

WITH A NEW PREFACE

MACHINES

AS THE MEASURE OF MEN



SCIENCE,
TECHNOLOGY,
AND IDEOLOGIES
OF WESTERN
DOMINANCE

MICHAEL ADAS

Machines as the Measure of Men

Cornell Studies in Comparative History

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Empires, by Michael W. Doyle

*Machines as the Measure of Men: Science, Technology, and
Ideologies of Western Dominance*, by Michael Adas

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*Science, Technology, and Ideologies
of Western Dominance*

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Cover: Portrait of Adam Schall, a Jesuit missionary to China in the seventeenth century. Hand-colored engraving.

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For John Smail

As teacher and scholar,

a model for us all

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THE PATTERNS I explore in this book began to coalesce decades ago when as a graduate student at the University of Wisconsin I was intrigued by the similarities between the arguments of modernization theorists, whose works were obligatory reading for non-Western specialists at the time, and of nineteenth-century advocates of European colonization, the focus of much of my own research and writing. The comparative methodology and cross-cultural orientation I gained in those years from participating in the Comparative Tropical History Program, which Philip Curtin had so skillfully put together in Madison, are as fundamental to this book as they have been to my previous work. In the ten years since I began sustained research for *Machines as the Measure of Men*, I have received generous support, useful critiques, and timely encouragement from a variety of sources. The John Simon Guggenheim Memorial Foundation and the Rutgers Research Council provided funding for two consecutive years of essential research and writing. Philip Curtin, Theda Skocpol, Joseph Miller, and Peter Stearns gave me useful advice and support in the formative stages of the project. I also benefited greatly at that point from responses to portions of the work by members of the history departments at Duke University, the University of Pennsylvania, and the School of Oriental and African Studies at the University of London. The collections and able staffs of the British Library, the India Office Records and Library, and the School of Oriental and African Studies greatly facilitated the often daunting task of research on themes covering several civilizations over five centuries. I owe a special debt to colleagues at Rutgers and other universities who have read and carefully criticized portions of the manu-

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My dependence on the research and scholarship of specialists in the areas compared in the book and of those who have preceded me in the exploration of cross-cultural themes will be obvious to the reader. I have tried to indicate in the footnotes particularly influential authors and works. As the notes suggest, the literature relating to the patterns considered is vast. I am well aware that a single book cannot possibly cover all the relevant sources or treat comprehensively all the issues related to the complex processes and broad themes addressed here. I cannot pretend that I have found definitive answers to the many questions my research has raised. I can only hope that I have got some of the questions right and have begun the search for answers that will help us to better understand the central process of modern history, the expansion of the West and Euroamerican interaction with the other cultures and civilizations of the globe.

MICHAEL ADAS

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PREFACE TO THE 2014 EDITION

Machines as the Measure of Men began as a critique of modernization theory. As a graduate student in Southeast Asian and global history in the late 1960s, I shared with my peers a compulsory immersion in the pretentiously theoretical works of W. W. Rostow, Daniel Lerner, Alex Inkeles, and an array of then prominent pundits. Virtually all of these priests of high modernism conceived it in exclusively Western-centric ways. They assumed there was a single proper trajectory through which the peoples of postcolonial nations should (and would inevitably) traverse the successive stages of human development culminating in industrialized, mass-consumerist democratic societies. For many of us preparing for careers in academe or foreign service, these convictions—and the policies that were shaped by them—were ethnocentric, hubristic, environmentally toxic, and grounded in a deeply problematic reading of the recent half-millennium or so of global history. Because the high tide of modernization theory ran concurrently with the American intervention in Vietnam and other misguided military forays into developing nations, its potential as a crusader ideology that legitimized mass killing was also apparent.

After several years of teaching and writing about European colonialism and movements of resistance to it, I was convinced that I needed to transform a rather narrow critique of modernization theory into a more ambitious project both in terms of the range of issues it addressed and breadth of the time frame and the geographical areas encompassed. As the number and diversity of the case examples I included in my comparative explorations grew, my scholarship focused increasingly on the pivotal—but very often neglected—role that science and technology

had played in European expansion, conquest, governance, and resource extraction in colonized areas. I also came to recognize the considerable extent to which European ideologies of dominance based on scientific and technological measures of human worth had prefigured and often explicitly informed the presuppositions and arguments of modernization theorists. Thus, it became clear to me that *Machines as the Measure of Men* needed to begin with chapters on the preindustrial genesis of the scientific and technological standards that Europeans deployed throughout four centuries of overseas expansion to assert the exceptional nature of Western aptitudes and achievement. Rather than a sweeping—and necessarily shallow—global survey of these developments, I decided to limit my comparison to three culture areas where my research, teaching, and writing had been focused during and since my graduate days at the University of Wisconsin: sub-Saharan Africa, India, and China. The opening chapter of the book on the early centuries of European expansion necessarily included reliance on Portuguese, Dutch, and to some extent German accounts, whereas the remainder of the study is devoted to the assessments and ideologies of the British and French.

While it is true that the Europeans in the first phase of their overseas ventures viewed their Christian faith as the primary measure of their superiority, they also stressed differences in material culture to set themselves apart from, and at times above, the peoples they contacted overseas. Cities, monumental architecture, sophisticated weaponry, and literacy were routinely cited as defining features of “high civilizations” well into the twentieth century. But often the remarkable achievements of the societies they encountered deflated rather than enhanced European pretensions of preeminence. Nonetheless, even their accounts of societies, such as the Ming Empire and the kingdoms of South Asia that consistently evoked wonder rather than disdain, were often punctuated with commentary on the unprecedented advancements Europeans had made in ship design and navigational instruments, weaponry, mapmaking, clocks and conceptualizing time, and representing spatial relationships.

Prior to the eighteenth century the Europeans’ sense of their own superiority with respect to material culture was highly ethnocentric, but it was rarely conducive to racism. This began to change in the last decades of the century when further scientific and technological advances provided what they considered empirical verification of what came to be rigid categories of racial difference. In the industrial era that followed, these markers of difference were increasingly driven by ideologies that sought to legitimize white or Caucasian racial supremacy over the rest of humankind. Thus, the chapters of Part II on the late eighteenth and nineteenth centuries explore the ways in which various formulations of the civilizing mission of the Western colonizers were infused with what were considered attributes of the dominant. These allegedly demonstrable measures of human aptitudes and societal achievement ranged from the ability to control and exploit the natural world to conceptions of time, work, discipline, accuracy, and space. The influence of these

presuppositions is then linked to the policies enacted and projects undertaken by British and French proconsuls and colonial administrators, both Europeans and their Western-educated, indigenous subordinate officials.

The epilogue on modernization theory that concludes *Machines as the Measure of Men* is preceded by a chapter that traces the erosion of European and Afro-Asian confidence in the credibility of purely material measures of human worth in the decades before and after World War I. The chapter centers on the intellectual and ultimately political repercussions of the catastrophic Great War between 1914 and 1918, in which most scientific-technical markers of Western superiority were undermined and in many cases reversed. Though I subsequently published several essays that dealt primarily with the Afro-Asian side of this global discourse, the chapter on the war focuses on the disillusionment of soldiers traumatized by four years of massive, seemingly senseless slaughter, made possible by advances in science and technology. These subaltern witnesses and the prominent European intellectuals who elaborated on their narratives of the horrors of the trench stalemate served to challenge prevailing European certitudes regarding their unprecedented rationality, discipline, and capacity for material improvement. These conceits had undergirded the civilizing mission for generations.

In the interwar decades indictments by those who fought in the war and prominent critics of the legacy of Western dominance fed a rising tide of resistance on the part of colonized peoples, who had been unwilling participants and witnesses to the spectacle of the suicidal European conflict. Though full liberation from colonial rule would be delayed until after a second global conflagration, in the post-World War I decades, Western-educated African and Asian intellectuals and political leaders were able to break free from the most potent of the ideological shackles that had made for their submission, compliance, and imitation through well over a century of industry-based colonization.

In the quarter century since the first edition of *Machines as the Measure of Men* appeared, science and technology continue to be seen as the most verifiable—hence objective—gauges of individual aptitudes and societal achievement. Even more than in the long nineteenth century (1815–1914) in which Euro-American imperialist expansion peaked, at the turn of the twenty-first century modern scientific practices and advanced technologies have been central to the processes by which key elements of the West’s “great divergence” have been disseminated to the rest of the world. These transfers have been pivotal to the transformation of several emerging nations of the postcolonial era—most notably India, China, and the “little tigers” of the Pacific Rim—into industrial societies and major nodes of the globalizing international economy. Significant innovations emanating from these developing societies, and especially the earlier industrializing Japan, have also made significant contributions to communications and manufacturing technologies as well as global culture, ranging from Korean and Turkish soap operas to Iranian films and Japanese animé.

The variable transformations of developing societies in Africa, Asia, and Latin America have been contingent on the acceptance by the political and intellectual elites of postcolonial nations of the epistemologies, modes of organization, and methods of production that have come to be associated with a broadly globalized modernity. But equally essential has been the widespread cultural internalization of empirical procedures and intellectual discourses that made possible the technological and scientific breakthroughs of the sixteenth through the early nineteenth centuries in the nations of western Europe. These achievements undergirded the unprecedented levels of pre-1914 material development and global dominance enjoyed by expansive industrial nations, which from the late nineteenth century included the United States and Japan. Surges in national wealth and power, and the pervasive Euro-American valorization of science and technology as keys to their own attainments and measures of all humans' worth, made their acquisition a priority, and at times an obsession, of postcolonial leaders and Western-educated elites.

Ironically, the imperative of obtaining, and in many cases improving on, the material advancement of the West (including Japan) was accompanied by a great deal of attention to the scientific and technological achievements of the Chinese, Arabs, Indians, and other non-Western peoples. Scholarly research and popular publications stressed not only the contributions non-European thinkers and craftsmen had made to the scientific and technological breakthroughs in Europe but also their centrality and acclaim in cultural centers from China to the Middle East from ancient times. Prominent Asian and Middle Eastern scholars, often in conjunction with European and American colleagues, sought to demonstrate that Europe's dominance in science and technology and consequent global hegemony was a rather recent phenomenon and largely a product of industrialization. That undergirding process was in turn deemed to have been heavily dependent on Western imperialist extraction of resources and cheap labor from much of the rest of the world. Some of these claims remain matters for (often heated) debate. But the recovery or reassertion of the contributions that non-Western societies have made to the material and intellectual advancement of humankind and the pivotal roles that nations formerly considered underdeveloped have in recent decades played in remaking the global economic and political order have thoroughly discredited the racist ideological agenda that was promoted by the travelers, theorists, champions of imperial expansion, and colonial officials who were major agents of the crosscultural interactions and the spread of the intellectual discourses explored in *Machines as the Measure of Men*.

I had originally intended to include chapters in each of the main sections of *Machines* on African and Asian responses to the emphasis Europeans, and later Americans, placed on their perceived superiority in matters scientific and technological when formulating and enacting colonial policies—from education to military training. It soon became clear to me, however, that these responses required a book of their own. That study has yet to be written, but several able scholars have

published nation-specific monographs on alternative approaches to science and technology in non-Western societies. Prodded by Ramachandra Guha and others working on these issues, however, I have published several articles that focus on critiques by prominent Indian and African thinkers and activists—including Rabindranath Tagore, Mohandas Gandhi, and Léopold Senghor—of the Europeans' materialistic excesses and their ill-founded confidence that science and technology were invariably forces for progress and human improvement.

The persistence of the colonial legacy in emerging nations has varied considerably owing to significant variations in the extent to which different overseas possessions had been the beneficiaries of technological and scientific transfers from the metropolises, opportunities for advanced education in the sciences and engineering, levels of industrialization, and numbers and sophistication of research and development facilities. All of these in turn depended on how far industrialization and scientific research had developed by the late nineteenth and early twentieth centuries in the metropolises of western Europe and the United States. Also critical was the accessibility of universities in the industrialized nations for students (usually) from the upper social levels of colonized societies who had qualified for higher educational pursuits. By all of these measures, India was by far the most fortunate, and the colonies of sub-Saharan Africa, particularly the Belgian Congo and the Portuguese enclaves, the least. On both sides of the postcolonial divide between developed and “underdeveloped” nations, the main agents of transnational technological and scientific transfers were members of the professional, entrepreneurial, and mercantile classes. But, aside from the considerable portion of development funding siphoned off by government functionaries, urban factory workers and village communities were very often the main recipients of foreign aid proffered by international agencies or each of the rival superpowers in the Cold War. In the early decades of the Cold War, both the Soviet Union and the United States emphasized megaprojects—large factories, dams, even highways in countries with very few automobiles—because policymakers regarded them as icons of modernity and optimum ways of propagating the virtues of the communist or capitalist model of development in the emerging nations of the postcolonial world.

Despite the persistence of widespread faith in science and technology as forces for improvement, global trends since the early 1990s provide ample reason to persist in challenging the standard narrative of science and technology as overwhelmingly progressive and essential sources of human betterment. Although we have thus far managed to avoid a nuclear Armageddon, the escalation of the deployment of high-tech weaponry by besieged regimes and Euro-American powers in the developing world has wrought vast human misery and infrastructural and environmental destruction. Likewise, the fossil fuel revolution—long touted as the crowning achievement of the scientific and technological advances of the West and now driving economic growth in developing nations—threatens the capacity to sustain life as we know it on the planet as a whole. Despite mounting evidence of the daunting

toll that climate change has already taken and growing concern that its devastating effects could become irreversible within the foreseeable future, it is highly problematic to say the least when leaders and concerned environmentalists from the early industrializing nations demand that the peoples of the developing societies moderate their exploitation of natural resources and reliance on polluting manufacturing technologies to promote economic growth and raise living standards. Together with the far more prodigious emissions of greenhouse gasses generated by the citizenry of the industrial nations, their excessive consumerism and endemic warfare have been far more responsible for the global environmental predicament than the formerly colonized peoples of Africa, Asia, and the Americas. Thus, if remedies are to be found, it is fair to presume that early industrializing societies will have to take the lead and most likely pay the highest price. Ironically, although fossil-fuel guzzling sources of energy have been the main cause of the perils to our planet, scientific discoveries and innovative technologies will be essential to finding solutions that will need to be implemented and shared on a global basis.

The fallout from the often unthinking valorization of scientific and technological advances for their own sake is considered in the introduction and later chapters of *Machines as the Measure of Men*, but it is often implicit, and I did not give the subject the in-depth attention it deserved. Soon after its publication the book elicited stimulating responses and debate on the part of those advocating alternative technologies and awareness of the value of incorporating local knowledge and indigenous practices in development programs in the emerging nations of the post-colonial world. The pathbreaking fieldwork and scholarship of leading advocates of these approaches and critics of “high modernity,” especially Jim Scott, Ramachandra Guha, and David Arnold, prompted me to treat these issues as central themes in my subsequent book, *Dominance by Design: Technological Imperatives and America’s Civilizing Mission* (Harvard University Press, 2006). In many respects I regard that study as a continuation of the overarching arguments proffered in *Machines as the Measure of Men*. Small, but often highly sophisticated, everyday technologies—including solar pumps providing clean water, inexpensive cellphones, and effective mosquito netting—have provided peasant communities, which still make up the major portion of the populations of postcolonial nations, with better health, improved nutrition, and ways of profiting from participation in expanding market economies. Funded by nonprofit organizations, and even U.S. aid agencies for a time in the 1970s and early 1980s, these genuinely grassroots initiatives have provided ways to raise living standards throughout the developing world (including pockets of poverty in such affluent societies as the United States and Malaysia) without the ravages wrought by deforestation and heavy dependence on fossil fuels.

The pervasive and near total dominance of men and near exclusion of women from scientific and technological pursuits is suggested in the title and focus on male gendering in *Machines as the Measure of Men*. But in my view the most serious omission in the book, notwithstanding such notable exceptions as Marie Curie and

Mary Kingsley, concerned the failure to integrate throughout the study women's issues, which I only dealt with episodically. This neglect was partly owing to my overly constricted focus on the class and racial dimensions of the construction and impact of scientific and technological gauges of Western superiority. But several decades of research and political contestation have since made clear how pernicious the deployment of scientific and technological measures of human worth and accomplishment have been for the status and career options of women throughout most of human history.

Full accounts of the gendering of science and technology in colonial and post-colonial history have yet to be written. But the ways in which longstanding assumptions about the proper roles of women in Western as well as African, Asian, and Latin American societies led to their virtual exclusion from education and careers in these fields both before and after 1945 are only briefly considered in *Machines as the Measure of Men*. The fuller exploration of these patterns in subsequent publications, including *Dominance by Design*, was made possible by the rich scholarship published in the decades on either side of the millennium on the male bias and neglect of women in both modernization theory and communist developmental strategies that dominated the Cold War era and often persist to the present. Championed most compellingly by the Indian economist Amartya Sen, the importance of women's participation in struggles against poverty, income inequality, and environmental degradation has underscored the persisting linkages among perceived aptitudes for scientific research and technological innovation and the gendering of educational opportunities, investment in entrepreneurial ventures, and development planning more generally. Enhancing the agency of women in these endeavors and their voice in decisions about marriage, reproduction, their career trajectories, and legal rights is essential for achieving a sustainable level of human population increase and a more equitable distribution of income and opportunity.

In the last half decade, issues relating to postindustrial scientific and technological proficiency have been central to scholarly research and public discourse on the processes of globalization. They have also informed contentious debates regarding the "wars on terror" and the rising tide of mass protest movements across the Middle East, the states carved out of the former Soviet Union, and throughout Latin America and Southeast Asia. From the impact of blogs and social media websites in the genesis of the successful revolution in Tunisia and less promising upheavals elsewhere in the Middle East to controversies relating to if and how to deploy drones in contested regions that could be the epicenters of future military conflicts, innovative technologies have become the hallmarks of adaptive and advanced nations. They have also shaped perceptions, which are globalized by the media, of terrorists (or freedom fighters), aggressive (or paternal) political oligarchs, and the oppression (or liberation) of women, particularly in developing societies. However unsettling these outcomes might be, there is little question that the globalization of postindustrial technologies, perhaps most notably the worldwide web and a proliferation of

cheap and lethal weaponry, has made possible both popular resistance to despotic regimes and the interventions of former and present industrialized great powers, including the Soviet Union and the United States. These processes have given very different meanings and applications to the representations, policies, and projects generated by proficiency in scientific and technological enterprises than was the case in the centuries of Western imperialist expansion and global dominance.

Michael Adas
Rutgers University at New Brunswick
April 2014

Machines as the Measure of Men

They are landing with rulers, squares, compasses,
Sextants
White skin fair eyes, naked word and thin lips
Thunder on their ships.

Léopold Sédar Senghor, "Ethiopiques"

INTRODUCTION

IN THE 1740s while the ship on which he was traveling was at anchor off the mouth of the Gambia River, William Smith went ashore to instruct one of the ship's mates in the use of surveying instruments. On a stretch of beach near a small town, Smith had begun to demonstrate how one could measure distances with his theodolite and odometer when he noticed a sizable band of armed Africans gathering nearby. Troubled by their hostile gestures, Smith questioned the ship's slave, who had come along to help him operate the instruments, as to why they were so vexed by activities that Smith regarded as entirely peaceful and nonthreatening. The slave explained that the "foolish natives" were alarmed by Smith's strange devices, which they believed he would use to bewitch them. The Africans had driven off their cattle, sent the women and children from the town to hide in a nearby forest, and marched out to confront the dangerous strangers who had appeared so suddenly in their midst. Concluding that attempts to reason with "ignorant savages" would be futile, and observing that the Africans were afraid to approach the surveying party, Smith continued with his instruction—though he cautioned the mate to keep his blunderbuss ready. As the slave measured the distance along the beach with the odometer, the frightened warriors tried to stop him by running in his path—but they were careful not to touch the wheel. The slave amused himself by trying to run into them. Smith and his companions found the Africans' fear of the wheel and their scrambling to avoid it a source of merriment which they wished the "other gentlemen" on board had been present to enjoy. But when Smith stopped to rest in the shade and sent the mate and slave off to make punch, the townsmen grew more and

more threatening. Alone and surrounded by the angry and well-armed warriors, Smith began to fear that he might be attacked. Just as it occurred to him that he could be "cruelly torn asunder," the mate returned, and together they chased away the band of warriors by making threatening gestures and discharging the weapons that the terrified Africans had left behind on the beach. The mate pleaded to be allowed to pursue them, but Smith insisted on returning to the safety of the ship.¹

Though in itself a relatively insignificant encounter, this incident reveals much about European attitudes toward and interaction with non-Western peoples in the centuries since the fifteenth-century voyages of exploration. It was the Europeans who went out to the peoples of Africa, Asia, and the Americas, and never the reverse—though at times Africans and Amerindians were carried back to Europe to be exhibited and studied. For the Africans the ship from which Smith and his small party disembarked was a marvel of design and workmanship. It represented an area of technology in which the Europeans had few rivals by the fifteenth century and in which they reigned supreme by the seventeenth. Sailing ships with superior maneuverability and armament permitted the Europeans to explore, trade, and conquer all around the world. Smith's instruments and his reason for taking them ashore convey both a sense of the curiosity that provided a major motivation for the Europeans' overseas expansion and their compulsion to measure and catalogue the worlds they were "discovering." With little thought for the reaction of the people who lived there, Smith set out to measure a tiny portion of the vast continent he was exploring. Much more than his physical appearance and dress, it was Smith's unknown instruments and what the Africans perceived as strange behavior in employing these devices that became the focus of their concern. He delighted in dazzling and terrifying the townspeople with his strange machines and continued his activities despite their obvious hostility to his intrusion. When threatened, he relied on the Africans' fear of his technology to drive them off. As he informs the reader, the guns that the warriors dropped and he and the ship's mate fired into the air were of European manufacture.

Our only source of information about this encounter is what we are told by Smith. It is the European observer who describes the Africans' reactions, interprets their motives, and even speculates about their underlying belief systems—in this case, with the assistance of a black slave whose views are filtered through Smith's own perceptions and memo-

¹William Smith, *A New Voyage to Guinea* (London, 1744), pp. 15–20.

ry. The explorer stresses that the awe and fear evoked by his innocuous surveying equipment is the main source of the power he is able to exert over the African townspeople. He suggests that they are too backward to have any comprehension of the use of these devices and too ignorant for him to attempt an explanation. He concurs with the slave's assumption that because the Africans have no natural frame of reference from which to comprehend these wondrous devices and cannot imagine humans creating them, they resort to superstitious notions rooted in witchcraft to explain them. The black slave, who is depicted as a loyal servant, has nothing but contempt for the Africans. The surveying instruments both tie him to his white masters and set him off from the African townspeople. Though he is supervised by Smith, his ability to use the hodometer places him above the "ignorant Savages," and he readily joins in the merriment caused by what he regards as their unfounded fear of the surveying equipment. It is implicit in Smith's account that the slave himself could not conduct sophisticated surveying operations, much less devise the instruments that make them possible. But he has been instructed in their use and understands that they are human fabrications, not the products of magic or witchcraft.

As Smith relates this encounter, it is superior technology—the surveying instruments and firearms—that set the European traveler and his companions off from the Africans and give them the upper hand in the confrontation that ensues. Taken in isolation, the incident overstates the importance of technology in an age when religion was still the chief source of western Europeans' sense of superiority. But it indicates how influential achievements in material culture had become, especially those relating to technology and science, in shaping European perceptions of non-Western peoples even before the Industrial Revolution. From the very first decades of overseas expansion in the fifteenth century, European explorers and missionaries displayed a great interest in the ships, tools, weapons, and engineering techniques of the societies they encountered. They often compared these with their own and increasingly regarded technological and scientific accomplishments as significant measures of the overall level of development attained by non-Western cultures. By the mid-eighteenth century, scientific and technological gauges were playing a major and at times dominant role in European thinking about such civilizations as those of India and China and had begun to shape European policies on issues as critical as the fate of the African slave trade. In the industrial era, scientific and technological measures of human worth and potential dominated European thinking on issues ranging from racism to colonial education. They also provided

key components of the civilizing-mission ideology that both justified Europe's global hegemony and vitally influenced the ways in which European power was exercised.

In view of their importance, it is remarkable that scientific and technological accomplishments as measures of European superiority and as gauges of the abilities of non-Western peoples have been so little studied. Most authors who have dealt with European attitudes toward African and Asian peoples in the industrial era acknowledge that Europe's transformation and the power differential that it created had much to do with the hardening of European assumptions of racial supremacy in the late nineteenth century.² But few writers have examined these complex connections in any detail, and in all cases consideration of them has been subordinated to discussion of racist issues. The rare works that deal in any depth with the pervasive effects of the scientific and industrial revolutions on European perceptions of non-Western peoples are focused on Africa, the geographical area that elicited the most extreme responses.³ Because these studies cover a wide range of topics beyond the impact of European advances in science and technology, even for Africa we have only a partial view of one of the most critical dimensions of European interaction with non-Western peoples in the modern era. For China, India, the Islamic empires, and the Amerindian civilizations of the New World, we have little more than chance comments on the superiority of European weapons, tools, and mathematical techniques. The accounts that deal with these observations often give little sense of the material conditions and the cultural and ideological milieus that shaped them or their place in the broader, ongoing process of European exchange with non-Western peoples which has spanned the last half-millennium.

This book examines the ways in which Europeans' perceptions of the material superiority of their own cultures, particularly as manifested in scientific thought and technological innovation, shaped their attitudes toward and interaction with peoples they encountered overseas. It is not a work in the history of science or technology as those fields are usually defined. The processes of invention and of scientific investigation which have traditionally occupied scholars in these fields and the patterns of

²See, e.g., Ronald Hyam, *Britain's Imperial Century, 1815-1914* (New York, 1976), pp. 47-50; Christine Bolt, *Victorian Attitudes towards Race* (London, 1971), pp. 27-28, 111-12, 211; Gérard Leclerc, *Anthropologie et colonialisme: Essai sur l'histoire de l'africanisme* (Paris, 1972), pp. 26-28; and Francis G. Hutchins, *The Illusion of Permanence: British Imperialism in India* (Princeton, N.J., 1967), pp. 121-24.

³The best of these include Philip Curtin, *The Image of Africa* (Madison, Wis., 1964); H. A. C. Cairns, *Prelude to Imperialism: British Reactions to Central African Society, 1840-1890* (London, 1965); and William B. Cohen, *The French Encounter with Africans: White Response to Blacks, 1530-1880* (Bloomington, Ind., 1980).

institutional and disciplinary development which have more recently come into favor are crucial to the themes I explore. But for my purposes, these discoveries and developments are important only insofar as they influenced the ways in which Europeans viewed non-Western peoples and cultures and as these perceptions affected European policies toward the African and Asian societies they came to dominate in the industrial era. Though varying forms of interaction—including trade, proselytization, and colonial conquest—often resulted in the diffusion of European tools and scientific learning to overseas areas, my main concerns are the attitudes and ideologies that either promoted or impeded these transfers rather than the actual processes of diffusion. Because the spread of European science and technology has been central to the global transformations that Western expansion set in motion, the assumptions and policies that determined which and how many discoveries, machines, and techniques would be shared with which non-Western peoples have been critical determinants of the contemporary world order.

As I stress in the early chapters on the growing impact of material achievement on European perceptions of non-Western peoples and societies, the meanings of “science” and “technology” changed considerably over the centuries covered in this book. It is therefore necessary to indicate at the outset how I define these terms for the purposes of the study as a whole. Though contemporary scholars continue to debate how they ought to be understood and struggle to delineate the boundaries between them,⁴ I have adopted broad definitions combining elements suggested by A. R. Hall and Edwin Layton. Hall terms scientific those endeavors that are aimed at gaining a knowledge of the natural environment, while he views technology as efforts to exercise a “working control” over that environment. Layton elaborates upon similar definitions: he sees the search for the understanding of fundamental entities as the essence of science, whereas technology seeks to solve more practical and immediate problems. Science may be theoretical or applied, but it is oriented toward systematic experimentation and the discovery of underlying principles. The primary objective of technology,

⁴As well as those between “pure” and “applied” science. For an introduction to many of the issues contested, see Robert Multhauf, “The Scientist as an ‘Improver’ of Technology,” *Technology and Culture* 1/1 (1959), 38–47; the essays by Peter Drucker and James Feibleman in *ibid.* 2/4 (1961); the contributions by A. R. Hall and Peter Mathias in Mathias, ed., *Science and Society, 1600–1900* (Cambridge, Eng., 1972); A. R. Hall, *The Historical Relations of Science and Technology* (London, 1963); and Charles C. Gillispie, “The Natural History of Industry,” in A. E. Musson, ed., *Science, Technology, and Economic Growth in the Eighteenth Century* (London, 1972).

though it may often involve theory and experimentation, is design, the application of rules to human artifice.⁵

I had originally intended to focus this study exclusively on the industrial age, when scientific and technological measures of human capacity peaked in importance. It soon became clear, however, that the impact of these standards in the industrial period could not be understood without some sense of their influence in the preceding centuries of European overseas expansion. European observers did not suddenly begin in the industrial era to distinguish their cultures from all others on the basis of material achievement; they had stressed the uniqueness of the extent and quality of their scientific knowledge and mechanical contrivances for centuries. In the early phase of overseas expansion, European travelers and missionaries took pride in the superiority of their technology and their understanding of the natural world. Their evaluations of the tools and scientific learning of the peoples they encountered shaped their general estimates of the relative abilities of these peoples.

Still, throughout most of the preindustrial period, scientific and technological accomplishments remained subordinate among the standards by which Europeans judged and compared non-Western cultures. Religion, physical appearance, and social patterns dominate accounts of the areas explored and colonized. When discussed, science and technology are generally treated as part of a larger configuration of material culture. Within this configuration, monumental architecture, sailing vessels, and even housing were often more critical than tools or astronomical concepts in determining European attitudes toward different non-Western peoples.

Throughout the centuries covered by this study, European judgments about the level of development attained by non-Western peoples were grounded in the presuppositions that there are transcendent truths and an underlying physical reality which exist independent of humans, and that both are equally valid for all peoples. Further, most of the travelers, social theorists, and colonial officials who wrote about non-Western societies assumed that Europeans better understood these truths or had probed more deeply into the patterns of the natural world which manifested the underlying reality. In the early centuries of overseas expansion, considered in Chapter 1, the Europeans' sense of superiority was anchored in the conviction that because they were Christian, they best understood the transcendent truths. Thus, right thinking on religious

⁵A. R. Hall, "Science, Technology, and Utopia in the Seventeenth Century," in Mathias, *Science and Society*, pp. 33-53; and Edwin Layton, "Mirror-Image Twins: The Communities of Science and Technology in 19th-Century America," *Technology and Culture* 12/4 (1971), 562-80.

questions took precedence over mastery of the mundane world in setting the standards by which human cultures were viewed and compared. The Scientific Revolution did not end the reliance on Christian standards. In fact, to the present day they remain paramount for certain groups and individuals, most obviously Christian missionaries. But as I suggest in Chapter 2, religious measures of the attainments of overseas peoples diminished in importance for many European observers beginning in the eighteenth century, while scientific and technological criteria became increasingly decisive.

The rise to predominance of scientific and technological measures of human capacity during the industrial era, which is discussed in Chapter 3, owed much to the fact that they could be empirically demonstrated. In the late eighteenth and nineteenth centuries, most European thinkers concluded that the unprecedented control over nature made possible by Western science and technology proved that European modes of thought and social organization corresponded much more closely to the underlying realities of the universe than did those of any other people or society, past or present. In Chapter 4 I examine the ways in which this assumption shaped ideologies of European imperialism. Chapter 5 focuses on two closely related themes: the impact of European scientific and technological superiority on arguments of white racial supremacy, and the ways in which European advantages in these fields influenced the educational policies by which European colonizers proposed to refashion non-Western societies.

In Chapter 6 I explore the reasons why the trench slaughter on the Western Front in World War I caused many European thinkers to challenge the assumption that better machines and equations demonstrated privileged access to physical as well as transcendent truths. In the Epilogue, I suggest some of the reasons why doubts about scientific and technological measures of human accomplishment were less pronounced in American intellectual circles after the war. I then consider the longstanding and increasing American addiction to technological innovation and the ways in which it contributed to the rise of modernization theory. This paradigm, resting on an assumed dichotomy between traditional and modern societies, represented a reassertion of scientific and technological standards. Its popularity in the post-World War II era reflected a restored confidence in the premise that there was close correspondence between Western thinking and external reality.

As these patterns suggest, European responses to non-Western peoples and cultures over the past five centuries have been strongly influenced by advances in Western understanding of and control over the material world. But the links between material advance and shifts in

perception or judgment were not always clear or direct. Both the conflicting views held by different thinkers or groups during the same "phase" of development, and the lag between changes in European material conditions and shifts in European ideas about non-Western peoples caution against attempts to periodize rigidly or to treat prevailing views as the consensus of a given age.⁶ Though I have identified general phases, I have tried to show that the boundaries between them are blurred. Ideas that were dominant in one era persisted but played lesser roles in the next, and various authors writing in the same period could draw widely varying conclusions from the same evidence. Thus, for example, reports of African material backwardness were cited in the eighteenth century both by writers who sought to prove the racial inferiority of Africans—and thereby justify their enslavement—and by abolitionists who argued that the Africans' vulnerability, reflected in their low level of development, made it morally imperative for Europeans to protect rather than exploit them. Some centuries later, European intellectuals proposed a range of often contradictory solutions to the crisis of Western civilization brought on by World War I. These included, on the one hand, assaults on science and industry, which were blamed for the horrific magnitude of the war, and, on the other, visions of Americanized technocracies of the future.

In each of the phases considered, I have attempted to examine these conflicting responses and to weigh their impact on European views of and interaction with non-Western peoples. I have also sought to avoid reducing the factors that shaped European attitudes to those involving material accomplishment by comparing the influence of these gauges in each period with the major alternatives to them, including physical appearance, religious beliefs, and social customs. Finally, I have had to take into account the fact that the impact of European scientific and technological breakthroughs on shifts in European responses to non-Western peoples was often not felt until decades later. The failure of sixteenth-century European explorers and missionaries to appreciate fully the advantages that the mechanical innovations of medieval artisans had bequeathed to them provides a major example of this lag. Another is illustrated by the fact that the eighteenth-century rage for *chinoiserie* peaked in the very decades when a number of French and British authors, who were attuned to the latest European advances in the sciences and familiar with the writings of the Jesuit missionaries on

⁶My thinking on these issues has been strongly influenced by John Greene's superb essays on approaches to the history of science; see esp. "Objectives and Methods in Intellectual History" and "The Kuhnian Paradigm," both reprinted in *Science, Ideology, and World View* (Berkeley, Calif., 1981).

China, had begun to dismiss the "Middle Kingdom" as despotic, superstition-ridden, stagnant, and hopelessly behind Europe in civilized attainments. For all these reasons, the phases and patterns I identify arise not from the delusion that the "messy realities" of history can be reduced to a rigid hierarchy of factors and precise categories but from an effort to give analytical coherence to the large and complex questions I address.

My central concerns are the attitudes toward non-Western peoples and cultures which were held by literate members of the upper and middle classes of western European societies, and the ways in which these attitudes shaped ideologies of Western dominance and informed colonial policy-making. Though these ideas often influenced the actual social interaction of all classes of Europeans with Africans and Asians, I deal only indirectly and peripherally with what George Frederickson has termed the "societal" dimensions of contacts between European and non-Western peoples.⁷ This approach reflects my agreement with Theda Skocpol that ideologies ought to be distinguished from cultural idioms. Arguments for or against the abolition of the slave trade, appeals to the "civilizing mission," and competing approaches to modernization theory were (or are) all "idea systems deployed as self-conscious political arguments by identifiable political actors."⁸ These ideologies tended to be less temporally specific and at times more oriented to intellectual and moral disputes than Skocpol's exclusively political definition would allow, but I strongly concur with her contention that they must be distinguished from the less consciously fashioned and more anonymous ideas and values that are constants in all cultural systems. Therefore, when I write of "European" views and responses, I am (unless I indicate otherwise) referring collectively to the ideas and arguments of those members of the "articulate classes"⁹ of western Europe who concerned themselves with issues relating to European involvement overseas. Most of the authors who dealt with these issues can at best be characterized as middle-level intellectuals, and some were little more than polemicists or popularizers in the worst sense of the term; only a handful—including Voltaire, John Stuart Mill, and René Guenon—were major thinkers.

As I seek to demonstrate in the book's early chapters, both the class

⁷George Frederickson, "Toward a Social Interpretation of the Development of American Racism," in Nathan I. Huggins, Martin Kilson, and Daniel M. Fox, *Key Issues in the Afro-American Experience* (New York, 1971), pp. 240–54.

⁸See the stimulating exchange on these issues between Theda Skocpol and William H. Sewell, Jr., in *Journal of Modern History* 57/1 (1985), 57–96 (quoted portion, p. 91).

⁹As G. M. Young has so aptly labeled them in *Victorian England: Portrait of an Age* (Oxford, 1964), p. 6.

and occupational background of those who wrote about overseas areas shifted considerably during the centuries covered. The bourgeoisie steadily increased in numbers and influence in the mix of aristocratic and middle-class observers. Explorers, traders, missionaries, and writers of fiction dominated the discourse on African and Asian lands in the early decades of expansion. Though they remained important, from the late eighteenth century on, natural scientists, colonial administrators, social theorists, and anthropologists became the leading experts on matters relating to the non-Western world. As the occupational backgrounds of these writers suggest, both thinkers within Europe itself and Europeans engaged in diverse enterprises overseas played critical roles in shaping responses to non-European peoples and cultures. From the first decades of expansion the two were constantly interacting. Medieval accounts of the fabled Orient and the African empire of Prester John aroused the expectations of early explorers, missionaries, and conquistadores. Their accounts of the worlds they had "discovered" provided the basis for the works of authors in Europe, from the philosophical tracts of Montesquieu and Voltaire to the disquisitions of naturalists such as Julien Virey and Johann Blumenbach. These works, and those by such later authors as James Mill and John Barrow, in turn shaped the attitudes of Westerners who went out to colonize or Christianize African and Asian lands in the nineteenth century, and who described them in unprecedented detail for the rapidly growing readership back home.

Because the British and French were prominent among the European nations involved in overseas expansion in each of the phases I consider, and because they were the foremost imperialist powers of the nineteenth century, the travelers and administrators and social theorists of these two nations have been by far the most important sources of information and opinion about the non-Western world. Both countries were also leading centers of scientific investigation and technological innovation throughout the centuries in question. Even though France was slower to industrialize than Great Britain, the French were as sensitive as the English to the profound differences, created by the scientific and industrial revolutions, between western Europe and the rest of the world. For these reasons, I concentrate on British and French writings in all but the earliest period and the latter half of the twentieth century. In dealing with the sixteenth and seventeenth centuries, I also make use of Iberian and Dutch and to a lesser extent Italian and German descriptions of overseas lands and cultures because accounts by explorers and travelers from these areas were among the most influential in this era. In the Epilogue I compare nineteenth-century European ideas with those of twentieth-century American social scientists, who have dominated

post-World War II thinking on the relevance of Western science and technology for the Third World.

Comparison of shared and divergent British and French responses throughout all the different phases discussed serves to identify both the assumptions that writers from the more advanced nations of western Europe held in common, and areas where perceptions and policies differed by nationality. A comparative approach applied also to the areas to which European observers were responding makes possible the identification of generalized patterns of European perception and policy as well as variations in European responses to specific cultures and the sources of those differences.

Among the many culture areas with which the Europeans interacted, I have concentrated on three: sub-Saharan Africa, India, and China. Not only have my teaching and previous research given me some familiarity with these areas, but each has proved ideal for testing the themes I am examining. Though their interaction with the agents of an expansive European civilization differed considerably, they were all major targets of early European exploration and remained primary centers of European overseas trade, proselytization, and conquest or informal domination. European observers saw in these three culture areas major examples of the differing levels of social development that eighteenth- and nineteenth-century writers sought to locate on a variety of evaluative scales. European thinkers also judged that the peoples of each had reached a different level of scientific understanding and technological mastery. Careful examination of these areas soon impresses one with the great diversity within each one, but in European thinking they were often treated as single civilizations or their achievements regarded as those of a single "race" or people. Thus, although I have noted important variations in cases where these differences were vital to the issues under consideration, I have generally followed my sources in comparing each with the others as a single and discrete entity.

Other culture areas, particularly Japan and various centers of Islamic and Amerindian civilization, have great potential for comparison and might well warrant examination in subsequent studies, but none proved as suitable for the present work as the three I have chosen. Some, such as Japan and Polynesia, were not at all or only marginally in contact with the Europeans during key phases of the centuries considered and thus were not consistently major objects of European intellectual inquiry. Others—the Middle Eastern centers of Islamic civilization, for example—not only shared the Mediterranean heritage of western Europe but had long been rivals of the Europeans and had maintained significant contacts for centuries through trade, war, and cultural ex-

change. As a result, the Muslims were never “discovered” like the Indians and Chinese, and the Semitic origins of the Arabs tended to muddy discussions of “racial” characteristics. This and the fact that they had bequeathed to the Europeans, whether as originators or as go-betweens, some of the technology and a good deal of the basic mathematical and scientific learning vital to the West’s transformation from backward outlyer to global hegemon make it difficult to distinguish clearly between the achievements of the two civilizations. The early phases of European interaction with the peoples of the New World produced patterns of response comparable to those discussed in Chapter 1, and I have been strongly tempted to include one of the Amerindian civilizations as a fourth case study. But the early conquest of the New World societies and the demographic catastrophes that followed, coupled with the early and relatively large migration of Europeans to the Americas, gave the patterns of thought and domination that I examine very different meanings in New World contexts. A consideration of these contrasts would have greatly extended the scope and length of the present work.

In view of the issues that have preoccupied writers on related subjects, it is vital that I indicate a number of things that this book does not attempt to do. It is not a study of racism or racial prejudice per se, even though the patterns I explore converge with racist ideologies in each phase. But the impact of racism in the only sense in which it has been a meaningful concept at the level of intellectual discourse—the belief that there are innate, biologically based differences in abilities between rather arbitrarily delineated human groups—varied greatly from one time period to another. Terms such as ethnocentrism, cultural chauvinism, and physical narcissism more aptly characterize European responses in the early centuries of overseas contact, and they remain more important than racism in much of the literature on two of the three culture areas considered. Though scientific and technological measures of human potential were used to support racist ideologies, particularly in the nineteenth century, these gauges were widely applied long before racist ideas were first systematically expounded by such writers as Edward Long and S. T. Soemmering in the late 1700s. Even in the nineteenth century, when racist theories relating to non-Western peoples won their widest acceptance among the articulate classes of Europe, many thinkers gave credence to scientific and technological proofs of Western superiority while rejecting those based on racist arguments. These patterns underscore one of the major findings of my research: racism should be viewed as a subordinate rather than the dominant theme in European intellectual discourse on non-Western peoples.

In this work I do not attempt to determine the accuracy of either

individual or collective European assessments of African and Asian technology and scientific thought at different points in time. Rather, my aims are to trace the history of these assessments, to give some sense of the conditions in Europe and overseas that influenced the choice of items selected for comment and how these were regarded, to explore how both objects of interest and evaluations changed over time, and to examine the impact of these changes on broader European attitudes toward non-Western peoples and on the formulation of ideologies of Western dominance. A determination of the validity of European commentary in different periods on the quality of African tools or the accuracy of Chinese astronomical calculations would entail a very different sort of inquiry.¹⁰ It would require extensive comparisons of European accounts with whatever contemporary writings are available from each culture area, and with the findings of research carried out in the past three or four decades by scholars working on the history of science and technology in China, Africa, and India.¹¹ Therefore, unless correctives were provided by contemporaries, I have refrained from specific commentary on the accuracy of European assessments of differing non-Western peoples' conceptions of the natural world and their level of material culture. However, in my more general discussions of European interaction with African and Asian peoples at different points in time, I have tried to indicate where statements and impressions unduly distort the actual relationship between the Europeans and the culture area in question.

As "the measure of men" in the title is intended to suggest, scientific and technological standards have been, with rare exceptions, applied by males to activities presumed to be dominated by males. The Marquise

¹⁰Some sense of the size of such a task can be gained from the detailed notes that J. L. Cranmer-Byng has appended as editor to Lord Macartney's journal of his visit to China in the 1790s; see *An Embassy to China* (London, 1962), pp. 355-98.

¹¹The most important work to appear thus far on non-Western science and technology is the monumental, multivolume study by Joseph Needham (assisted by Wang Ling), *Science and Civilization in China* (Cambridge, Eng., 1954-).

On China, see also the useful essays in Nathan Sivin, ed., *Technology in East Asia* (New York, 1977); and Sivin and Shigeru Nakayama, eds., *Chinese Science: Explorations of an Ancient Tradition* (Cambridge, Mass., 1973). For an overview of scientific investigation in India, see the contributions in D. M. Bose, S. N. Sen, and B. V. Subarayappa, *A Concise History of Science in India* (New Delhi, 1971). David Pingree's *Census of the Exact Sciences in Sanskrit* (Philadelphia, 1970-81) conveys a sense of the depth and range of Indian scientific learning, while Shiv Visvanathan's monograph *Organizing for Science* (New Delhi, 1985) provides numerous insights into the nature and organization of industrial research in modern India. Robin Horton's essay "African Traditional Thought and Western Science," *Africa* 37/1-2 (1967), 51-71, 155-87, is a good place to begin an inquiry into African approaches to the natural world. Jack Goody's *Technology, Tradition, and the State in Africa* (London, 1971) provides a provocative interpretation of the role of technology in African history. See also Ralph A. Austin and Daniel Headrick, "The Role of Technology in the African Past," *African Studies Review* 26/3-4 (1983), 163-84.

du Chatelet and Marie Curie notwithstanding, European and North American thinkers have assumed that the unprecedented achievements in experiment and invention which they invoked to demonstrate Western superiority, as well as the African and Asian scientific learning and tools with which these accomplishments were compared, were the products of male ingenuity and male artifice. Colonial proposals to train physicians and railway engineers were drawn up with male students in mind, just as colonial development schemes and post-independence modernization proposals (both capitalist- and socialist-inspired) have been for the most part male-oriented.¹² Throughout the five centuries surveyed here, male attainments and male potential were being measured; better machines and equations were being invoked to demonstrate that men of one type were superior to those of another.

The phrase "ideologies of dominance" in the subtitle indicates that assessments of African tools, Chinese timepieces, and the Indians' capacity to run steam locomotives were not simply academic exercises. They were expressions of power relationships. Especially in the industrial era, science and technology were sources of both Western dominance over African and Asian peoples, male and female, and of males over females in European and American societies. As I note in Chapter 5, at times the parallels between European women and non-Western "races" in this regard were explicitly stated. But usually it was simply assumed that women knew and cared to know little about mathematics and engineering and that the power derived from superiority in these fields should be monopolized by white males.

Machines as the Measure of Men is not intended to be an exercise in anti-scientific or antiindustrial polemic. In fact, it has occurred to me as I work at my personal computer—surely one of the more remarkable products of Western (and increasingly Japanese) inquiry and innovation—that it would be hypocritical to engage in such an exercise. I have no utopian system to propose as a replacement for the scientific-industrial order, nor do I believe that the non-Western rivals it has come to domi-

¹²Ester Boserup's *Woman's Role in Economic Development* (New York, 1970) pioneered the study of the impact of colonial development and postcolonial "modernization" schemes on the women of Africa and Asia. For a recent appraisal of Boserup's work which takes into account the considerable research conducted since *Woman's Role* first appeared, see Lourdes Beneria and Gita Sen, "Accumulation, Reproduction, and Women's Role in Economic Development: Boserup Revisited," *Signs* 7/2 (1981), 279–98. For additional studies on these issues, see esp. Barbara Rogers, *The Domestication of Women: Discrimination in Developing Societies* (London, 1980); Maxine Molyneux, "Women in Socialist Societies: Problems of Theory and Practice," in Kate Young, Carol Wolkowitz, and Roslyn McCullagh, *Of Marriage and the Market* (London, 1981), pp. 167–202; the essays in the symposium published in *Signs* 7/2 (1981); and the earlier collection, "Women and National Development," in *Signs* 3/1 (1977).

nate were intrinsically better. For all the problems associated with scientific and technological innovations, they remain the only way we have yet discovered to provide a decent standard of living for a high proportion of the populations of human societies. That all societies or all groups within industrialized societies have not equally enjoyed these benefits is a matter for continued reform efforts but not in itself cause to conclude that science and technology have led humankind down the wrong path.

Nevertheless, as I seek to demonstrate, evidence of scientific and technological superiority has often been put to questionable use by Europeans and North Americans interested in non-Western peoples and cultures. It has prompted disdain for African and Asian accomplishments, buttressed critiques of non-Western value systems and modes of organization, and legitimized efforts to demonstrate the innate superiority of the white "race" over the black, red, brown, and yellow. The application of technological and scientific gauges of human potential has also vitally affected Western policies regarding education and technological diffusion which go far to explain the varying levels of underdevelopment in the Third World today.

The misuse of these standards has not only impeded and selectively channeled the spread of Western knowledge, skills, and machines; it has also undermined techniques of production and ways of thinking about the natural world indigenous to African and Asian societies. Concern for the decline of these alternatives is not simply a matter of relativistic affirmation of the need to preserve difference and heterogeneity. Their demise means the neglect or loss of values, understandings, and methods that might have enriched and modified the course of development dominated by Western science and technology. The possibilities of alternative systems are suggested, for example, by the recent Western recognition of the efficacy of Chinese acupuncture, as well as Indian, African, and Amerindian healing techniques. As we better understand the attitudes toward the environment and material acquisition that were fostered by non-Western philosophical and religious systems, we also begin to appreciate how they might have tempered the Western obsession with material mastery and its consequences: pollution, the squandering of finite resources, and the potential for global destruction. It is, I think, significant that a passage from the *Bhagavad-Gita* "floated through the mind" of the "father" of the atomic bomb, Robert Oppenheimer, as he witnessed the detonation of the first of these weapons: "I am become death, the shatterer of worlds."¹³

¹³Quoted in Peter Goodchild, *J. Robert Oppenheimer: The Shatterer of Worlds* (Boston, 1981), p. 162.

Less arrogance and greater sensitivity to African and Asian thought systems, techniques of production, and patterns of social organization would also have enhanced the possibility of working out alternative approaches to development in non-Western areas, approaches that might have proved better suited to Third World societies than the scientific-industrial model in either its Western or its Soviet guise. At the very least, the first generations of Western-educated leaders in the newly independent states of Africa and Asia would have been more aware of the possibilities offered by their own cultures and less committed to full-scale industrialization, which most of them viewed as essential for social and economic reconstruction. The reappraisal in recent decades of Gandhian social and economic philosophy, which was long a favorite target for the sarcastic barbs of development specialists, reflects a growing recognition that the paths followed by western Europeans, North Americans, and the Soviets are not the only possible routes to national solvency and material well-being.¹⁴

¹⁴For an early defense of Gandhi's economic thinking, see Shiva Nand Jha, *A Critical Study of Gandhian Economic Thought* (Agra, 1955), esp. chap. 4. For later reappraisals, see A. K. N. Reddy, "Alternative Technology: A View from India," *Social Studies of Science* 5/3 (1975), 331-42; and Abdul Aziz, "Gandhian Economic System: Its Relevance to Contemporary India," in J. T. Patel, ed., *Studies on Gandhi* (New Delhi, 1983).

PART ONE

BEFORE THE INDUSTRIAL REVOLUTION

If any man should make a collection of all the inventions and all the productions that every nation, which now is, or ever has been; upon the face of the globe, the whole would fall short, either as to number or quality, of what is to be met with in China.

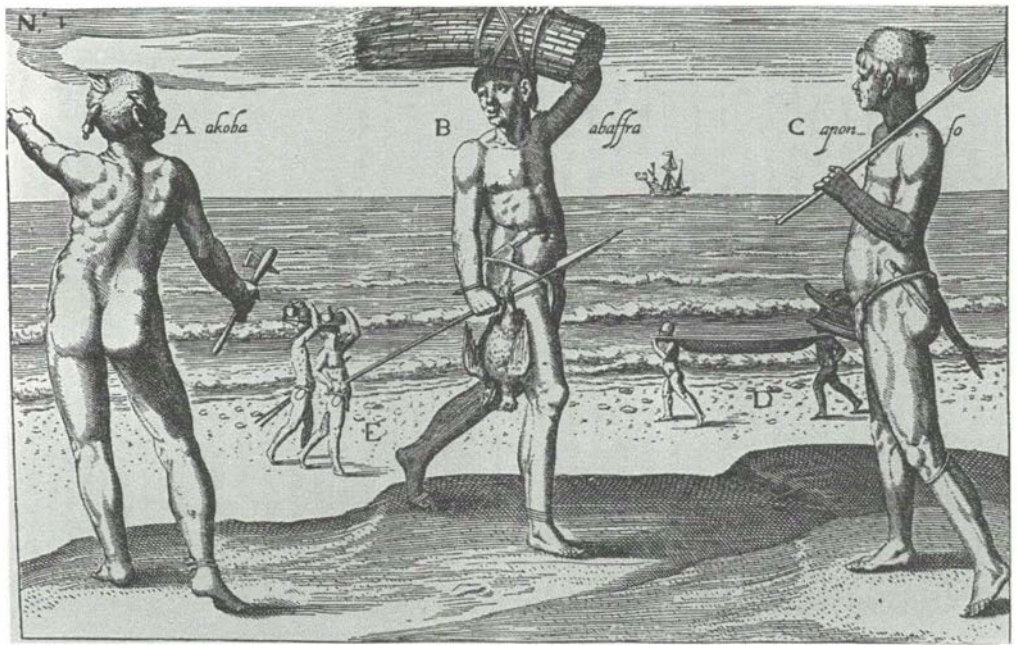
Isaac Vossius (1618–89), quoted in
John Barrow, *Travels in China* (1804)

If the renowned sciences of the ancient Bragmanes of the Indies consisted of all of the extravagant follies which I have detailed, mankind have indeed been deceived in the exalted opinion they have long entertained of their [the Indians'] wisdom.

François Bernier, *Travels in
the Mogol Empire* (1656–68)

I conversed with great numbers of the northern and western nations of Europe; the nations which are now in possession of all power and all knowledge; whose armies are irresistible, and whose fleets command the remotest parts of the globe. When I compare these men with the natives of our own kingdom, and those that surround us, they appear almost another order of beings. In their countries it is difficult to wish for anything that may not be ordained: a thousand arts, of which we have never heard, are continually labouring for their convenience and pleasure; and whatever their own climate has denied them is supplied by their commerce.

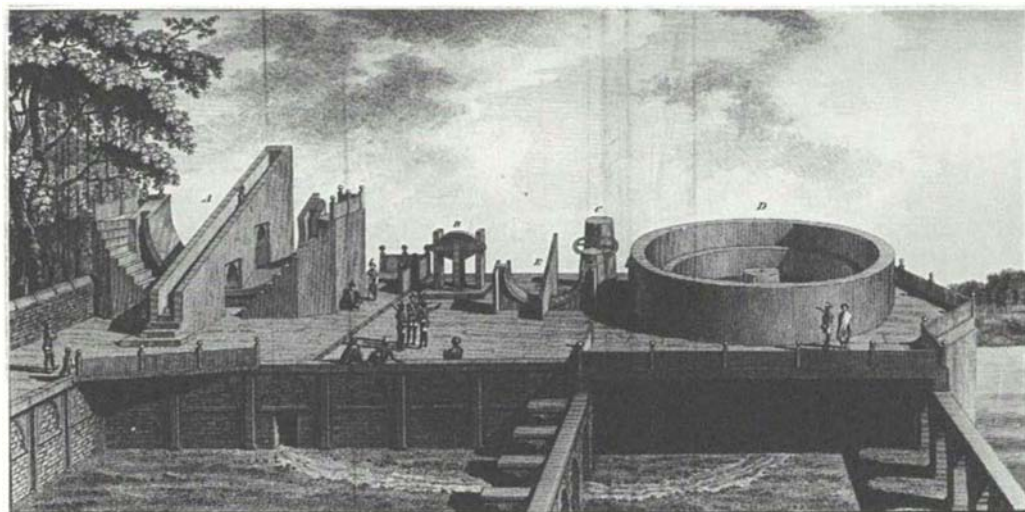
Samuel Johnson, *The History of Rasselas* (1759)



Sketch from Pieter de Marees's *Beschryvinghe ende historische verhael van het gout koninckrijck van Gunea* (1602) illustrating African tools, weapons, modes of transportation, and scant clothing. The drawing focuses on aspects of material culture that were of great interest to early explorers and merchants. (Reproduced by courtesy of the Trustees of the British Museum)



Late seventeenth-century engraving of Adam Schall, one of the most prominent members of the Jesuit mission to China. He is depicted in full Chinese scholar-gentry regalia among the European globes, maps, and astronomical instruments that had proved so critical in the Jesuits' efforts to win access to the Ming and Qing courts. (Reproduced by courtesy of the Trustees of the British Museum)



An engraving of the Hindu observatory at Banaras from Robert Barker's *Account of the Brahmins' Observatory at Benares* (1777). The careful illustration of the astronomical instruments, whose functions and dimensions Barker describes in detail, was prompted by a growing European interest in Indian scientific learning during this period. (Reproduced by courtesy of the Trustees of the British Museum)

*First Encounters: Impressions
of Material Culture in
an Age of Exploration*

ACCORDING TO estimates made in recent decades, by the fifteenth century the peoples of western Europe possessed an advantage of three or four to one over the Chinese in per capita capacity to tap animal and inanimate sources of power.¹ Though the poor quality of the data for both civilizations renders these estimates rough approximations, the comparison suggests just how far the Europeans had advanced in technological mastery during the medieval period. Among all preindustrial civilizations only western Europe could rival China, which had excelled in invention for millennia, in the application of technology to everything from farming and transportation to scholarship, bureaucracy, and war.² Without the agricultural and mechanical innovations of the Middle Ages and the development of new instruments in the Renaissance, the Europeans would not have had the means to undertake the explorations that culminated in the voyages of Columbus and Vasco da Gama. Advances in weaponry, shipbuilding, and manufacturing were equally vital to the efforts of Europeans to project their influence overseas through trade and warfare from the sixteenth century onward.

These patterns suggest that evidence of material achievement ought to have had a major impact on European attitudes toward the peoples and cultures they encountered in the first phase of overseas expansion. In

¹Estimates by historians of the *Annales* school. See Pierre Chaunu, *L'expansion européenne du XIIIe au XVe siècle* (Paris, 1969), pp. 336–39, who interpolates from Fernand Braudel's rather impressionistic eighteenth-century statistics in *The Structures of Everyday Life: Civilization and Capitalism*, vol. 1 (New York, 1981), esp. chap. 5.

²See Joseph Needham, *Science and Civilization in China* (Cambridge, Eng., 1954–), esp. vol. 4, pt. 2 on mechanical engineering, and pt. 3 on civil engineering.

fact, it provided at best a subordinate standard by which travelers and missionaries assessed the attainments of other cultures and compared them with their own. Tools, modes of transportation, and cropping patterns were mentioned by most sixteenth- and seventeenth-century travelers, but they rarely described African and Asian technology and production techniques in any detail. Even in its most applied forms, scientific knowledge was discussed still less frequently. Most observers treated tools and scientific instruments as individual objects of inquiry. Few viewed them as proof of superior European achievements in science and technology as a whole. In contrast to the practice of the eighteenth and nineteenth centuries, inventiveness and scientific knowledge were rarely stressed as standards by which to judge the level of development attained by African or Asian societies or to evaluate the capacities of non-Western peoples.

A variety of factors account for the Europeans' lack of emphasis, (relative to later centuries) on their technological and scientific accomplishments in the early centuries of expansion. The conditions under which they traveled to Africa and Asia were not conducive to detailed, much less accurate, observation and description. This was particularly true for such aspects of culture as manufacturing techniques and scientific learning, which African and Asian peoples were reluctant to share with outsiders. In addition, most of the Europeans who went overseas had a very limited knowledge of their own societies' achievements in these areas, and few were as interested in the tools and cosmologies of the peoples they encountered as in physical appearance, customs, and ceremonies. Whether they were merchants or missionaries, European travelers in this era viewed their Christian faith, rather than their mastery of the natural world, as the key source of their distinctiveness from and superiority to non-Western peoples. But assessments of the sophistication of African and Asian science and technology as aspects of larger configurations of material culture did affect European attitudes toward different peoples and cultures. This was especially evident in the contrasts they perceived between African and Asian societies and in their tendency to elevate China above all the civilizations they had "discovered." Exploration of both the reasons for the relatively marginal role of scientific and technological measures of human achievement in this era and the situations in which these standards were invoked reveals much about the Europeans' sense of themselves and their own culture. It also tells us a good deal about the nature of their interaction with non-Western peoples in the first phase of overseas expansion.

Between the twelfth century, when the Europeans first employed the sternpost rudder and such navigational instruments as the compass and

astrolabe, and the fourteenth and fifteenth centuries, which saw major innovations in hull design and rigging, western Europe's oceangoing ships were transformed from unwieldy tubs that seldom ventured from the sight of land into highly maneuverable vessels capable of transglobal voyages.³ Despite these improvements, the earliest explorers and merchants went out to Africa and Asia in ships that were shallow-keeled, rather primitively rigged, small (most of them less than thirty meters in length, or the size of a modest modern yacht), and very much at the mercy of the elements. Even more than the crews of the larger and more seaworthy vessels Joseph Conrad immortalized in his sea tales centuries later, the sailors and passengers on the caravels and *naos* that were the mainstay of early exploration efforts were all too aware of the power of stormy seas to "toss and shake" their flimsy craft "like a toy in the hand of a lunatic."⁴ Though more sheltered and commodious vessels came into wide use in the early decades of the sixteenth century,⁵ crews and travelers were still crammed for weeks—sometimes months, if the weather was unfavorable—into roach- and rat-infested quarters that stank of the garbage and human waste sloshing about in the bilge water below. In addition to seasickness and dysentery, seamen were vulnerable to contagious diseases that spread quickly through unwashed and closely packed crews. Subsisting on a monotonous diet of salted meat and fish, hardtack, and dried vegetables, many travelers suffered from the painful and potentially lethal bouts of scurvy which ravaged ships' companies that were too long at sea without fresh fruits or vegetables.

Vulnerability to disease and inclement weather was of course shared by the populace of Europe as a whole. Thus, whatever aspirations such European thinkers as Francis Bacon may have had for humans to control their natural environment, until well into the eighteenth century it was not readily apparent that their level of mastery was superior to that of other civilizations, particularly those in Asia.⁶ Europeans, even wealthy Europeans, suffered from extremes of heat and cold as much as or a good deal more than most of the peoples they contacted overseas. They had no more potent defenses against disease, as recurrent epidemics of

³The best discussions of ship construction and navigational instruments in the medieval period and the early centuries of expansion can be found in J. H. Parry, *The Discovery of the Sea* (Berkeley, Calif., 1974), esp. chaps. 1, 2, and 8; and Chaunu, *L'expansion européenne*, pp. 273–307. For sea weaponry, see Geoffrey Parker, *The Military Revolution* (Cambridge, Eng., 1988), chap. 3.

⁴Joseph Conrad, *The Nigger of the "Narcissus"* (Harmondsworth, Eng., 1968), p. 53. See also the storm sequence in Conrad's *Youth: A Narrative* (1902).

⁵On the drawbacks of the larger sixteenth- and seventeenth-century ship designs, see James Duffy, *Shipwreck and Empire* (Cambridge, Mass., 1955).

⁶The fullest treatment of Bacon's famous aspiration can be found in Carolyn Merchant, *The Death of Nature: Women, Ecology, and the Scientific Revolution* (San Francisco, 1983), chap. 7.