Introduction

Let us not, however, flatter ourselves overmuch on account of our human conquest over nature. For each such conquest takes its revenge on us.
—Friedrich Engels, *Dialectics of Nature*, 291–92

Enough is enough. This is a mantra of the "enough movement," a movement of largely Western citizens concerned about the rapid degradation of the earth caused by the wrath of unending growth and industrialization, manifesting itself in the existential crisis of our time: the "wicked universality" of climate change.[1] The enough movement argues that unmitigated economic growth, assumed to be a basic and justified goal of every nation and every individual on earth since at least the advent of the Industrial Revolution, is patently unsustainable.[2] Perhaps to the detriment of a focus on the systemic and strategic political issues of regulation, the movement focuses on the tactical consumer choices of individuals. A majority of those individuals in the West already have every basic thing they need: food, clothing, shelter. We don't need single-use plastics or a brand-new wardrobe every season or vacations halfway around the globe. We must unlearn the wantonness of the consumer culture that is force-fed to us by the marketeers of late capitalism. Just as responsible people do not spend more money than they earn, so too should we resist the temptation to place a burden on the global commons that is greater than what it can handle. *Enough is enough*.

The bedrock on which this urgent philosophical turn to questions of sufficiency and consumer culture originates is not humanism but science. As Dipesh Chakrabarty argues in his landmark essay "The Climate of History: Four Theses," the Anthropocene, the period in which human agency became powerful enough to disrupt geology, is an unequivocal reality that in turn disrupts the continuity of human experience.[3] In other words, a disruption of geology is a disruption in the human experience, which in effect necessitates

a disruption in thinking. Even if the cynic wipes away pop movements like the enough movement and buzzy lingo like "Anthropocene" and "disruption," what remains is a cold, hard reality that can be ignored only by a very real and new cult of post-truthism. The quest of the "enough" movement, despite its fixation on the consumer instead of the regulator, holds important tenets that may help us leverage Chakrabarty's theses from the outside in. The philosophical pursuit of enough—of sufficiency—has in it the capacity to transcend the -isms that might otherwise preoccupy the foreground of a scholarly consideration of the modern period: neoliberalism, progressivism, Marxism. Capitalism and its limits, in this context, are a matter not of ideology but rather of the survival of flora and animal species, including *Homo sapiens*. Histories of imperialism, colonization, and globalization and the methodological focus of feminism, poststructuralism, and decolonization all take on new valences when framed as a matter not only of the value of the human but also of her survival. Whether framed as an intersection or a dialectic of science and humanism, we can reject this reality only if we believe that the two pillars of human knowledge—science and humanism—are mutually exclusive. Chakrabarty poignantly reminds us that the "mansion of modern freedoms stands on an ever-expanding base of fossil fuel use."[4] An architectural historian will not—and should not—resist the temptation to see something specific in Chakrabarty's allegorical mansion.

Which brings us to a question. Where does architecture figure in this picture of a brave new world of enoughness? That question, the speculative force behind this book, is not an easy one to answer. Architecture can just as easily be no-nonsense shelter—*enough*—as it can be superfluous, gluttonous, *more than enough.* We do not need indoor skiing centers in the desert. We do need to house the homeless. Beauty in architectural form is a worthy pursuit. Excess is not. What is the difference?

The field of architectural history has yet to tackle this question wholeheartedly, and there are some logical reasons why this might be the case. The most obvious is that the climate crisis—and our adaptation to it—is something that is unfolding today and into our future and that history can imperil its own autonomy and intrinsic value when it subordinates itself to instrumental purposes, such as explaining a path to current events. The contemporary and prospective condition, after all, would seem to be the domain of designers. We can simply analyze their decisions in twenty or more years' time and make sense of them with the safe distance that time provides. This position, which until recently seemed so admirable for its disinterestedness, feels increasingly untenable and neglectful. Do we even have twenty years to wait? What can we contribute now, rather than later? How can the discipline of history address our ecological crisis and offer our colleagues in design and other fields synthetic ideas that are rooted in history and resist the facile cliché of history repeating itself or the need to learn some sort of inevitable lesson?

In pursuit of this task, there are two clear ways forward. The first is to displace the human from the center of architectural history, a displacement that may be an ethical imperative in light of the trouble humans have wrought on the earth by placing themselves at the center to begin with. This is not to argue that humans are unimportant or negligible in the creation of architecture—they are clearly and inarguably the core of everything that architecture is about. Yet all too often our notion of

the human is framed around tropes and concepts, such as "masterpiece," that patently resist holistic, ecological narratives and promote timeless ideals in their stead. This framing goes back more than a century to the formation of architectural history as a discipline, and to its largely uncritical adoption of the conventions of art history and the words that are used to describe the solitary pursuits of media like painting and sculpture.[5]

Take the concept of genius, for example, an adjective and noun that has been used to describe countless architects of the past and the present. "Genius," as a word, has a long history involving two etymological origins and several distinct meanings. Nevertheless, the word has carried with it an air of being utterly self-evident in the modern period, requiring close to no qualitative or quantitative explanation. As Ann Jefferson notes, the word "genius" acts as "an accolade that defines its object as an exception in a class of its own . . . possessing rather more evaluative purpose than precise semantic content. . . . If one pauses to reflect, however, 'genius' is oddly hard to define, and what is odder still, this does not seem to count against its viability as a concept. Speakers continue to use the word as if they can count on listeners to understand what they mean, and the attribution of genius is often used as a clincher in discussions as if to suggest that the word is entirely self-justifying."[6] This is precisely the case in the monographic strain of architectural history, which has reified Wright, Mies, and Le Corbusier, among others, without sufficiently pausing to fully probe the innumerable other people—architects, engineers, builders, and users—who are, unlike in the case of painting or sculpture, necessarily involved in a work of architecture. Nor does this strain of architectural history fully wrestle with the ecological contexts of these figures. By this I do not mean their appreciation for the natural environment, something that seems essential for any decent work of architecture, but rather how the materials and processes they employ interface with the materials and processes of nature itself—in other words, the roles of these multiple authors as designers not merely of form but of ecological relationships.

The second way forward is to emphasize materiality. This seems to be a logical next step in thinking about the built environment after displacing the human from the center, as it surreptitiously brings us back to what Bruno Latour calls the "terrestrial," in which one occupies a territory that is bound to earth, the power of which derives from what can be sustained there.[7] The ecologist and indigenous theorist Robin Wall Kimmerer provides a useful new template with which to think like a scientist, as the climate crisis demands, while also thinking about the spiritual value of deanthropocentrizing our knowledge systems, as humanism, ironically, demands. She explains this through the act of weaving baskets with sweetgrass:

> In weaving well-being for land and people, we need to pay attention to the lessons of the three rows [of basketmaking]. Ecological well-being and the laws of nature are always the first row. Without them, there is no basket of plenty. Only if that first circle is in place can we weave the second. The second reveals material welfare, the subsistence of human needs. Economy built upon ecology. But with only two rows in place, the basket is still in jeopardy of pulling apart. It's only when the third row comes that the first two can hold together. By using materials as if they were a gift, and returning that gift through worthy use, we find balance. I think that third row goes by many names: Respect. Reciprocity. All our Relations.[8]

What if steel (or glass, or any other material) is rethought as a gift from the earth, not some endless resource? How valuable is that gift when we consider what sacrifices and labor have gone into it? How do we accept that gift with humility? And how do we find "worthy use" of that gift and return our gratitude to the source from which it came? The architecture of the modern period, like a brilliant new basket with brand-new techniques, was conceived afresh largely based on the invention of new materials and the enhanced performance of old ones. But we have not treated it like a gift; we have made it a workhorse. What's more, the importance of materiality in the making of architecture in the modern period has been subsumed under the more fashionable rubrics of form, function, and cultural meaning, divorcing it from ecology. What of the inherent value of materiality in the study of architecture, which can, in addition to the ecological, also relate architecture to broader social and political implications? This book follows both of these paths—decentering the human and emphasizing materiality—as concurrent ways forward, interweaving and interrelating them at every possible juncture.

The questions of ethics that run through any study of the built environment and its relationship to human ecology are enormous. This book attempts to make them more manageable by focusing on two materials, iron and steel, and it goes yet further by circumscribing the investigation within certain sensible contours of both geography and chronology. Those contours center on the time and place where modernism began its radical break with history, the industrial West in the long nineteenth century. This was an era that saw the gradual dissolution of dynasties and the rise of the nation-state, whose greatness lay in the new, not in the spoils of or references to the past. Indeed, architectural modernism has often touted its material innovations as ex nihilo.

That this book both begins and ends in the earth is not incidental. "The very notion of soil is changing," says Latour, directly addressing the semantic shift of the word "soil" in the framework of climate change. "The soil of globalization's dreams is beginning to slip away," he notes. "Now if there is no planet, no earth, no soil, no territory to house the Globe of globalization toward which all these countries claim to be headed, then there is no longer an assured 'homeland,' as it were, for anyone."[9] Such is the predicament of the twenty-first century, argues Latour, the first century in which we will become fully aware of the long-term climatic effects of what is now called the Anthropocene, not only exerting pressure on our planet but setting into motion mass migrations that have already begun to overhaul the rules of politics on a global scale. The destabilization of soil, the contemporary loss of the sacred concept of terra firma, is not tangential to the history of architecture. The very heavy industrial processes that brought us plate glass, iron, steel, and plastic are among the many anthropogenic achievements that have also turned up temperatures and raised the level of the sea. Globalization, fueled as it is by carbon emissions, has been transformed from a cosmopolitan idea into one that is frighteningly provincial and small-minded.[10] The result is a self-aggrandizing narrative of progress that also advocates a kind of apolitical, anti-ecological framework, one in which modern architecture exists both apart from history and outside the natural world in which things, including buildings, are born, die, and return to the earth. Needless to say, modernism does not exist outside history or ecology, and one of the

main goals of this book is to introduce ways to read modernism from the bottom up, so to speak.

It is worth noting that the term "ecology," the spatial and temporal patterns of the distribution, abundance, and interrelationship of organisms with nature and one another, was indeed coined in Germany in the period this book focuses on, by Ernst Haeckel in his book *Generelle Morphologie der Organismen*, published in 1866. Although the roots of ecological thinking go back at least to the ancients, it was in the nineteenth century, through the collective work of Haeckel, Alexander von Humboldt, Isaac Newton, Eugenius Warming, Carl Linnaeus, and Charles Darwin, foremost among others, that ecology emerged as a credible way of discussing life on earth. With that credibility began the tabulation of the human habitat's growing imbalance in nature. If the era of the Anthropocene was hatched in the age of discovery, it was in the nineteenth century that it gained self-awareness. This self-awareness came at a time that could not have been more inconvenient: industry was booming and cities were growing horizontally and vertically with the outsized help of iron and steel. The capacity for critical inquiry into the inability of human ecology to coexist with modernity and modernism was always stunted because capitalism accelerated the dissymmetry.

Of all the heroic building materials of modernism, steel and iron are perhaps the ripest for this effort. Steel and iron, the most ubiquitous of humankind's advanced metals, are the culmination of a succession of metals that are often used to measure humans' civilizational sophistication over time and, in two cases—bronze and iron—to periodize three millennia of human and, by extension, archaeological history.[11] To understand steel, we must first understand iron. Both derive

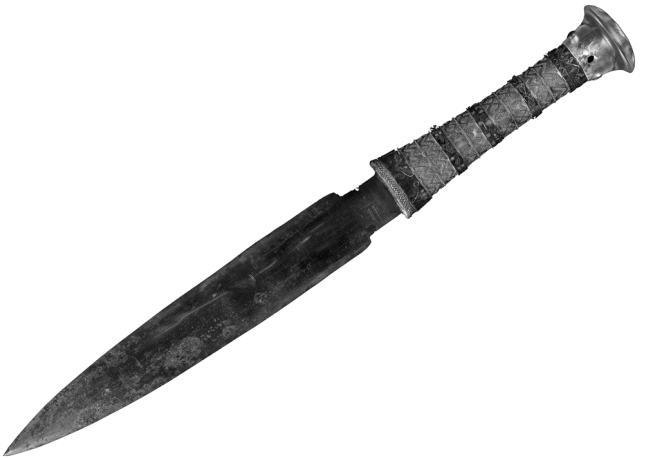

Figure 1. King Tutankhamun's meteoric iron dagger, ca. fourteenth century BC. Photo courtesy Sandro Vannini / laboratoriorosso.

from iron ore, and they remain chemically similar, with minor differences in their proportions of iron, carbon, silica, sulfur, phosphorus, and manganese that make for significant differences in their structural carrying capacity. Following centuries of sporadic and unsystematic smelting elsewhere, iron gained a deep cultural currency in ancient Egypt. At some point during his short reign (ca. 1334–1325 BC), Tutankhamun, popularly known as King Tut, acquired a dagger whose blade was later discovered to be made of iron hammered from a meteorite (fig. 1).[12] The dagger is one of a handful of precious objects made of meteorite iron that signal the material's extremely rare—and valuable—status, as iron from outer space has a higher nickel content than earthly iron. These objects therefore indicate that humans' initial contact with the metal occurred when it was serendipitously found on the earth's surface. King Tut's dagger is a symbol of the end of a chronological period when metals, found on or near the ground, served as décor for the everyday modification of humans' bodies and

their environment.[13] In the period that followed, humankind would turn its focus to that which was not readily apparent on the earth's surface but lay beneath it, and society would be fundamentally changed by the structural use of these metals.

The ferrous metallurgy of terrestrial iron ore, requiring a sustained melting point of 2,800 degrees Fahrenheit, necessitated kilns and hearths, which appeared in different places at different points in time and in different civilizations, including the Achaemenids in the Near East, the Greek, Roman, and Viking civilizations in Europe, and the Ashoka people of the Indian subcontinent. The written records of these civilizations and their successors indicate an increasingly common association between the material superiority associated with iron and moral achievement. The mining of iron ore entered a feedback loop with the mining of coal, which allowed the iron ore to be heated at higher temperatures and in greater amounts, and this in turn provided for objects of greater size, utility, and strength. Steel emerged from this loop, with its superiority to cast and wrought iron, and its greatest first applications lay in the creation of weaponry.[14] These advances, coupled with some misfortune in the immune systems of the people of the "New World," are what Jared Diamond has famously argued tilted the rest of history's fate in favor of Europe from the early modern period onward.[15] The orientation toward the New World also signaled an elementary orientation shift in global affairs away from the Mediterranean world to that of the Atlantic, a shift that we see reflected in the steel industry centuries later.[16] The year 1492, in which Columbus "discovered" the Americas, marks a massive change in the stratigraphic record, demonstrably showing the impact of carbon on the environment for the first time—which, according to T. J. Demos and numerous others, justifies identifying this point as the beginning of the Anthropocene.[17]

The rapid uptick in the production of knowledge that coursed through the age of discovery and ultimately the Enlightenment put an abrupt end to several misconceptions about the planet, such as the notion that it was flat, and all of this led to a far more complex understanding of human ecology. But, as the Copernican revolution demonstrated, advances in human knowledge were not always tantamount to a fuller or more ethical philosophy of the environment. While Copernicus may have refuted pseudosciences such as astrology and alchemy, his placement of the earth at the periphery rather than the center of the universe would ultimately prepare modern subjects to resist deep ecology, or the idea that every living being has an inherent worth regardless of its utility to humans.[18] Crazy as it may sound, for many, scientific discovery supplanted superstition and faith-based thinking, and justified the idea that the complex interrelationships between living and nonliving things on earth were not particularly unique or fragile and that anthropocentrism was in turn fully justifiable.

It would be overly causal to suggest that this perversion of Enlightenment science facilitated the imminent Industrial Revolution and the environmental degradation that would follow it, but at the very least it makes clear how the drive for the accumulation of capital associated with the period could be justified in anthropocentric terms. As it turns out, capitalism has no intrinsic implements for enforcing environmental accountability. Lest we forget, it was this drive toward wealth accumulation, so well documented by Weber, Marx, Engels, Malthus, and others, that led to the vertiginous

detonation of inequality and the confusion today between living standards and quality of life.[19] This is just one reason for the suggestion that we adopt the word "capitalocene" in place of "anthropocene" to honestly describe the situation from the nineteenth century onward.[20]

The earliest decades of the Industrial Revolution witnessed a rise in the availability of portable commercial goods like plows and pots made of ferrous metals, although structural wrought iron, cast iron, and steel were largely still too difficult to produce. Their potential, however, could no longer be in doubt after the completion of Thomas Farnolls Pritchard and John Wilkinson's Iron Bridge at Coalbrookdale in the north of England, the world's first major bridge to be made of cast iron, in 1781 (fig. 2).[21] The Iron Bridge served as a harbinger of Britain's dominance in structural metals for the century that followed.

Henry Cort's puddling process led to further advances in the use of structural wrought iron in the hulls of ships and bridges.[22] Engineers and inventors all seemed to know, though, that the future of structural metals lay in the premium potential of steel. That is what led Henry Bessemer to unveil the metallurgical process bearing his name in 1856, a process in which air was blown through molten pig iron to remove its impurities, which in turn allowed for the production of very high-quality steel that was easier, quicker, and seven times less expensive to produce than was possible with earlier methods.[23] Bessemer's method is one of the punctuation points of the second Industrial Revolution and laid the groundwork for early steel works such as Sir John Fowler and Benjamin Baker's Forth Bridge, completed in 1890.

The open-hearth, puddling, and rolling processes all advanced at breakneck speed, which led

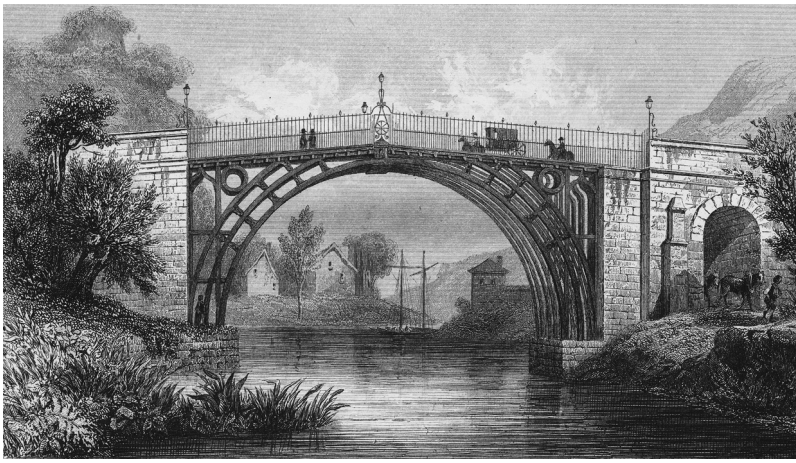

Figure 2. Unknown, Iron Bridge at Coalbrookdale. Photo: akg-images / De Agostini / Biblioteca Ambrosiana.

one American entrepreneur, Andrew Carnegie, to declare, "Farewell, then, Age of Iron; all hail, King Steel."[24] By the final quarter of the nineteenth century, steelmakers and some iron manufacturers on either side of the Atlantic were producing wide flanged beams and other structural steel units adaptable, in concert with one another, to any number of recombinations in architecture and civil engineering. Certain historical events—such as the Great Chicago Fire of 1871 and the expansion of railways across the American West—were particularly fruitful for the development of structural steel in that they furnished tabula-rasa opportunities to conceive and create radically new building typologies, such as the skyscraper and the open-span railway station. Structural steel became the measuring stick by which all other materials were judged, and was in fact the wellspring of its own greatest competitor in the twentieth century: reinforced concrete.

But at what cost? The economic success of many companies, including those in the steel and

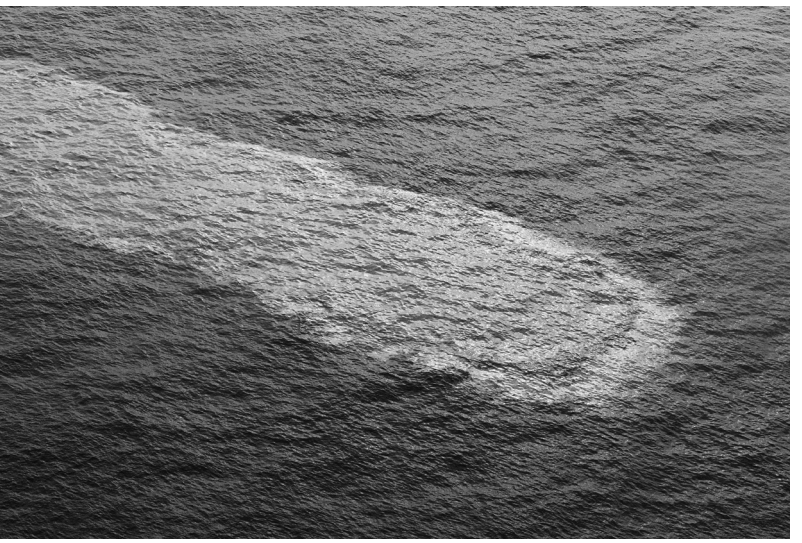

Figure 3. Aerial view of oil on the surface of the sea during the Deepwater Horizon oil spill, coast of Louisiana, Gulf of Mexico, August 2010. Photo: Nature Picture Library / Alamy Stock Photo.

construction industries, was measured by their ability to meet investor expectations over absurdly long periods of time, some as much as a century. This enshrined the necessity, barring the production of any comparable energy alternative, of burning fossil fuels to meet long-term financial expectations. The commonalities between today's climate crisis and colonialism, which began in earnest in the period this book addresses, are increasingly clear: both meant dispossession, the former of territory, the latter of sovereignty.

The difficulties associated with making images of the slow, gradual process of climate change has also stymied a more robust response over the past few decades. It is only recently that we have finally begun to see and highlight those images. The Deepwater Horizon oil spill of 2010, for example, put a painful, if necessary, image into circulation, one that showed the unmitigated damage caused by the exploitation of fossil fuels (fig. 3). This book, as part of its attempt to force a reckoning in the field, offers some less obvious but equally important images of the slow impact that architecture has concomitantly played in altering our climate.

This book does not seek to condemn iron or steel. To be clear, these metals have had a radical impact on architecture, forever changing how we perceive and inhabit buildings: they liberated the floor plan from columns, allowed the pursuit of the cantilever, and provided the ability to hang façades as if they were curtains. This we already know, and these are things we should all admire. What isn't discussed, however, is that these metals also produced a radical new ecology that reflected a changed (although not depristinated) relationship between humans and the environment, not to mention between disparate cultures. These two ecologies, natural and intercultural, constitute the two lenses of the proverbial glasses through which this book was researched and written, and they color every object and theoretical concern it raises. These lenses will necessarily show the damage wrought by steel production while also highlighting the occasional moments when it has acted with particular efficiency and suggested untapped ecological potential. This book jettisons iron and steel's familiar guise as the heroic aid to the "genius" architects and "masterpieces" of modernism; instead, the ordering logic of this book considers steel's ecology as distinct in time, coming from the earth, passing through human hands, and eventually returning, in some way, back to the earth.

This brings us to the geographical and chronological circumscription of the book and what enables a "horizontal" approach also to proffer "vertical" depth, something that histories rooted in primary sources ought to do. The book's

documentary center of gravity features Krupp, the global titan of the German steel industry during the second Industrial Revolution. For about a forty-year period leading up to World War I, Krupp exemplified the stratospheric rise of German might that followed the consolidation of the German Empire in 1871. Prior to this, Germany was well behind England, and afterward it would be eclipsed by the United States. The story of German steel can thus serve as a primer on the nature of industrial power as it transitioned from the world of empires to the world of nations: Krupp is an entity that emerged from a regional culture centered on crafts and interregional trade to become an industrial and military powerhouse with immense political capital on the global stage. However, broad-minded historical studies of the nineteenth century have tended to gloss over Germany, relying on the rather simplistic aphorism that the eighteenth century belonged to France, the nineteenth to England, and the twentieth to the United States (with speculation that the twenty-first will belong to China, in no small part the result of its booming steel industry).[25]

Yet this book also has a decidedly global and international scope, as it not only examines the macro implications of the steel industry in Germany but also interweaves that analysis with a considerable amount of substantive comparative material from France, the Ottoman empire, the Indian subcontinent, the Austro-Hungarian Empire, England, the United States, and elsewhere. As with Bethlehem Steel and later Ford in the United States, Peugeot in France, and Mitsubishi in Japan, the confluence of corporate, industrial, and national history found at the Krupp headquarters in the Ruhr Valley is stunning in how it marks the corporation as a microcosm of the nation and its economy.[26] This microcosm of German power has attracted a fair share of scholarship, particularly Marxist interpretations, but the Marxist framework has also limited the scholarly cone of vision to the analogic dyad of corporation and nation. This book moves beyond this dyad and the fields of economic and political history by exploring the role of steel in a global context through the lenses of architectural and environmental history, two fields that are absent in the scholarship. Further, to limit the story to Krupp, as important as the company may have been, would be to ignore too many other pivotal companies and production sites that promote, in much the same way that the genre of biography can, a kind of hagiographic narrative that works against the ecological situatedness of this book.

This roughly forty-year period, known in Germany as the *Gründerboom* and globally as the "age of steel," is strategic not only because it isolates the singular importance of Germany's role in shaping the ecology of steel both nationally and internationally, but also because it highlights a set of discrete historical conditions that can easily be overshadowed by the sheer scale of twentieth-century wars and markets.[27] The most important of these historical conditions is the ambiguity of the environmental impact of mass industrialization. During this period, in which the Romantic movement in art and literature that prized nature so highly began to fade, there was an understanding that the soot and pollution of the steel and other industries were at least fleetingly problematic for the quality of life on earth. However, a bona fide environmentalist movement, including the concept of a carbon footprint, was yet to materialize. This made for a moment in which confidence in industry and technology prevailed over a stirring insecurity about the mortgage that mankind

was placing on the future. This moment may be instructive as the second great wave of techno-optimism recedes in the twenty-first century and we encounter a new wave of hope that technology can reverse the very problems we let it create in the first place—which raises the question: which leaps of faith merit our collective investment and which do not?

As a revisionist interpretation of the history of metals that combines the methods of environmental history with business and trade history collected from various archives, this book necessarily engages a wide body of primary and secondary literature. *Stuff Matters: Exploring the Marvelous Materials That Shape Our Man-Made World*, by Mark Miodownik, brings a material scientist's lens to the study of steel and ten other common materials. Although *Precious Metal* adopts some similar strategies, it extends the depth of Miodownik's approach by focusing on a specific material. Sigfried Giedion's *Bauen in Frankreich, Eisen, Eisenbeton* is an important early example of material-focused architectural history that examines a composite material also discussed in this book: reinforced concrete. *Precious Metal* draws on Giedion's historiographic legacy but goes one step further by inscribing it within the concerns of deep ecology. Adrian Forty's *Concrete and Culture: A Material History* is another material study, influential in focusing not on a material's technical properties but rather on its effects on culture across time and space. Tony Fry and Anne-Marie Willis's *Steel: A Design, Cultural, and Ecological History* addresses steel's role in industrial design and mechanics. While both *Concrete and Culture* and *Steel* are comprehensive, neither addresses the environmental aspects at the center of *Precious Metal*.

Suraiya Faroqhi and Zülal Kılıç's *Osmanlı Zanaatkarları* is an important work on Ottoman craftsmen that examines how individual guilds developed largely around concepts of expertise as they related to specific materials, in turn shaping, among other things, the organization of labor in the sphere of construction. Suzanne Preston Blier and James Morris's work on adobe architecture in West Africa, Elisabetta Conti's edited volume on steel in Italy, Hamady Bocoum's study of Africa's metallurgical history, and Mario Rinke and Joseph Schwartz's edited volume on wood all provide superb models of material-centered studies whose methodologies and gleanings offer the most sophisticated and up-to-date approaches in this small and emergent methodological subfield to date.

Of all the actors that shape the narrative of this book, be they corporate or individual, none enjoys a more developed body of literature than Krupp, with particularly strong works in political and economic history. Harold James's *Krupp: A History of the Legendary German Firm* is the most recent comprehensive biography of the firm over many generations, synthesizing a vast body of scholarship and augmenting it with some new archival research.

This book is divided into six chapters, each representing a distinct phase in the life cycle of steel. The first chapter, "Origin," explores the birth of steel in architecture by examining the mining of coal and iron ore for steel production, the geological and metallurgical research behind iron and steel, and the processes of environmental degradation and displacement this entailed. Mining is a robust subfield of environmental history,[28] and this chapter brings the concerns of that field to bear on architecture by examining how prospecting

developed and how the earth came to be understood as a site of immense financial opportunity, despite considerable engineering challenges. The chapter looks at sites in the industrial West—Nevada, northern England, and, of course, the Ruhr Valley—along with sites that the steelmaking powers sought to exploit in Spain, Algeria, and Anatolia.

The second chapter, "Industry," turns to corporate headquarters and examines the cultural dynamics of local labor forces. For example, Krupp was one of the first companies to attract migrant workers from across Europe, and it housed them in carefully designed homes and planned communities. This chapter examines factories along with the company's architectural and urban visions in settlements like the one at the Margarethenhöhe, in which a stylistic emphasis was placed on a German *Heimat* instead of on international industrial culture. These largely nostalgic environments, built from traditional materials and in traditional styles, also belied the progressive nature of steel as a product, and this chapter pays special attention to the array of actors who negotiated the tension between old and new and looks at how companies at the forefront of the production of modern architecture sublimated much of its technologically progressive ethos in their own building projects.

The third chapter, "Production," examines the array of iron- and steelmaking processes that evolved at Krupp and elsewhere, paying particular attention to the methods and systems used in the production of structural units such as the I-beam, as well as base trims, girts, angles, channels, rigid frame systems, secondary framing systems, sheeting, and panels, and the machinery, equipment, and labor necessary to support them. The chapter also explores the increasingly diverse inventory of parts that manufacturers imagined and engineered to allow for enormously complex building systems, while also taking into account the implications of these open-ended construction systems and their popularity for both the origin site and the building site.

The fourth chapter, "Dissemination," focuses on how the architectural iron and steel industry took its show on the road and internationalized itself economically through cultural venues, representing steel to audiences at expositions and trade fairs. Two very prominent examples include the 1851 Crystal Palace Exhibition in London and the 1893 World's Columbian Exposition in Chicago. In these exhibitions and in smaller regional ones, steelmakers went to great lengths to produce impressive exhibits showing that they were culturally transposable. These exhibitions thus offer vivid glimpses into how a corporation positioned itself as a producer of goods with global cultural value. This chapter also examines a number of important, internationally circulated publications that supported the sale and design of iron and steel building parts.

The fifth chapter, "Building," traces the markets for and dispersal of architectural steel as these markets gradually became international, aided by the expansion of transportation systems and global shipping routes. This chapter examines the rise of systems design and its relationship to structural metals and the training practices of prominent schools of architecture like the École des Beaux-Arts in Paris. It also explores the role of iron and steel in the success of bold new projects in reinforced concrete, such as Max Berg's Jahrhunderthalle, and in the development of infrastructure in ventures like Berlin's U-Bahn. And it looks at how structural metals found their way abroad

into open-source design systems like the Arif Paşa Apartments in Istanbul, the Ottoman empire's first building with a structural metal frame.

The final chapter, "Return," examines the rise of the scrapyard and the origins of structural steel recycling in the nineteenth century. Although steel buildings seldom came down during this period, a handful did, and, more commonly, nonessential steel parts were often scrapped when buildings were updated. This chapter brings the volume full circle, returning to metallurgical science to examine how a new recycling system that mixed scrap steel with iron and oxygen and burned off carbon for purification, along with the advancement of alloy technology, facilitated an entire ecology for the steel industry.

In a time of imperatives to think ecologically, our built environment matters more than ever. The focus of this book—Germany's globally situated role in the making of the "steel age"—is intended to demonstrate the importance of "horizontal" history for creating a more ecologically aware history of architecture. The book's subtitle, "German Steel, Modernity, and Ecology," reminds us that the brave new built world that modern men and women have imagined would not have been possible without incurring a tremendous debt to the natural world. This book is the ledger of that debt.