped the intellectual stage for Charles Darwin. Men of the eighteenth century, Franklin, Smith, and Malthus could not anticipate the transformation to come in the nineteenth: they were all concerned with the problem of prosperity in organic, preindustrial societies. Franklin and Malthus were more pessimistic, seeing a close, zero-sum relationship between growing populations and limited resources, and seeing a threat of the dreaded "positive check" if land – in the colonial American case – ceased to be free for the taking, or if a society failed to exert virtue in the preventive check. In his classic formulation, Malthus argued that "[t]he ultimate check to population appears … to be a want of food, arising necessarily from the different ratios according to which population and food increase."[5] Malthus published his interpretation of populations and natural resources in 1798, and this formed part of Darwin's intellectual background when he began to develop his thinking on evolution and natural selection in the 1830s. In particular, Malthus's analysis of a steady pressure of population driving a relentless competition for resources shaped Charles Darwin's

[5] Thomas Robert Malthus, *An Essay on the Principle of Population: A View of Its Past and Present Effects on Human Happiness; with an Inquiry into Our Prospects Respecting the Future Removal or Mitigation of the Evils which It Occasions*, sixth edition (London: John Murray, 1826), book 1, chapter 2.

insight into how natural selection of adaptive traits formed the basic engine of biological evolution. Allied with the new gradualist geology that posed the operation of observable processes over vast stretches of time (as against Christianity's six-thousand-year history and its great dramas of Creation and the Flood), Darwin framed the concept of natural selection as a tooth-and-nail struggle for resources in a context of perpetual overpopulation.

Malthusian and Darwinian thought must be seen as inseparable intellectual frameworks. Both assume a fundamental gradualism in which a close calculus of population and resources constantly threatened individual survival. Each are oddly antihistorical, assuming that the conditions of this struggle vary within a minor and negligible range. Each posited an individual solution: Malthus's salvation lay in the preventive check of sexual restraint; Darwin's lay in the advantages accruing to individuals and evolving species from unique qualities of positive traits, later demonstrated to be operating at the genetic level by Gregor Mendel and at the molecular level by Watson and Crick.[6]

Among the classical economists, while he still only visualized gradual change in an organic economy, Adam Smith was far more optimistic than Franklin, Malthus, or Darwin. Smith posited growing prosperity per capita with an intensifying division of labor pursuing expanding markets opened by a liberal, post-mercantilist state. If energy supplies remained essentially stable, "the skill, dexterity, and judgment" of the deployment of human labor would drive the advance of human well-being.[7] In the 1950s and 1960s, Danish economist Ester Boserup formulated a restatement of this Smithian model of growth in an explicit assault on Malthus. She argued that Malthusian crises were rare events in human history because incremental innovation and intensification had generally kept population ahead of the grim reaper.[8] But Smith and Boserup shared with Malthus and Darwin basic assumptions about the

[6] Robert M. Young, "Malthus and the Evolutionists: The Common Context of Biological and Social Theory," *Past and Present* 43 (1969), 109–45; Silvan S. Schweber, "The Origin of the *Origin* Revisited," *Journal of the History of Biology* 10 (1977), 229–316; Sandra Herbert, "The Darwinian Revolution Revisited," *Journal of the History of Biology* 38 (2005), 51–66. For recent statements of the Darwinian synthesis, see Richard Dawkins, *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design* (New York, 1986; rev. ed., 1996); and Geerat J. Vermeij, *Nature: An Economic History* (Princeton, NJ, 2004).

[7] Adam Smith, *An Inquiry in the Nature and Causes of the Wealth of Nations* (Edinburgh, 1843), 1; Hiram Caton, "The Preindustrial Economics of Adam Smith," *JEconH* 45 (1985), 833–53.

[8] Ether Boserup, *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure* (London, 1965). Though I now dissent from important aspects of their arguments, I have learned a lot from Ronald D. Lee, "Malthus and Boserup: A Dynamic Synthesis," in David Coleman and Roger S. Scholfield, eds., *The State of Population Theory: Forward from Malthus* (Oxford, 1986), 96–103; and James W. Wood, "A Theory of Preindustrial Population Dynamics: Demography, Economy, and Well-Being in Malthusian Systems," *CA* 39 (1998), 99–216.

slow, gradual, and uniform trajectory of biological and social change. For none of these theorists is there room for sudden jolts: Malthus and Darwin saw an unremitting contest over resources by human and biological populations limited by inherently slow capacities for adaptation and change; Smith and Boserup saw those capacities as sufficient – if well enough organized – for human effort to produce significant though limited results. Running through all of these frameworks was – consciously or not – the basic principle that energy available to organic biological and economic systems is limited by an annual input of solar radiation and a product of photosynthesis. And we should remember that Adam Smith, while focusing his attention on the virtues of peaceful commerce, was well aware that the prosperity of one society might also come at the cost of another, in the "dreadful misfortunes" of those subjected to the "plundering" of conquest by expanding empires.[9]

Two quite different intellectual ventures have challenged the gradualist assumptions of the classical theorists in both economics and evolution. First, the impact of the industrial revolutions of the nineteenth and twentieth centuries exposed the limits of the perspectives developed by Smith, Malthus, and their contemporaries. Rapidly advancing technologies, designed on rigorous scientific and mathematical principles and powered by the "free" energy of fossil fuels, fundamentally challenged classical economics. Karl Marx and Frederick Engels were among the first to wrestle with the impact of the new technologies as they transformed the relationship of labor and capital. Marx's understanding of the modern capitalist economy was elaborated in the 1920s by Soviet economist Nikolai Kondratiev into a cyclical sequence of expansions and contractions, which was reformulated in the 1930s by conservative economist Joseph Schumpeter into business cycles driven by technological innovation. There is a general contemporary consensus that the modern economy is fueled by an accelerating, technology-driven Schumpeterian growth, rather than a gradual Smithian growth. Coming in unique waves rather than recurring cycles, successive technologies of increasing capacity and improving efficiency have swept through the modern economy since the early nineteenth century, overturning older systems in surges of "creative destruction."[10]

[9] Smith, *An Inquiry*, 258–9 (book IV, chapter 7, part 3).

[10] On Malthus, Smith, and Schumpeter, see William N. Parker, *Europe, America, and the Wider World: Essays on the Economic History of Western Capitalism* (New York, 1984), 1: 191–213; for two recent works on the Kondratiev-Schumpeter synthesis, see Carlota Perez, *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages* (Cheltenham, 2002); and Chris Freeman and Francisco Louçã, *As Time Goes By: From the Industrial Revolutions to the Information Revolution* (Oxford, 2001). Schumpeter saw modern, technologically driven economic growth as overturning Malthus and refused to accept that population played any role in the modern economy. In Part IV of this book, I suggest that surging population growth from the early modern period, especially since the eighteenth century, provides a critical component of the demand that ultimately launched and sustained Schumpeterian growth.

A remarkably similar "catastrophism" has emerged in the arena of the natural sciences. As the first efforts to model the tectonic history of the earth were made in the 1960s, new understandings of earth history and of evolution suddenly developed, fundamentally challenging Darwinian gradualism. First fully articulated in the pioneering work of Stephen Jay Gould and Niles Eldredge, the new understanding argues that biological evolution proceeded at different rates, even in fits and starts. This punctuated equilibrium, or "pluralistic evolution," was driven by major events in earth history, in which massive geological processes –super-plume events – interrupted periods of relative stability, rupturing continents, changing sea levels suddenly, raising mountain ranges, and driving the earth's climate and environment back and forth between "greenhouse" and "icehouse" conditions. Responding to these stresses and stabilizations, one model suggests that rates of Darwinian natural selection accelerated and subsided as species, families, and phyla were subjected to mass extinctions that opened the way to equally sudden periods of speciation and expansion – the Gouldian version of Schumpeter's creative destruction.[11] An even more radical view is gaining ground, arguing that natural selection is actually a conserving force and that evolutionary breaks are biochemical responses to environmental stress, operating during the development of the embryo to establish new physical traits in the "phenotype."[12]

If the new science is mapping these processes of geological and evolutionary history since the origin of the earth, it has also mapped them in the relatively recent past, over five million years of increasingly glacial conditions of the Pliocene and Pleistocene, and over the past ten thousand years of reasonably stable and warm interglacial conditions known as the Holocene, which encompasses the entire agricultural history of humanity. The result, quite simply, is that it is now quite clear that abrupt climatic and environmental

[11] Niles Eldridge and Stephen Jay Gould, "Punctuated Equilibria: An Alternative to Phyletic Gradualism," in Thomas J. M. Schopf, ed., *Models in Paleobiology* (San Francisco, CA, 1972), 82–115; Stephen Jay Gould and Niles Eldridge, "Punctuated Equilibria: The Tempo and Mode of Evolution Reconsidered," *Paleobiology* 3 (1977), 115–51. The parallels between the Gould-Eldredge model of evolution and the Schumpeterian model of modern economic growth are suggested in Joel Mokyr, "Punctuated Equilibria and Technological Progress," *AER* 80 (1990), 350–4; and Vaclav Smil, *Creating the Twentieth Century: Technical Innovations of 1867–1814 and Their Lasting Impact* (New York, 2005), 5–13. It might be proposed that Malthus's inclusion of natural calamity as a "positive check" anticipated Gould and Eldridge's punctuational theory. This is not, however, the general understanding.

[12] Robert G. B. Reid, *Biological Emergences: Evolution by Natural Experiment* (Cambridge, MA, 2007); Eva Jablonka and Marian J. Lamb, *Evolution in Four Dimensions: Genetic, Epigenetic, Behavioral, and Symbolic Variation in the History of Life* (Cambridge, MA, 2005); Mary-Jane West-Eberhard, *Developmental Plasticity and Evolution* (New York, 2003); Robert G. B. Reid, *Evolutionary Theory: The Unfinished Synthesis* (Beckenham, 1985).

change has been a fundamental dimension of the long history of humanity. Trends and abrupt shifts in climate drove human evolution in Miocene-Pliocene Africa; severe glacial cycles and megadroughts episodically reduced human numbers in the Pleistocene, shaping the final evolutionary modeling of modern humanity. Even during the Holocene, milder but nonetheless significant global climatic shifts had enormous, indeed punctuating, impacts on fragile agrarian economies.

But where the Gouldian punctuation model poses a challenge to gradualism, this challenge is only to the pessimistic gradualism of Darwin and Malthus. The punctuation model posits expansionary growth as the aftermath of crisis, and not just because free resources are suddenly available. The winnowing – the creative destruction – imposed by the stresses of punctuation provides space for new adaptive strategies to take hold and to persist. In evolutionary ecology there is considerable ongoing work on the ecology of these adaptive strategies of stability and "coordinated stasis."[13] Just as there are useful analogs to be drawn between Gould-Eldredge punctuations and Schumpeterian "creative destruction," there are analogs to be drawn between this evolutionary literature on stability and stasis and the optimistic gradualism of Adam Smith, Ester Boserup, and a newly emerging literature on human resilience.[14] Increasingly, a variety of literatures are coming to an understanding that ancient and medieval/premodern populations and societies were much more stable – and resilient – than previously thought. We should not be too sanguine about the quality of life in these premodern societies; growing population density in the absence of modern public health meant shorter life spans – and shorter adult stature – than the recent modern norm. But rather than a constant story of peaking and crashing at the edge of technological capacity, long stretches of human history have been shaped by constant gradual Boserupian innovation – and occasionally even by "Smithian" economic growth. The emerging consensus here is that, within certain limits, organic economies of the past were adaptive and resilient, with the result that ancient societies lasted for enormous stretches of time, relative to the record of modernity.[15] Thus I argue throughout this

[13] Stephen J. Gould, *The Structure of Evolutionary Theory* (Cambridge, MA, 2002), 745–1024.

[14] Lance H. Gunderson and C. S. Holling, eds., *Panarchy: Understanding Transformations in Human and Natural Systems* (Washington, DC, 2002).

[15] Eric L. Jones, *Growth Recurring: Economic Change in World History* (Ann Arbor, MI, 2000 [1988]); Jack A. Goldstone, "Efflorescences and Economic Growth in World History: Rethinking the 'Rise of the West' and the Industrial Revolution," *JWH* 13 (2002), 323–90; Jan de Vries, "Economic Growth before and after the Industrial Revolution: A Modest Proposal," in Maarten Prak, ed., *Early Modern Capitalism: Economic and Social Change in Europe, 1400–1800* (New York, 2001), 177–94; Karl W. Butzer and Georgina H. Endfield, "Critical Perspectives on Historical Collapse," *PNAS* 109 (2012), 3628–31; Karl W. Butzer, "Collapse, Environment, and Society," *PNAS* 109 (2012), 3632–9; Patricia A. McAnamy and Norman Yoffee, eds., *Questioning Collapse: Human Resilience, Ecological Vulnerability*

book that the structure of human history is distinctly "Gouldian"/punctuational, with long periods of relative stability (stasis) interrupted by well-defined breaks best understood as episodic (not necessarily cyclical) global climate crises – Dark Ages, perhaps – increasingly augmented and surpassed by the eruption of epidemic disease and destructive warfare.[16]

I have not come to this nature-driven argument easily or lightly. When I first began this project, I was very resistant to a climate-driven thesis, and I assumed that I would be telling a fairly standard story of Malthusian sustainability crises in which episodic population growth drove both the crises and regime shifts in human history. This argument has been most powerfully advanced in Jared Diamond's *Collapse*.[17] But, after closer consideration of the literature in a variety of fields, I have abandoned this position, which I call the *endogenous argument*. I find a growing skepticism among prehistoric, ancient, and medieval specialists toward rigidly theoretical Malthusian interpretations, and among paleo-ecologists toward arguments

and the Aftermath of Empire (New York, 2010); Joseph Tainter, "The Archaeology of Overshoot and Collapse," *ARA* 35 (2006), 59–74; Carl Folke, "Resilience: The Emergence of a Perspective for Social-Ecological Systems Analysis," *GEC* 16 (2006), 253–67; Charles L. Redman, "Resilience Theory in Archaeology," *AmAnth* 107 (2005), 70–7.

[16] Epidemics are certainly density dependent, requiring threshold levels of population. But they are not necessarily density determined – it is clear that their arrival in and impact on ancient and medieval worlds was not inexorably determined by some long-brewing Malthusian crisis of population and resources. Indeed, in many cases, simplistic as it may sound, epidemics followed war, and war followed adverse climate change. The team led by David D. Zhang has established this exogenous argument regarding abrupt climate change, agricultural crisis, warfare, and regime collapse for China and the Old World more broadly in the recent past. These authors stress the inconsistency of this pattern with a traditional Malthusian endogenous explanation of crisis. As they put it, "this view is contrary to the traditional one of Malthus, Darwin, and many ecologists who hold land carrying capacity as a constant" (2006, 460). See David D. Zhang et al., "Global Climate Change, War, and Population Decline in Recent Human History," *PNAS* 104 (2007), 19214–19219; "Climate Change and War Frequency in Eastern China over the Last Millennium," *HumEcol* 35 (2007), 403–14 (esp. 413); "Climatic Change, Wars, and Dynastic Cycles in China over the Last Millennium," *ClimCh* 76 (2006), 459–77; and Solomon M. Hsiang, et al., "Quantifying the Influence of Climate on Human Conflict," *Science* 341 (2013), 1235367.

[17] For important recent statements of the standard Malthusian understanding of premodern human history, which I respectfully dispute, see Diamond, *Collapse*; Christian, *Maps of Time*; and Joachim Radkau, *Nature and Power: A Global History of the Environment*, trans. Thomas Dunlap (New York, 2008). See also Michael Williams, *Deforesting the Earth: From Prehistory to Global Crisis* (Chicago, IL, 2003), 37–144; Sing C. Chew, *World Ecological Degradation: Accumulation, Urbanization, and Deforestation, 3000B.C.–A.D. 2000* (Walnut Creek, CA, 2001); Charles L. Redman, *Human Impact on Ancient Environments* (Tucson, AZ, 1999); Neil Roberts, *The Holocene: An Environmental History*, second edition (Malden, 1998), 159–206; Clive Ponting, *A Green History of the Earth* (London, 1992); and Mark Nathan Cohen, *The Food Crisis in Prehistory: Overpopulation and the Origins of Agriculture* (New Haven, CT, 1977). Marvin Harris laid out the fundamentals of the "endogenous model" in *Cannibals and Kings: The Origins of Cultures* (New York, 1977).

for significant human-induced environmental degradation in premodern eras.[18] At the same time, climate scientists are finding compelling evidence for severe climate change at key periods of human crisis and transformation. I argue that until the onset of modern accelerated population growth, no premodern society of consequence occupying a reasonably adequate biome[19] suffered a purely endogenous "Malthusian crisis"; rather adversity, crisis, and collapse were fundamentally shaped by *exogenous forces*: the impacts of drought, cold, and epidemic disease drove episodic and abrupt reversals in societal complexity and the human condition. Diamond's book and many other environmental histories of the ancient past, I argue, are more jeremiads on the very real sins of modern society than descriptions of the central tendencies of past human history. Thus, to my own surprise, I argue that Malthus was wrong regarding most of human history. Contrary to the standard account, most of the human experience has not been shaped by endogenously driven overpopulation, but by a dialectic between moderately successful organic economies and the regular impact of exogenous natural forces. Only in the recent past, as we have suddenly escaped from the constraints of epidemic disease to vastly increase our numbers, has overpopulation become an earth-systemic crisis.[20]

Thus the fundamental insights informing this book are Gould's qualification of Darwin and Boserup's qualification of Malthus, with Marx and Schumpeter thrown in for good measure. In the long course of organic economies from the Paleolithic/Neolithic to the eighteenth century – during long periods of relative stability – Boserupian-Smithian processes of gradual innovation and slow cumulative economic growth on balance offset and occasionally transcended population growth. Until the onset of true Schumpeterian economic growth around the north Atlantic in the mid-nineteenth century, the human condition was governed not by a Darwinian-Malthusian synthesis of constant struggle on the razor edge of crisis and collapse, but by a combination of the Gould-Eldredge model of natural punctuation and an intervening equilibrium/stasis-Boserupian model of innovation and resilience. In sum, over the long run, human societies and

[18] Here compare Charles Redman's 1999 *Human Impact on Ancient Environments* with his comments in his 2005 "Resilience Theory in Archaeology."

[19] I exclude the occasional case of isolated situations such as Easter Island. But even here the Malthusian interpretation is under challenge: see Terry L. Hunt and Carl P. Lipo, "Ecological Catastrophe, Collapse, and the Myth of 'Ecocide' on Rapa Nui (Easter Island)," in Patricia A. McAnamy and Norman Yoffee, eds., *Questioning Collapse: Human Resilience, Ecological Vulnerability, and the Aftermath of Empire* (New York, 2010), 21–44.

[20] For an analysis, with ongoing commentary, of the earth system's limits on modern human populations and economies, see Johan Rockström et al., "Planetary Boundaries: Exploring the Safe Operating Space for Humanity," *Ecology and Society* 14/2/32 (2009) and "A Safe Operating Space for Humanity," *Nature* 461 (2009), 472–5. See also Will Steffen, "Observed Trends in Earth System Behavior," *WIREs Climate Change* 1 (2010), 428–49.

economies got through by getting better, but fairly regularly adverse natural forces set very bad things in motion. Only in the very recent past, when the beginnings of modern political governance, the first precursors of medical practice, and the establishment of global empires led to spreading focal points of extremely rapid population growth, did a truly Malthusian calculus begin to operate – first in England and China in the eighteenth century – and with critical transitions driven by the push of population rather than natural forcings. Paradoxically, Malthus was right – but for his own time and place, and for our own time. But before that point, population growth was not necessarily the fundamental driver of the human condition, except as it moved a gradual Boserupian process of incremental adjustment and adaptation.

Given such resilience and adaptive capacity, such gradual but effective innovation in the organic economy, fundamental crisis and collapse required a very big push, which did not come all that often. And over the course of premodern human history, when they did come, some of these exogenous impacts were simply temporary setbacks without lasting structural impacts. But others qualify as revolution drivers, Gouldian punctuations with Schumpeterian consequences. During the Pliocene and the Pleistocene, human revolutions shaped by global climate stresses included the three key junctures in human evolution: the Australopithecine divergence from advanced primates, the speciation of the genus *Homo*, and the development of modern human anatomy and cultural capacity now called the Middle Paleolithic Revolution. In the prehistoric and ancient Holocene, these moments include the origins of domestication, the rise of complex agrarian societies, the rise of the Bronze Age state, and a critical "axial" transition from Bronze Age to Iron Age polities and economies. These Iron Age structures framed the technological and sociological outlines of the entire era down to the beginnings of modernity, itself launched during an epoch of devastating natural catastrophe. Throughout each of these critical transitions in the human condition, earth systemic forces shaped an epoch of "creative destruction" leading to key departures in technology and social formation. These were bottlenecks of population, resources, and adaptive capacity/technology – but they were fundamentally shaped by abrupt climate change, not critical overpopulation.

The transition to modernity involved the launch of self-sustaining Schumpeterian growth driven by quantum leaps in technology, and is now driving an accelerating alteration of global environments and climates. It is abundantly clear that this transition necessarily involved three factors: global empires, a fruitful linkage between experimental science and artisanal technology, and cheap and accessible fossil fuels. It also followed – and was shaped by – the overlapping impacts of the Black Death and the Little Ice Age. In an age of global natural crisis perhaps more severe than anything experienced in the Holocene, the benefits of intensified organic