


Learning *to*
Die
in the
Anthropocene



REFLECTIONS ON THE
END OF A CIVILIZATION

Roy Scranton

“Scranton draws on his experiences in Iraq to confront the grim realities of climate change. The result is a fierce and provocative book.”


—Elizabeth Kolbert, author
of *The Sixth Extinction*



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INTRODUCTION

COMING HOME

The knowledge of future things is, in a word,
identical with that of the present.

—Plotinus, *Enneads* IV.12

Driving into Iraq in 2003 felt like driving into the future. We convoyed all day, all night, past Army checkpoints and burned-out tanks, till in the blue dawn Baghdad rose from the desert like a vision of hell: flames licked the bruised sky from the tops of refinery towers, cyclopean monuments bulged and leaned against the horizon, broken overpasses swooped and fell over ruined suburbs, bombed factories, and narrow ancient streets.

With “shock and awe,” the US military had unleashed the end of the world on a city of six million—a city about the same size as Houston or Washington, D.C. Baghdad’s infrastructure was totaled: water, power, traffic, markets, and security fell to anarchy and local rule. The government had collapsed, walls were going up, tribal lines were being drawn, and brutal hierarchies were being savagely established. Over the next year, the city’s secular middle class would disappear,

squeezed out by gangsters, profiteers, fundamentalists, and soldiers.

I was a private in the United States Army. This damaged world was my new home. If I survived.

Two and a half years later, still in the Army but safe and lazy back in Fort Sill, Oklahoma, I thought I had made it out. Then I watched on television as Hurricane Katrina hit New Orleans. This time it was the weather that inspired shock and awe, but I saw the same chaos and collapse I'd seen in Baghdad, the same failure of planning and the same tide of anarchy. The 82nd Airborne Division took over strategic points and patrolled streets now under de facto martial law. My unit was put on alert and trained for riot control operations. The grim future I'd seen in Baghdad had come home: not terrorism, not WMDs, but the machinery of civilization breaking down, unable to recuperate from shocks to its system.

That future is not going away. According to Admiral Samuel J. Locklear III, head of the US Pacific Command, global climate change is the greatest threat the United States faces, more dangerous than terrorism, Chinese hackers, and North Korean nuclear missiles.¹ Upheaval from increased temperatures, rising seas, and climatic destabilization “is probably the most likely thing that is going to happen that will cripple the security environment, probably more likely than the other scenarios we all often talk about,” he said. Thomas E. Donilon said much the same thing in 2014 as National Security Advisor, arguing that the “environmental impacts of climate change present a national security

challenge.”² James Clapper, Director of National Intelligence, told the Senate in 2013 that “Extreme weather events (floods, droughts, heat waves) will increasingly disrupt food and energy markets, exacerbating state weakness, forcing human migrations, and triggering riots, civil disobedience, and vandalism.”³ President Obama’s 2010 *National Security Strategy*, the Pentagon’s 2014 *Quadrennial Defense Review*, and the Department of Homeland Security’s 2014 *Quadrennial Homeland Security Review* all identify climate change as a severe and imminent danger.⁴ More recently, the Pentagon’s 2014 *Climate Change Adaptation Roadmap* warned: “Rising global temperatures, changing precipitation patterns, climbing sea levels, and more extreme weather events will intensify the challenges of global instability, hunger, poverty, and conflict. They will likely lead to food and water shortages, pandemic disease, disputes over refugees and resources, and destruction by natural disasters in regions across the globe.”⁵

On the civilian side, the World Bank’s 2013 report, *Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience*, and their 2014 follow-up *Confronting the New Climate Normal*, offer dire prognoses for the effects of global warming, which climatologists now predict will raise global temperatures 3.6 degrees Fahrenheit above pre-industrial levels within a generation and 7.2 degrees Fahrenheit within 90 years.⁶ As hotter temperatures liquefy glaciers and ice sheets from Greenland to Antarctica, all that melted ice flows into the sea: Some worst-case estimates suggest we might see seven or eight feet of sea level rise as soon as 2040.⁷ The collapse of the West Antarctic ice sheet alone,

already underway, will eventually raise sea levels by as much as twenty feet.⁸

As glaciers and ice sheets melt, so too will carbon and methane long frozen in seabeds and permafrost. As a greenhouse gas, methane is more than twenty times more powerful than carbon dioxide, and thousands of gigatons of the stuff lies locked under the oceans in clathrate hydrates, waiting to be released: “These solid, ice-like structures are stable only under specific conditions,” writes oceanographer John Kessler, “and are estimated to contain a quantity of methane roughly equal in magnitude to the sum of all fossil fuel reservoirs on Earth.”⁹ Methane-rich sinkholes have appeared in Siberia and methane bubbles have been tracked leaking from the floor of the Arctic Ocean, possibly signaling the beginning of a massive planetary “belch” capable of generating catastrophic runaway greenhouse effects.¹⁰ As geophysicist David Archer warns, “The potential for planetary devastation posed by the methane hydrate reservoir . . . seems comparable to the destructive potential from nuclear winter or from a comet or asteroid impact.”¹¹

We’re fucked. The only questions are how soon and how badly. The Intergovernmental Panel on Climate Change’s (IPCC) 2014 report on climate impacts cautions: “Without additional mitigation efforts beyond those in place today, and even with adaptation, warming by the end of the 21st century will lead to high to very high risk of severe, widespread, and irreversible impacts globally.”¹² According to the World Bank, 2.7 degrees Fahrenheit of warming now appears inevitable, even if we were to stop emitting carbon

dioxide (CO₂) worldwide right now.¹³ Projections from researchers at the University of Hawai‘i find us dealing with “historically unprecedented” climates as soon as 2047.¹⁴ Climate scientist James Hansen, formerly with NASA, has argued that we face an “apocalyptic” future—a bleak view that is seconded by researchers worldwide.¹⁵

This chorus of Cassandras predicts a radically changing global climate causing widespread upheaval, and their visions of doom are backed by an overwhelming preponderance of hard data. Global warming is not the latest version of a hoary fable of annihilation. It is not hysteria. It is a fact. And we have likely already passed the point where we could have done anything about it. From the perspective of many policy experts, climate scientists, and national security officials, the concern is not whether global warming exists or how we might prevent it, but how we are going to adapt to life in the hot, volatile world we’ve created.

There is a name for this new world: the Anthropocene. The word comes from ancient Greek. All the epochs of the most recent geological era (the Cenozoic) end in the suffix “-cene,” from *kainós*, meaning new. *Anthropos* means human. The idea behind the term “Anthropocene” is that we have entered a new epoch in Earth’s geological history, one characterized by the advent of the human species as a geological force.¹⁶ The biologist Eugene F. Stoermer and the Nobel-winning chemist Paul Crutzen advanced the term in 2000,

and it has gained acceptance as evidence has grown that the changes wrought by global warming will affect not only the world's climate and biodiversity, but its very geological structure, and not just for centuries, but for millennia.¹⁷ In the prophetic words of William Blake, written at the dawn of the carbon era more than two hundred years ago, "The generations of men run on in the tide of Time / But leave their destin'd lineaments permanent for ever and ever."¹⁸

The International Commission on Stratigraphy, the geologists responsible for driving the "golden spikes" that demarcate different geological periods, have adopted the Anthropocene as a term deserving further consideration, "significant on the scale of Earth history," and are discussing what level of geological time-scale it might be and at what date we might say it began.¹⁹ Is it an "epoch" like the Holocene, or merely an "age" like the Calabrian? Did it start with the beginning of the Industrial Revolution, around 1800, or during the Great Acceleration in the middle of the 20th century? With the dawn of agriculture, 12,000 years ago, or on July 16, 1945, with the first atomic bomb?²⁰

Whenever it began, it is the world we now live in. Within a few generations we will face average temperatures 7 degrees Fahrenheit warmer than they are today, rising seas at least three to ten feet higher, and worldwide shifts in crop belts, growing seasons, and population centers. Unless we stop emitting greenhouse gases wholesale now, humans will within a couple hundred years be living in a climate the Earth hasn't seen since the Pliocene, three million years ago, when oceans were 75 feet higher. Once the

methane hydrates under the oceans and permafrost begin to melt, we may soon find ourselves living in a hothouse climate closer to that of the Paleocene-Eocene Thermal Maximum, approximately 56 million years ago, when the planet was ice-free and tropical at the poles. We face the imminent collapse of the agricultural, shipping, and energy networks upon which the global economy depends, a large-scale die-off in the biosphere that's already well under way, and our own possible extinction as a species. If *Homo sapiens* survives the next millennium, it will be survival in a world unrecognizably different from the one we have known for the last 200,000 years.

In order for us to adapt to this strange new world, we're going to need more than scientific reports and military policy. We're going to need new ideas. We're going to need new myths and new stories, a new conceptual understanding of reality, and a new relationship to the deep polyglot traditions of human culture that carbon-based capitalism has vitiated through commodification and assimilation. Over and against capitalism, we will need a new way of thinking our collective existence. We need a new vision of who "we" are. We need a new humanism—a newly philosophical humanism, undergirded by renewed attention to the humanities.

Admittedly, ocean acidification, social upheaval, and species extinction are problems that humanities scholars, with their taste for fine-grained philological analysis, esoteric debates, and archival marginalia, might seem remarkably ill-suited to address. After all, how will thinking about Kant or Frantz Fanon help us trap carbon dioxide? Can ar-

guments between object-oriented ontology and historical materialism protect honeybees from colony collapse disorder? Are ancient Greek philosophers, medieval poets, and contemporary metaphysicians going to save Bangladesh from being inundated by the Indian Ocean?

Perhaps not. But the conceptual and existential problems that the Anthropocene poses are precisely those that have always been at the heart of humanistic inquiry: What does it mean to be human? What does it mean to live? What is truth? What is good? In the world of the Anthropocene, the question of individual mortality—What does my life mean in the face of death?—is universalized and framed in scales that boggle the imagination.²¹ As environmental philosopher Dale Jamieson puts it, “The Anthropocene presents novel challenges for living a meaningful life.”²² Historian and theorist Dipesh Chakrabarty has claimed that global warming “calls us to visions of the human that neither rights talk nor the critique of the subject ever contemplated.”²³ Whether we are talking about ethics or politics, ontology or epistemology, confronting the end of the world as we know it dramatically challenges our learned perspectives and ingrained priorities. What does consumer choice mean compared against 100,000 years of ecological catastrophe? What does one life mean in the face of mass death or the collapse of global civilization? How do we make meaningful decisions in the shadow of our inevitable end?

These questions have no logical or empirical answers. They cannot be graphed or quantified. They are philosophical problems *par excellence*. If, as Montaigne asserted, “To

philosophize is to learn how to die,” then we have entered humanity’s most philosophical age, for this is precisely the problem of the Anthropocene.²⁴ The rub now is that we have to learn to die not as individuals, but as a civilization.

Learning to die isn’t easy. In Iraq, at the beginning, I was terrified by the idea. Baghdad seemed crazily dangerous, even though statistically I was relatively safe. We got shot at, mortared, and blown up by IEDs, but we wore high-tech ballistic armor, we had great medics, and we were part of the most powerful military the world had ever seen.²⁵ The odds were good that I would come home, maybe wounded, but probably alive. Yet every day I drove out past the wire on mission, I looked in my Humvee’s mirror and saw a dark, empty hole.

“For the soldier death is the future, the future his profession assigns him,” wrote Simone Weil in her 1939 meditation on war, *The Iliad, or the Poem of Force*. “Yet the idea of man’s having death for a future is abhorrent to nature. Once the experience of war makes visible the possibility of death that lies locked up in each moment, our thoughts cannot travel from one day to the next without meeting death’s face.”²⁶ I recognized that face in the dark of my Humvee’s mirror. Its gaze almost paralyzed me.

I found my way forward through an old book: Yamamoto Tsunetomo’s 18th-century Samurai manual, the *Hagakure*, which advised: “Meditation on inevitable death

should be performed daily.”²⁷ I took that advice to heart, and instead of fearing my end, I practiced owning it. Every morning, after doing maintenance on my Humvee, I would imagine getting blown up, shot, lit on fire, run over by a tank, torn apart by dogs, captured and beheaded. Then, before we rolled out through the wire, I’d tell myself that I didn’t need to worry anymore because I was already dead. The only thing that mattered was that I did my best to make sure everyone else came back alive.

To survive as a soldier, I had to learn to accept the inevitability of my own death. For humanity to survive in the Anthropocene, we need to learn to live with and through the end of our current civilization. Change, risk, conflict, strife, and death are the very processes of life, and we cannot avoid them. We must learn to accept and adapt.

The human psyche naturally rebels against the idea of its end. Likewise, civilizations have throughout history marched blindly toward disaster, because humans are wired to believe that tomorrow will be much like today. It is hard work for us to remember that this way of life, this present moment, this order of things is not stable and permanent. Across the world today, our actions testify to our belief that we can go on like we are forever: burning oil, poisoning the seas, killing off other species, pumping carbon into the air, ignoring the ominous silence of our coalmine canaries in favor of the unending robotic tweets of our new digital imaginarium. Yet the reality of global climate change is going to keep intruding on our collective fantasies of perpetual growth, constant innovation, and endless energy, just as

the reality of individual mortality shocks our casual faith in permanence.

The greatest challenge the Anthropocene poses isn't how the Department of Defense should plan for resource wars, whether we should put up sea walls to protect Manhattan, or when we should abandon Miami. It won't be addressed by buying a Prius, turning off the air conditioning, or signing a treaty. The greatest challenge we face is a philosophical one: understanding that this civilization is already dead. The sooner we confront our situation and realize that there is nothing we can do to save ourselves, the sooner we can get down to the difficult task of adapting, with mortal humility, to our new reality.

Carbon-fueled capitalism is a zombie system, voracious but sterile. This aggressive human monoculture has proven astoundingly virulent but also toxic, cannibalistic, and self-destructive. It is unsustainable, both in itself and as a response to catastrophic climate change. Thankfully, carbon-fueled capitalism is not the only way humans can organize their lives together. Again and again throughout our history, we have shown ourselves to be capable of shedding maladaptive systems of meaning and economic distribution, developing resilient social technologies in response to precarity and threat, and transforming obsolete social practices into novel forms of life. Humanity's survival through the collapse of carbon-fueled capitalism and into the new world of the Anthropocene will hinge on our ability to let our old way of life die while protecting, sustaining, and reworking our collective stores of cultural technology. After all, our ca-

capacities to innovate and adapt depend on our being able to draw from our immense heritage of intellectual production, living and dead, exotic and close at hand: from the Iñupiat and from Islam, from Heraclitus and Zhuangzi, from the Torah and from the Buddha, from the *Federalist Papers* and from the *Communist Manifesto*. Carbon-fueled capitalism has given rise to a truly marvelous liberal multiculturalism, but if we are to survive its death throes, tolerance must mature into conservation and synthesis, grounded in a faith in human community existing beyond any parochial identity, local time, or single place.

The argument of this book is that we have failed to prevent unmanageable global warming and that global capitalist civilization as we know it is already over, but that humanity can survive and adapt to the new world of the Anthropocene if we accept human limits and transience as fundamental truths, and work to nurture the variety and richness of our collective cultural heritage. Learning to die as an individual means letting go of our predispositions and fear. Learning to die as a civilization means letting go of this particular way of life and its ideas of identity, freedom, success, and progress. These two ways of learning to die come together in the role of the humanist thinker: the one who is willing to stop and ask troublesome questions, the one who is willing to interrupt, the one who resonates on other channels and with slower, deeper rhythms.

The form this book takes is that of a story, but not a story about a person. Climate change is too big to be reduced to a single narrative, and the problems it presents

us with demand that we transcend visually representative “picture-thinking” and work instead to create a sense of collective humanity that exists beyond any one place, life, or time. The story this book tells is of the human soul coming to know itself in its mortality. It begins in the deepest origins of our primal relationship with the Earth’s climate, in Chapter 1: Human Ecologies, which traces that relationship up through our current moment and our contemporary predicament. In Chapter 2: A Wicked Problem, we consider that predicament. Carbon-fueled capitalism and its technoutopian ideologues have promised infinite growth and infinite innovation, yet they have proven incapable of saving us from the disaster they have made. Various “solutions” to climate change have been offered, from carbon taxes to geoengineering, but none of them are likely to work. This chapter takes a look at the reasons why.

The global failure to address climate change is fundamentally a collective action problem, meaning it is a political problem. In Chapter 3: Carbon Politics, we consider how our collective failure to respond to climate change is an effect of the very structures of our political systems and the way that they are built around decentralized flows of oil and gas. The systems that structure our political desires and constrain our political will have a material history. As the human animal developed increasingly complex social technologies for producing power, from hunting bands tracking migrating herds of giant elk and mastodons to agricultural empires harvesting grain to fossil-fuel-burning global capitalism, we also developed increasingly complex technologies of collec-

tive life. As our technologies of producing power changed, so did our technologies for distributing and controlling it. Today, global power is in the hands of a tiny minority, and the system they preside over threatens to destroy us all. With this in mind, we turn back to the collective danger that carbon-fueled climate change poses, this time considered in terms of our primal human responses to existential threat: fight or flight. Facing the fear of death and the inevitability of conflict in the Anthropocene is the task of Chapter 4: The Compulsion of Strife. Progressivist belief in the infinite perfectibility of the human animal depends significantly on carbon-fueled capitalism's promises of infinite economic growth. Accepting our limits means coming to terms with our innate violence and our inescapable mortality.

By learning to die, though, we can connect with and open up new possibilities for the human future, as I argue in Chapter 5: A New Enlightenment. Through interrupting social circuits of fear and reaction, looking deep into the face of death, and cultivating our rich stocks of human cultural technology, from the *Epic of Gilgamesh* and the *Bhagavad-Gita* to imagined Anthropocene futures, we open up a human relationship to the universe in which we might live not as parasitic consumers, but as co-creators—a relationship in which we might learn to live as the very light from which all our power ultimately flows.

The crisis of global climate change, the crisis of capitalism, and the crisis of the humanities in the university today are all aspects of the same crisis, which is the suicidal burnout of our carbon-fueled global capitalist civilization.

The odds of that civilization surviving are negligible. The odds of our species surviving are slim. The trouble we find ourselves in will likely prove too intractable for us to manage well, if we can manage it at all. Yet as German philosopher Peter Sloterdijk observes: “It is characteristic of being human that human beings are presented with tasks that are too difficult for them, without having the option of avoiding them because of their difficulty.”²⁸ We cannot escape our fate. Our future will depend on our ability to confront it not with panic, outrage, or denial, but with patience, reflection, and love.

Our choice is a clear one. We can continue acting as if tomorrow will be just like yesterday, growing less and less prepared for each new disaster as it comes, and more and more desperately invested in a life we can’t sustain. Or we can learn to see each day as the death of what came before, freeing ourselves to deal with whatever problems the present offers without attachment or fear.

If we want to learn to live in the Anthropocene, we must first learn how to die.

City Lights

ONE

HUMAN ECOLOGIES

*Erþe toc of erþe erþe wyþ wob,
Erþe oþer erþe to þe erþe droh,
Erþe leyde erþe in erþene þroh,
Do heude erþe of erþe erþe ynob.*

Earth took of Earth, Earth with woe,
Earth other Earth to the Earth drew,
Earth laid Earth in an Earthen trough,
Then had Earth of Earth Earth enough.

—Anonymous Middle English Lyric²⁹

The first human beings appeared in tropical Africa around two hundred thousand years ago, evolving out of proto-human hominids, born into a world that was even then undergoing intense climatic transformation.³⁰ The Earth was on average about 3.5 degrees Fahrenheit colder than it is today, and would soon average between 5 degrees and 9 degrees Fahrenheit colder. The global climate was frigid, dry, and harsh. The northern hemisphere was mantled in vast ice sheets up to two and a half miles thick that reached as

far south as Ohio, England, Germany, and northern China. Thirty percent of the Earth's surface was covered in glaciers. The oceans were more than 270 feet lower than they are now. This was the world in which we first evolved and learned to survive.

Our ancestors, omnivorous hunter-gatherers who traveled in small bands, lived in equatorial Africa for many thousands of years. But when temperatures warmed up about 135,000 years ago, reaching averages as much as 5 degrees Fahrenheit warmer than the present, our ancestors fled the tropics for more temperate climes, hunting their way into the then-verdant grasslands of the Sahara. The Earth had entered what geoscientists call an interglacial period, a regular period of warming that occurs between much longer periods of colder temperatures every hundred thousand years or so.³¹ These periods are typically brief, geologically speaking, each lasting around ten thousand years.

So it was for our ancestors on the Sahara: After a few millennia, temperatures dropped, getting even colder than before (between 7 and 10 degrees Fahrenheit colder than the present), glaciers once again advanced toward the equator, and the oceans shrank. The Sahara lost the humid warmth that had kept it green, and our hunter-gatherer ancestors scattered back south to tropical Africa, east to the Nile valley and beyond, and north around the Mediterranean and into Europe, where they lived alongside, interbred with, and then wiped out our close cousin, the Neanderthal. Over a long winter lasting thousands and thousands of years, as minor climate variations shifted temperatures up and down

slightly over decades and centuries, human hunting bands expanded across Asia, eventually crossing the Bering land bridge to the Americas.

Sometime in that period, between one hundred thousand and fifty thousand years ago, we developed the key social technologies that have proven our most substantial predatory advantages: culture and symbolic reasoning.³² This advance was doubtlessly part of what helped us exterminate the Neanderthals and survive the harsh winters, and it also helped us turn the basic tool-use we had inherited from earlier hominids into the intricate technologies of the Cro-Magnon hunter: multilayer winter clothing, mammoth-bone houses, sewing needles, antler-tipped spears, religious rituals, and sophisticated tribal organization. Then, from about fifty thousand to about ten thousand years ago, Upper Paleolithic peoples experienced a veritable cultural explosion. The artifacts they left show technologies more advanced in almost every way than those of their predecessors, more varied, more elaborate, more refined, and more beautiful, with some tools even seemingly designed to be purely aesthetic in function—which is to say, works of art.³³

About fifteen thousand years before Hurricane Katrina, the planet started to warm up again, entering another interglacial period, with the most intense and rapid warming happening around 11,000 BCE. Humans began developing villages, basic animal husbandry, and more deliberate systems of gathering. A brief, localized cold snap called the Younger Dryas, caused by glacial meltwater spilling into the Atlantic Ocean and shutting off the Gulf Stream, brought

frigid temperatures to Europe and drought to southwest Asia for a thousand years.³⁴ According to archaeologist Brian Fagan, it was almost certainly this drought that drove the people in a small village on the Euphrates, who had until then depended for their sustenance on hunting desert gazelles, harvesting nuts, and gathering wild grasses, to begin deliberately cultivating rye, lentils, and a grain called einkorn.³⁵ By 9000 BCE, after the Younger Dryas had ended and the Gulf Stream had switched back on, the agricultural revolution had begun. Neolithic humans hunted, herded, gathered, and farmed from Europe to South America, thriving in the warm and mild climate of what is now called the Holocene.

A few thousand years later, the Laurentide ice sheet in northern Canada collapsed, causing a rapid rise in sea levels, and, as had happened with the Younger Dryas, shutting off the Atlantic Gulf Stream. Cold, dry conditions descended on Europe and southwest Asia. This cold drought lasted four centuries before the Gulf Stream switched on again. In the marshy confluence of the Tigris and Euphrates rivers, farmers began constructing irrigation canals to control flooding and increase crop yields. Villages grew into towns, and as the people living in these new towns struggled to deal with the complex, difficult group effort required to construct and maintain levee systems, keep records of floods and farm yields, and bring in the harvest, they began to develop refined divisions of labor, hierarchical political structures, sophisticated religions, and writing. Temples and marketplaces were built, traders carried goods from one town to

another, and priests accumulated power as they hoarded knowledge of weather patterns and seed growth. The settlements of Ur, Eridu, and Uruk grew from clusters of villages to immense cities of tens of thousands. Through a complex interplay of droughts, population growth, and the increasing centralization of agriculture, human society based in and around cities—what we call “civilization”—emerged in the fertile crescent of land arcing from present-day Lebanon through Syria and Iraq to the Persian Gulf. From approximately 3100 to approximately 2200 BCE, Sumerian and then Akkadian kings ruled a vibrant collective form of life that stretched across Mesopotamia. But when a three-hundred-year-long drought hit the region, that vibrant empire fell apart.³⁶ Mighty Uruk stood desolated.

From ancient Uruk to modern-day Iraq we span about five thousand years, including nearly all of recorded human history—the Greeks, the Romans, the Tang dynasty, the Mongolian khanate, World War II, the invention of the cellphone, and all seven seasons of *Mad Men*. If human existence on Earth were a day, our approximately five millennia of recorded history would take up the last half hour before midnight. Throughout 99.9 percent of humanity’s two hundred thousand years on Earth, the average planetary temperature never rose above 61 degrees Fahrenheit and carbon dioxide concentrations never went above 300 parts per million (ppm). Nearly all of our energy came from photosynthetic processes: most of our fuel was plant food, for ourselves directly, through the animals we used and preyed on, or through biomass like wood, with some use of water

and air power through technologies like mills and sails, and negligible use of coal and oil.

Then, in 1781, James Watt invented the continuous-rotation steam engine. Suddenly power was portable, independent of living beings or natural forces, and able to run continuously. The steam turbine offered a vast improvement in energy production over wind, water, and animal labor, but it needed dense, hot-burning fuel for maximum output. Luckily for Watt, there happened to be loads of the stuff all over England: fossilized carbon in the form of coal.

Industrial coal changed everything. For the last two hundred years, just about one tenth of one percent of human existence, most of our energy has come not from direct photosynthesis but from stored carbon energy in fossil fuels. Switching from a photosynthetic-based energy economy to a carbon-based energy economy increased human wealth beyond what anyone could have possibly imagined, raising the overall standard of living across the world through such technologies as diesel-fueled tractors, Haber-process nitrogen-fixed fertilizer, Bessemer steel, railroads, steamships, airplanes, electric power plants, plastics, the internal combustion engine, and the automobile. It also began a massive transformation of the physical systems regulating life on Earth. By transferring millions of tons of carbon from the ground into the air, we have wrought profound changes in the Earth's climate, biosphere, and geology. Average atmospheric CO₂ levels have rocketed from 290 ppm to over 400 ppm, a level the planet hasn't seen in more than two million years. At the same time, methane (CH₄) levels have

increased from 770 parts per billion to more than 1,800 parts per billion, the highest concentration of atmospheric methane in at least eight hundred thousand years.³⁷ These changes have disrupted the climate patterns regulated by the Earth's orbit around the Sun and will continue to disrupt them for thousands of years.

Our planet can sustain life because when energy from the Sun strikes the Earth, some of it is trapped in the atmosphere as heat. There are several greenhouse gases that help this happen, including carbon dioxide, methane, water vapor, and nitrous oxide. These gases are integral to the planet's complex geophysical homeostasis. That homeostasis has shifted, over millions of years, back and forth between "greenhouse" and "icehouse" states. During the last major greenhouse state, in the Eocene, the planet was ice-free, tropical from pole to pole, up to 20 degrees Fahrenheit warmer than it is now, and had CO₂ concentrations up to ten times those of today. The oceans were 300 feet higher. Large reptiles and dwarf mammals ranged through lush forests: a forty-foot-long snake that weighed more than a ton, a tiny horse the size of a dog, sleek feline predators, and lemur-like primates. Crocodiles and palm trees thrived along the Arctic Circle. That was fifty million years ago. Since then, the Earth has cooled, and it has been in an "icehouse" state for more than two and a half million years. We have very likely brought that state to a premature end.

For the first sixty thousand years of *Homo sapiens*' life on Earth, global temperatures 5 to 9 degrees Fahrenheit colder meant an ice sheet covering what is now Chicago