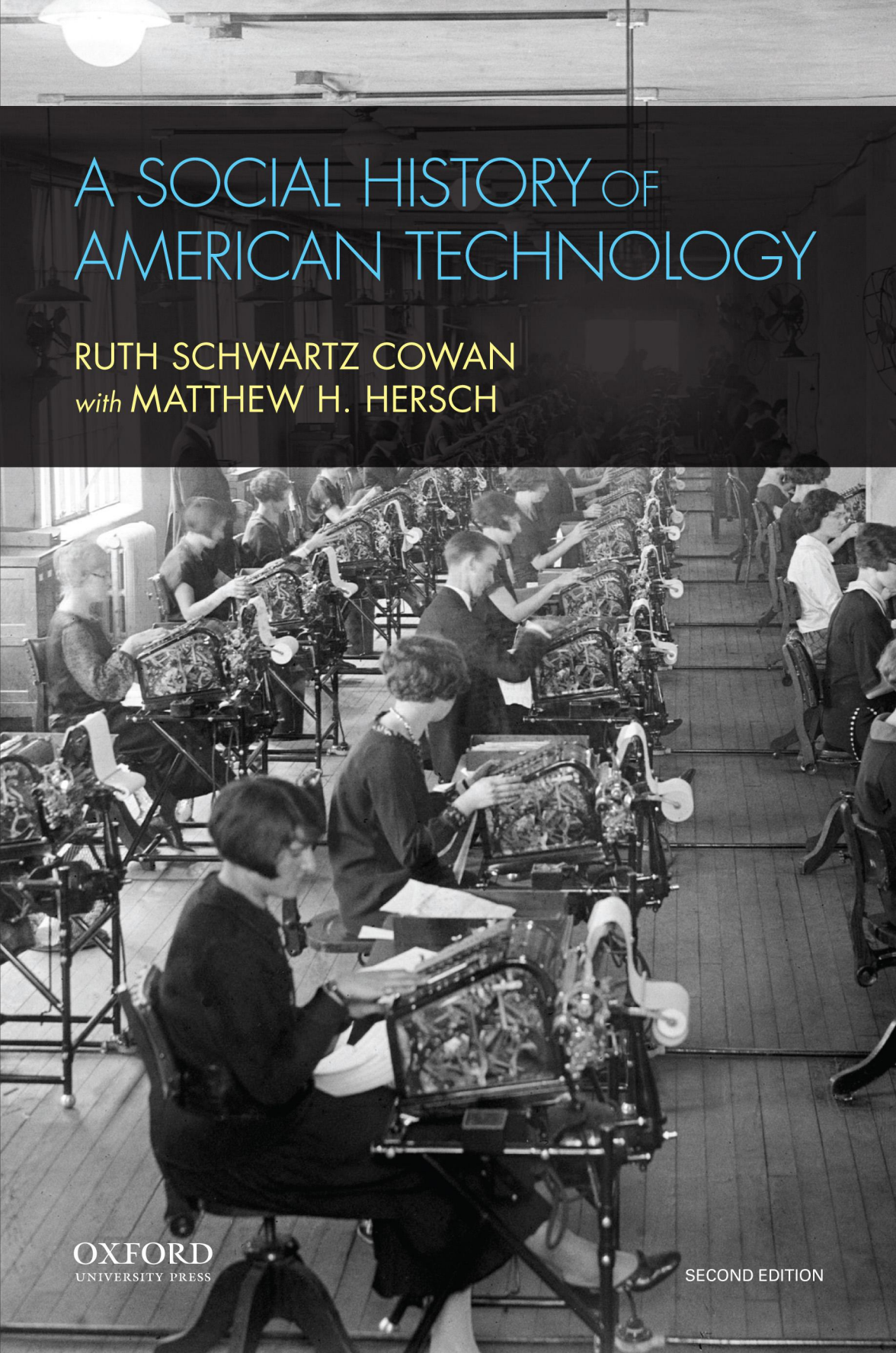
A SOCIAL HISTORY OF AMERICAN TECHNOLOGY

RUTH SCHWARTZ COWAN
with MATTHEW H. HERSCH



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SECOND EDITION

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In this 1924 photograph, employees of the Bonus Bureau's Computing Division use state of the art Burroughs adding machines to calculate bonuses for World War I veterans. Electric fans mounted along the walls keep the workers cool.

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DEDICATION

In Memory of
Neil M. Cowan (1937–2011)
LC in LGA

. . .
In the labor of engines and trades and the labor of fields I find the developments
And find the eternal meanings.

. . .
Strange and hard that paradox true I give,
Objects gross and the unseen soul are one.

. . .
The hourly routine of your own or any man's life, the shop yard, store or factory,
These shows all near you by day and night-workmen! whoever you are, your daily life!

. . .
In them the realities for you and me, in them poems for you and me, . . .
In them the development good—in them all themes, hints possibilities.

Walt Whitman, *Leaves of Grass* [Book XV]
"A Song for Occupations"

CONTENTS

ACKNOWLEDGMENTS

RSC: Scholarship is a communal pursuit. I could not have conceived, let alone written this book, without the devoted labor of my predecessors and colleagues, several hundred passionate historians, social scientists, collectors, editors, librarians, and curators—all of them students of American history and American material culture. My gratitude goes to all of them—but most particularly to those who paved the way by creating and sustaining the two wonderful institutions that created and sustain our discipline: the Society for the History of Technology and its lively journal, *Technology and Culture.*

My ideas and my prose have also been tested and honed by the reactions, pro and con, bored and engaged, of the students who sometimes struggled and sometimes soared through my courses in the history of technology. I am grateful to the undergraduates whom I taught at the University at Stony Brook and the University of Pennsylvania for teaching me how to narrate history comprehensibly. In addition, because of the insistent questions, lively intellects, and wide-ranging interests of the graduate students in History and Sociology of Science at Penn, I had not only to refine but also to broaden my understanding both of history and of technology. I am particularly glad that one of those former students, Matt Hersch, agreed to collaborate with me on this second edition, putting his scholarly expertise, his superb writing skills, and his utterly amazing understanding of all things digital not just at my disposal but also at the disposal of the readers of this book.

I am also grateful to Brian Wheel, formerly of Oxford University Press, who encouraged me to update the first edition and then waited, patiently and always graciously, over the course of the many years that it took me to finish the job. I dearly wish that he had been able to see the book through to publication.

My last thanks, springing from the fullest heart, are reserved for the members of my immediate family. During the years in which I was preparing the first edition, my daughters Jennifer, May, and Sarah and my husband, Neil, were a loving scholarly support system, providing calm when I panicked and inspiration when I flagged. By the time I began working on the second edition, my family was diminished by my

husband's death, but was also enlarged by the addition of sons-in-law and grandchildren, all of whom, in numerous and wonderful ways, continued the tradition. I am especially grateful to my daughter May, who, in the midst of her often overburdened days, made the time to focus on locating new images for this edition.

MHH: I have much to thank Ruth Schwartz Cowan for, least of all the opportunity to participate in the creation of this new edition of her much-respected textbook. My identity as an historian of technology is indelibly molded by our many experiences working together. It is my hope that this new edition represents, in some small way, the fruits of our long collaboration.

I also wish to share a brief word of thanks to my partner and best friend, Whitney Laemmli, in whose nicely appointed studio during a sweltering Berlin summer several chapters of this new edition first took shape, and who has proven to be the best reason to go to graduate school.

NOTE TO READERS OF THE SECOND EDITION

In the two decades that have passed since the publication of the first edition of this book, the meaning of the word "technology" has been greatly diminished in popular usage. These days, too many people think the word signifies only those tools that are digital, as in "technology class" or "technology revolution," or "high tech industry."

In the first edition of this book, "technology" was defined more broadly as "all those things that people have used to exploit or manipulate their environments." We believe that this definition is more useful and interesting, so we have stuck with it. It is also more historically accurate. We hope that you will find, as you read the book, that the history and impact of digital technology makes more sense in this wider and deeper context.

NEW TO THIS EDITION

Authorial vision often surpasses publishing realities. In order to update and expand this second edition, some material in the first had to be compressed or eliminated.

One chapter is entirely new, Chapter 13: "Technoscience and the Biotech Industry." In order to prepare readers for this chapter, the former chapter on biotechnology (now Chapter 12: "Foods, Drugs and Unintended Consequences"), while still focusing on the examples of hybrid corn, antibiotics, and oral contraceptives, has been reframed to begin introducing the concept of *technoscience*. Chapter 13 picks up this theme as essential to the discussion of the DNA-based technologies which now produce some foods and drugs. Chapter 13 focuses on recombinant insulin and genetically modified foodstuffs, such as tomatoes, corn, and soybeans; it also pays attention to the troubling aspects of the technoscience on which these new technologies are based, as well as the controversies that still swirl about the technologies themselves.

What was a single chapter on electronic technologies in the first edition has become two chapters in the second. The first new chapter (Chapter 10: "Electronic Communication and Social Control") begins with wireless telegraphy and ends with cable television. The second new chapter (Chapter 11: "Electronic Brains and Global Villages") begins with analogue calculators and ends with the internet, social media, and the smartphone. Along the way, this new chapter says a good deal more than the old one about both large-frame and personal computers, as well as the relationship between innovative businesses, the federal government, and the academic world that made these new technologies possible.

Several chapters have been updated. The old chapter on automobility ended with the effects of the 1973 oil embargo; the new version (Chapter 8: "Automobiles and Automobility") extends into the twenty-first century, discussing the decline of the American automobile industry and the fear of global warming, as well as adding new material on fuel-efficient engines, lighter frames, and electric (or partially electric) vehicles. The old chapter on aerospace ended with the space shuttle in the 1990s; the new chapter (Chapter 9: "Taxpayers, Generals, and Aerospace") has been updated to include satellites, global positioning systems (GPS), and precision-guided weapons. It also contains an expanded discussion of managed research.

Unfortunately, in order to add all this new material, some old material had to be dropped. As a result, two original chapters in the first section of the first edition—on technology in the colonial period—have been compressed into one in this new version. Regrettably, the chapter on American ideas about technology which appeared in the first edition had to be dropped in its entirety in the second, although some of its crucial ideas have been reprised in its Coda.

On the positive side, this second edition contains more than twice as many images as the first edition, and the size of many of them has been increased for (we hope) both greater legibility and greater enjoyment.

A Social History of American Technology

PART I

Introduction

In the middle of the eighteenth century in Europe, some taxonomists—the people who classify and name the different species of animals and plants—had an argument. Having decided that human beings, men and women, ought to be classified with the animals, they could not agree on a name for our species: *Homo politicus*, the primates who create governments? *Homo sexualis*, the primates who are perpetually in heat? *Homo sapiens*, the primates who think? Or *Homo faber*, the primates who make things? Eventually they settled on thinking as the crucial characteristic that sets human beings apart from the orangutans and the chimpanzees, which seem anatomically to be our closest relatives.

This book focuses on one of the human characteristics that the eighteenth-century taxonomists rejected, *making things*. Our opposable thumbs, our hands, and the things that we make and manipulate with our hands are as much a part of our humanity as our brains and the thoughts we have had, our governments and the constraints they have put on our behavior, even our sex hormones and the ways in which they have influenced our lives.

Technology has been a fact of human life as long as there have been human lives. From the time that human beings emerged as a separate species on this earth, we have been trying to control, to manipulate, to exploit, and sometimes even to subdue the earth with tools. Technological change occurred so rapidly in the twentieth century that people became accustomed to thinking of themselves as living in a characteristically technological age, surrounded as they were by automobiles and superhighways, skyscrapers and plastics. A moment's thought should convince us, however, that in reality we are no more (nor less) technological than any of our ancestors. In all times and all places, human beings have attempted in some fashion to use tools to control the natural environment in which they were living—and this is as true of the human beings who first learned how to rub two stones together to make a spark as it is of those who subsequently created the internet. We like to think that in times past people lived more "natural" lives than we do today, but in point of fact, log cabins, tepees, and grass huts are as "artificial" as

hydraulic cement, atomic bombs, antibiotics, and computers. They are all equally products of human hands, of human artifice, of making things, of *homo faber*.

Which is why we should be suspicious whenever we see the labels "handmade" or "natural" on a product, no matter what that product may happen to be, no matter how "old fashioned" it may happen to look or feel or taste. *All* products are both handmade and natural because all human beings are naturally equipped to make things with their hands. Is a piece of cloth more handmade if it has been woven on a wooden loom rather than on a metal one? Is bread that has been baked in a wood-fired brick oven more natural than bread baked in a metal oven fired by "natural" gas? And when we actually do encounter something that is more handmade than something else (for example, bread dough that has been kneaded by someone's hand rather than a machine), why do we assume instantly that the former is better than the latter? Studying the history of technology may help us to understand why so many people seem to believe that being handmade and natural somehow means simultaneously both "better" and "traditional."

WHAT IS TECHNOLOGY?

We use the word "technology" to denote those things that people have created so that they can exploit or manipulate the environment in which they are living. Technology is a more general word than "tool." Tools are used to produce things, but both the things that are produced (like bridges, houses, gears, woolen cloth, and clean laundry) and the things that are used to do the job (like wrenches, hammers, drill presses, looms, and washing machines) are included in the term "technology." Domesticated animals and plants are technologies that people created in order to secure food supplies; medications are technologies that people created in order to improve their health. Even languages and the things that contain languages (such as books, letters, computer software, and student essays) are technologies: they are things that people have created so as to better control and manipulate the social environment.

Technological systems are arrays of technologies. Once primitive human beings had passed beyond the use of digging sticks, they had passed out of the realm of technology into the realm of technological systems. A single tool, even the most primitive of them, is usually not sufficient to get the job done. A hammer, for example, must be applied to something (a nail, a board), which is itself also a tool, in order to function as a hammer; a can needs a can opener; even the original digging stick may have needed to be sharpened with a stone. All technological systems, of necessity, have people embedded in them; a hammer is not really a hammer until someone picks it up and uses it. This point can be made more emphatically by speaking of socio-technological systems, rather than just technological systems. Socio-technological systems can, and sometimes do, become quite large and quite complex: the paradigm would be a personal computer which requires an entire electrical network plus software, printers, and modems—as well as programmers, technicians, trainers, and manufacturers—in order to function properly.

If the things we make and manipulate with our hands, technologies and technological systems, are as much a part of our humanity as the ideas we think and the governments we create, then they also ought to be part of our history. The history of technology is an effort to recount the history of all those things, those artifacts that we have produced over the years. The *social* history of technology goes one step further, integrating the history of technology with the rest of human history. It assumes that objects have affected the ways in which people work, govern, cook, transport, and communicate: the ways in which they live. It also assumes that the ways in which people live have affected the objects that they invent, manufacture, and use. A social history of technology, in short, assumes a mutual relationship between society and technology; it also assumes that changes in one can, and have, induced changes in the other.

A SOCIAL HISTORY OF AMERICAN TECHNOLOGY

American history has been recounted from many different perspectives over the years—biographical, economic, and intellectual, to name just a few—but rarely from the perspective of technology. This is odd because for over 250 years American technology has been regarded—by Americans and by foreigners—as the hallmark of our culture, one of the things setting us apart from our European brethren and one of the important factors contributing to our extraordinary prosperity. Understanding our history from this perspective means that we can begin to understand not only how profoundly technological change—think of birth control pills and computers—has affected our way of life, but also—think of our country's size and our superhighways, or our role in the Cold War, and our space program—to understand how profoundly our way of life has affected our technology.

The first section of this book examines the technological character of part of North America between the beginning of human settlement and the full flowering of industrialized society in the second half of the nineteenth century.

In the first chapter, we try to describe, albeit very briefly, the material culture of the many peoples who were indigenous to the continent before the Europeans arrived—and the profound differences between the technologies of those two groups of people: natives and settlers. By way of introduction, we have also used that chapter to say something about the differences between the North American and European environments, differences that ultimately put a uniquely American stamp on some of the technological systems that subsequently developed here.

The second chapter is devoted to both traditional agriculture (since that was the enterprise in which the vast majority of European Americans were engaged in the years between their settlement and the middle of the nineteenth century) and traditional work in the artisanal crafts, such as carpentry, blacksmithing, printing, and iron foundering. Because the United States was born as an agricultural, rural culture, its unique governmental system was derived from that culture. As a result, colonial agriculture has been enveloped in the mists of patriotic nostalgia for a very long time. In the first part of Chapter 2, we dispel those mists by examining the way in which the colonists actually wrested their livings from the ground.

The second part of the chapter is devoted to the lives of the men and women who made their livings in the crafts. Here we demonstrate that relationships between masters and apprentices in the American colonies were very different, in crucial ways, from what had been customary in English and European societies. Despite being only a tiny fragment of the population, colonial artisans were historically important, partly because of the crucial roles that they played, first in the revolutionary period and then in succeeding decades, as the economic character of the new nation began to take shape.

The next two chapters explore the industrializing sector of that new national economy. In Chapter 3 we focus on the lives of several innovators of the early national period: Oliver Evans, Eli Whitney, and Samuel Slater. These men were not the only technologically adept movers and shakers of their times, but their stories reveal an enormous amount about the United States in the years during which it was starting to industrialize. We explore the reasons why so many successful innovations of that time involved devices that lowered the labor costs of production and also the reasons why the military needs of the new nation played such a crucial role in the industrializing process. Chapter 3 also explains why industrialization in the United States was so different from the somewhat earlier industrial development of England—so different, in fact, that by the middle of the nineteenth century the British had started calling it "the American system of manufacture."

In the fourth chapter we explore another crucial aspect of American industrialization: the upgrading of its transportation infrastructure. In the first decades of the nineteenth century several political leaders believed that transportation improvements were absolutely necessary to create a unified sense of nationhood among the new country's widely dispersed citizens. A few of those leaders also suspected—and they turned out to be right—that roads, canals, steamboats, and railroads would be vitally important in creating an enormous national market in which new industrial products could be sold at reasonable prices to millions of people. In the nineteenth century transportation improvements were financed by public-private partnerships. As a result, this chapter also demonstrates the crucial role that governments—federal, state, and local—played in the first half of the nineteenth century, in creating a secure foundation on which an industrialized society could be built.

CHAPTER 1

The Land, the Natives, and the Settlers

The unique characteristics of American technology, those things that set it apart from English, Japanese, Canadian, Mexican, or any other technology, derive, at least in part, from the unique characteristics of North American geography. That particular part of North America now called the mainland United States is a natural environment that people have been manipulating and to which they have been adapting for thousands of years. It is also a vast stretch of land, reaching from the Pacific Ocean to the Atlantic, across three climate zones (semitropical, temperate, and semiarctic), encompassing at least a dozen very different ecological regions.

Virtually every observer who has ever recorded an impression of this geographic area regarded it as very specially blessed: blessed because the climate, in most places and at most times, is reasonably temperate; blessed because much of the land is fertile and many of the woods and streams, bountiful; blessed because there are rich lodes of minerals and fuels on the surface of the land and far below it; and blessed, finally, because in its varied terrain, the land is awesomely beautiful. From time immemorial this land has sustained human existence; most of the continent was inhabited by 10,000 BCE.

After migrating across the Bering Strait, the earliest settlers made their homes in the area that is now Alaska. As the years wore on, as the centuries and the millennia passed, the descendants of these early settlers migrated southward and eastward, eventually filling the whole of North America, including the part that is now called Central America. People often say that necessity is the mother of invention, but in fact, opportunity can be just as powerful a spur. As the Native Americans migrated to different geographical regions, they met with opportunities to feed and clothe themselves in new ways, and they responded to these opportunities by modifying the technologies they had brought with them, creating both new technological systems and new cultures. Some remained nomads, wedded to the traditions of their ancestors, but others learned to domesticate plants, to farm, to form settled communities—even small cities—and to give up their nomadic

heritage. In this they were very similar to their long-separated cousins across the seas, who were, during those very same millennia, passing from what is called the Paleolithic—nomadic—stage of culture to the Neolithic—agricultural—stage.

THE LAND AND THE NATIVE INHABITANTS

The various geographic regions of the United States are very different from each other. The Pacific coast (the one first inhabited by the earliest settlers) is very rugged terrain; there are few beaches and many mountains dropping off suddenly into the sea. The southern section of this coast has a dry climate, but in the north it is quite wet; from north to south there are many fertile mountain valleys (some of them immense), and from east to west several large rivers flow down from the mountains into the sea.

Farther east, separated from the coastal ranges in some areas by deserts and in others by arid lowlands, there is another range of mountains, considerably more menacing, now called the Rockies. East of the Rockies there are plains and prairies, the former virtually treeless, the latter somewhat more wooded, but both dominated by grasses and interrupted by some very large rivers, the Mississippi and its tributaries. The prairies end in the heavily wooded Appalachian highlands, much less forbidding mountains than the Rockies, and these highlands are themselves bounded, yet farther east, by the Atlantic coastal plain. This plain is very narrow in the north, but in the south, in the modern-day Carolinas, it is almost 500 miles wide. Unlike the Pacific, the Atlantic coast is full of beaches, protected coves, bays, and inlets.

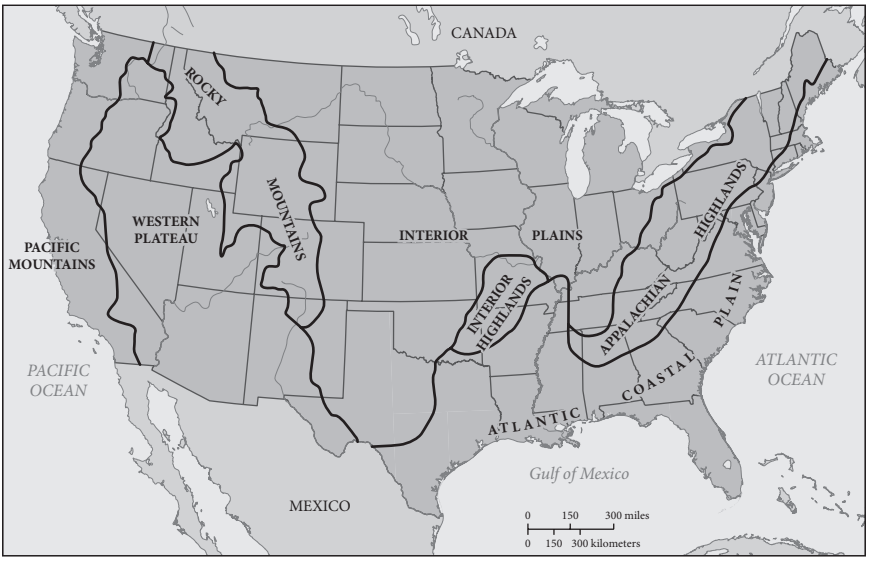

Figure 1.1 Physiographic Map of the Mainland United States. (Copyright 2018, Oxford University Press)

As human beings migrated into these very different geographic regions, the cultures and the technologies that they developed differed just as markedly. New environments create opportunities for people to modify their old tools so as to sustain and maintain themselves in new ways. Although we often make the mistake of lumping them together in one generic term, each Native American tribe was in fact unique. The tribes differed in their languages, their religions, their social systems, and also their technologies. Indeed, had these technological adaptations not occurred, anthropologists and archeologists would today find it difficult to distinguish some ancient Native American cultures from others since it is from their tools that we have come to know them.

When the first human settlers arrived in North America, they carried tools and technological skills with them. By our standards those tools were primitive, but they were nonetheless tools, and very large quantities of them (principally chipped stone spearheads) still survive. From the form and the distribution of those surviving tools, archeologists guess that those early settlers were nomadic (no house foundations have been found), land-based, big game hunters who knew how to make fires. They probably also knew how to fashion wood (into digging roots or the shafts on which spearheads were mounted), but these wooden instruments no longer survive.

In the frozen wastes of the Arctic regions, the first Native Americans developed technological systems focused not on land but on the sea and on sea mammals. They used harpoons (a spear with a detachable head attached to a flexible line) to catch whales and sea lions; the boats with which they prowled the icy waters searching for prey were made of the hides of animals previously caught. They learned how to fashion shelters out of blocks of ice, how to build sleds, and how to liquefy the body fat of their prey in order to provide fuel with which to cook.

Centuries—perhaps millennia—later, the Native Americans who had migrated to the arid Southwest possessed technological skills that were largely unknown to their brethren farther north. Some of these people built single dwellings—and others, whole villages—out of clay, now called adobe. Instead of animal skins, they wore woven cotton for clothing. They had learned not only how to domesticate the cotton plant but also how to cultivate the crop with hoes and how to straighten the cotton fibers with combs. They had invented spindle whorls (wooden shafts over which perforated disks of wood, stone, or clay have been slipped) for twisting and stretching the fibers (to make thread) and looms for weaving thread into cloth. These southwestern tribes were also skilled potters; they knew how to fashion complex vessels out of clay and then to decorate and fire the vessels so that they would be both beautiful and watertight.

Along the middle of the Pacific coastline (in the areas which are today the states of Oregon and Washington and the Canadian province of British Columbia), very different cultures and technologies emerged. These people subsisted on fish, but unlike the natives of the North, they were not nomadic. They built houses out of wood planks, having learned not only to fell trees but also to cut planks, using various stone-based woodworking tools such as axes and cudgels. The tribes

of the Pacific Northwest used nets (which they fashioned out of vines) and weirs (underwater traps made of stone or wood) to catch fish. They did not practice agriculture, but they ate various wild roots and berries, and the techniques that they used to preserve these plant products by drying served also to preserve the vitamin and mineral content of their food. As a result, the members of these tribes were exceptionally well fed; there are no records of famine ever having beset them.

On the plains and the prairies, there were yet other tribes who lived a nomadic life, hunting buffalo. These people were skilled leather workers. Their dwellings, their clothing, and their footwear all derived from the skins of the animals they hunted. On the plains and the prairies, Native Americans had learned how to stretch the hide of an animal by pulling it between stakes driven into the ground; they removed the hair and flesh by passing a sharp tool over the hide, then dressed it to make it soft and easy to manipulate by applying suitable "chemicals"—sometimes the brains of the animal that had provided the skin, sometimes human urine.

Some of the prairie tribes were only partially nomadic and farmed for part of the year. They had developed the skills needed to clear land, to plant crops, and to harvest. They also possessed the tools for grinding grain (principally corn) so that it could be eaten, as well as the utensils needed for cooking it.

The tribes of the eastern coastal plain and of the Appalachian highlands had adapted themselves to woodland living. They practiced settled forms of agriculture, but they did so without destroying the forests in which they dwelled. When a section of forest was chosen for farming, its underbrush was cleared by burning and its trees were killed (not uprooted) by girdling (cutting a strip of bark and surface tissue out of the circumference of the trunk). The soil thus created was exceptionally rich, composed of generations of decomposed leaves combined with vegetable ash; the dead trees remained standing but did not come into leaf. Under these circumstances no preparation of the soil was really needed; holes could be dug with a simple stick and seeds planted. These eastern tribes also knew how to interplant crops (corn and beans together, for example) so that one species could provide support for the other and weeds could be kept to a minimum.

The Native Americans of the eastern coastal plain were exceptionally adept at utilizing wood and other tree products. They built their houses from wooden poles, sheathed in overlapping layers of bark, stitched together as shingles. They sweetened their food with the sap of some trees and made their houses and their boats watertight with the sap of others. Their boats, their utensils, and their weapons were all fashioned either from wood or from bark, while their baskets were made from the stems of plants that grew between the trees. Like the tribes of other regions, they had adapted their technological systems to the unique characteristics of the environment that they inhabited.

Thus over the course of many centuries, as the Native Americans migrated into the various regions of North America, technological as well as cultural change had occurred. Some of the tribes were nomads, while others lived in permanent villages. Some ate small fish and game, while others hunted large mammals both on land and at sea. Some knew how to clothe themselves as protection from the

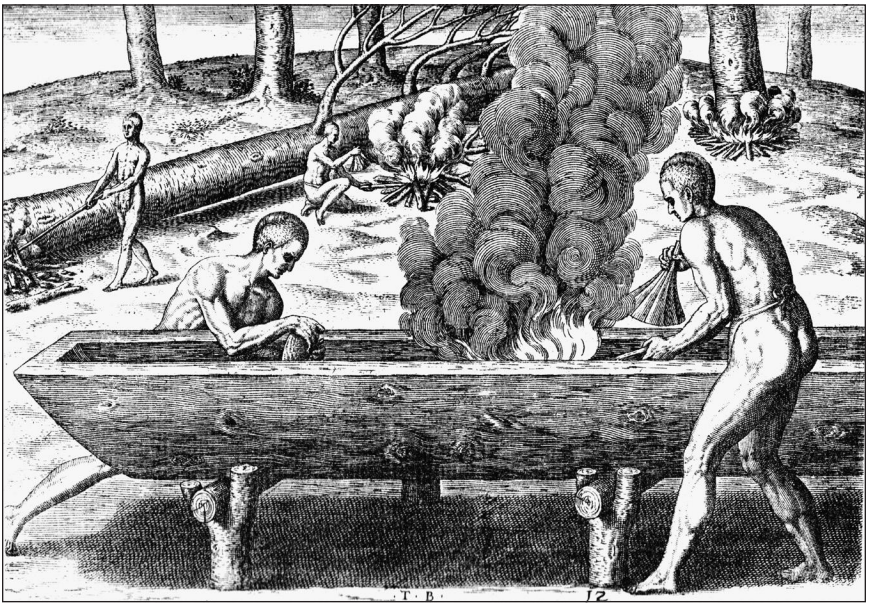

Figure 1.2 "The manner of makinge their boates in Virginia is verye wonderfull," Hariot wrote. Fire was used to fell a tree (*rear right*), remove its branches (*rear left*) and burn a trench down its center (*front*). Then shells were used to scrape and smooth the trench. "For whereas they want Instruments of yron," Hariot continued, "yet they knowe howe to make them [boats] as handsomelye . . . as ours." (Thomas Hariot, A brief and true report of the new found land of Virginia (1590))

frigid winds of the Arctic, and others lived, barely needing clothes, in tropical zones. Some dug up wild roots and collected wild berries, while others planted the seeds of domesticated plants such as corn, beans, and pumpkins. The primitive spears of the first settlers had been made more versatile as harpoons and then as arrows fitted to bows. People who had once lived in tribal nomadic bands had settled down in some places and had become farmers; in those places they developed the skills of spinning, weaving, potting, and woodworking—skills their ancestors had not had.

Yet the pace of change had always been slow, so slow that the natural environment had had time to recover from whatever ecological damage each technological change had produced. One of the technological systems that had developed in Europe, Africa, and Asia (but not in North America) in those prehistoric centuries was the use of mineral ores—copper, tin, lead, iron—to create metal tools—knives, axes, plowshares, swords, and guns. Lacking bronze and brass and iron, the Native Americans had been unable to devastate forests or uproot sod or alter the contours of the land or decimate animal populations. Lacking large numbers—the population density of the indigenous peoples was always low—they managed to sustain themselves without damaging, or even profoundly altering, their natural environments.

Thus, over the course of several millennia, because their populations were small and their rate of technical change profoundly slow, the Native Americans had lived, as nearly as it was possible for humans to do, in harmony with nature. The technological systems that they had perfected were not capable of profoundly or permanently disturbing the environments in which they were living. Those sixteenth- and seventeenth-century European explorers who believed that the wealth of the North American continent was largely untapped were absolutely right—despite the fact that people had been living on that continent for a very long time. The native tribes had manipulated the environment in order to feed, clothe, and house themselves, but they had not extensively exploited the land, had not taken out of it all, or even a large part, of what it was capable of yielding.

THE EUROPEAN SETTLERS

From a technological point of view, the sixteenth- and seventeenth-century European explorers and settlers must have looked like visitors from another planet to the natives of North America who first greeted them. Although apparently members of the same species—having two arms and two legs, opposable thumbs, and erect posture—these newcomers were, in virtually all other respects, frighteningly weird. They did not eat the same foods, wear the same clothes, speak the same languages, fight battles the same way, or utilize the same implements for even the simplest of human endeavors, like cooking or eating.

Consider, just for a moment, not the people but some of the things that must have come over to North America on the *Mayflower* in 1620. The Pilgrims brought with them several books (Bibles)—an object no Native American had ever seen before, containing pieces of a technological system (written language) in which no Native American had ever been embedded. They also brought axes, hatchets, knives, saws, hammers, augers, and a jackscrew—all implements made of a material, iron, that the natives could neither produce nor manipulate. (Archeologists tell us that the Iron Age began, in Europe, Africa, and Asia, sometime between 1800 and 1200 BCE.) At least one wooden plow was on board, an implement intended for turning over the soil, a job that the natives of the eastern seaboard had never needed to accomplish.

Either the *Mayflower* itself or a subsequent supply ship carried pigs and cows and oxen, so that the Pilgrims might be supplied with meat, milk, and draft labor. Domesticated animals were yet another technological system that must have startled the Native Americans, who, with their intimate knowledge of deer, wolves, and beavers, had probably never dreamed that there were animals that would sit still long enough to be milked or to have a yoke thrown over their shoulders. The Pilgrims protected their bodies with clothing made of woven cloth—a material the natives of the Atlantic shore, clad in leather and furs, had never seen and did not know how to make. In addition, the Pilgrims possessed implements—guns—the sight, sound, and effects of which must have terrified the people who had suddenly become their neighbors.

If the objects were strange, so too was the culture, the whole system of symbols and behaviors that had been built over around and through these objects. The Europeans, whether they were French, Dutch, Spanish, or English, were accustomed to communicating in written languages, something that their forebears, descendants of the Neolithic peoples of the Middle East and the Mediterranean, had been doing for at least two millennia. When Europeans wanted to signify that some agreement had been made between two parties, they wrote it down. When they wanted to exchange pieces of real estate, they composed a deed. When they wanted to exchange valuable goods without too much inconvenience, they composed bills of exchange. When they wanted to establish some new way of behaving, they developed instructions and wrote them down. When they were feeling introspective or momentous, they created diaries. When they wanted to communicate with people at a distance, they wrote letters. The most prominent symbol of their entire culture, the object that meant more to them than any other, the focus of their communal and individual spiritual lives, was a book.

The Native American also needed frequently to communicate with each other, or on occasion with their new neighbors. They too exchanged valuable commodities or pieces of real estate; they too wanted to teach new behaviors; they too felt introspective and momentous; they too had religious ceremonies and spiritual longings. But none of these was accomplished through, or symbolized by, writing, an activity as meaningless to the natives as it was meaningful to the settlers. The Native American and the Europeans were not just speaking two different languages; they were embedded in two different language systems, one that was entirely oral and the other that was partly oral and partly written. Between those two systems communication was difficult indeed—perhaps, ultimately, impossible.

But poor communication was not the only source of difficulty. The Europeans came from societies that had been practicing settled agriculture for many, many centuries; the traditional practices of European agriculture were ancient, going back, in some cases, to the traditions of the peoples who had been farmers and shepherds in ancient Babylonia, Egypt, Greece, Rome, and Palestine. When they wanted to farm, the Europeans cleared the land of trees: chopped them down, uprooted them completely. At the beginning of each growing season, they broke through the winter-crusted earth and turned it over so that seeds would root and plants would grow. When they planted vegetable seed, Europeans planted it neatly in rows, the better to be able to cultivate during the growing season. Each field that they planted had a regular time to be left fallow, after which it would be planted again. They used their fields over and over again, renewing the soil, when it was depleted, sometimes by letting it lie fallow, sometimes by plowing under decayed plant material, and sometimes by collecting and distributing animal manure. Since their animals were valuable commodities (for food, labor, and manure), they built shelters as protection from predators. Europeans also created fences to keep their animals out of the fields in which their crops were growing.

All of these agricultural practices were alien to the Native Americans. They did not build fences and did not understand what straight lines of wood or stone

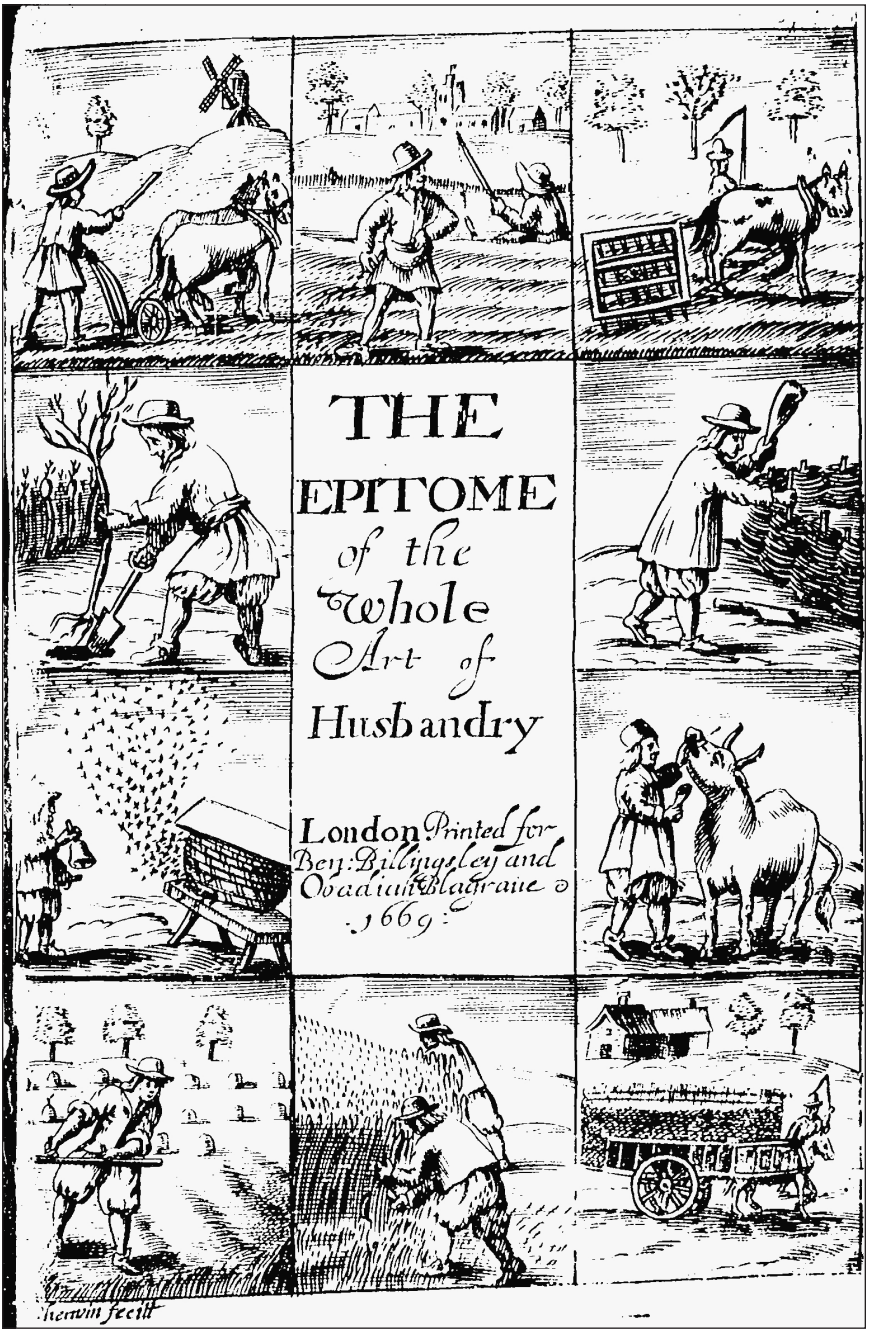

Figure 1.3 Some of English tools and domesticated animals that might have astonished the native inhabitants of eastern North America. This title page from an English book by Thomas Blagreve, *The Epitome of the Whole Art of Husbandry* (1675), shows (*clockwise from upper left*) a plow, straight furrows, a harrow, fencing, an ox**,** a cart, a sickle, a scythe, a bee hive, a shovel. (Courtesy of New York Public Library)

were intended to signify. They did not own animals and so considered a pig or cow or ox found wandering in the woods (which the colonists frequently allowed their animals to do) to be, quite literally, fair game. The natives, especially those in the vicinity of Plymouth and Massachusetts Bay, believed that the English were insanely overworked, laboring from dawn to dusk to dig rocks and tree roots out of fields. To the natives, the English seemed profoundly stupid since they were very poor hunters and did not know how to regulate their diets in winter so as to go for several days without eating. The English, in turn, regarded the natives as irresponsible since they did not labor especially hard to store large quantities of food for the winter.

European settlers tried to build permanent homes for themselves and, having struggled so hard to clear the land, tried to keep their farms fertile indefinitely. The natives didn't bother; when yields proved scanty on one piece of land, they gave it up, let it revert to its natural state, and moved somewhere else. Accumulation of goods and attachment to objects such as houses, fences, and plows seemed to them to be the height of foolishness; "They love not to bee encumbered with many utensils," as one seventeenth-century observer put it.[1]

Nothing, however, was quite so strange, or created quite so much hostility, as the habit Europeans had of giving parcels of land in perpetuity to individuals and their offspring—of owning land. From the European, most especially the English, point of view, a person could become the owner of a piece of land in one of three ways: by developing it for use, by buying it, or by receiving it as a gift. Once that person owned the land, he or she had control of it absolutely: to sell it, give it as a gift to someone else, rent it, or alter it. From the native point of view, people owned the produce of the land that they had worked, but not the land itself. Native families did not expect to live on or work any given piece of ground for any great length of time; hence they had no reason to think about buying or selling, donating, or setting restrictions on any piece of territory.

We will probably never know what Chief Powhatan thought he was doing when he "sold" Manhattan Island to the Dutch for a dozen or so packhorses loaded with "Indian goods," but we can be fairly certain Peter Stuyvesant thought something different. The governors of Plymouth and Massachusetts Bay, citing Genesis ("And God blessed them: and God said unto them: 'Be fruitful, and multiply, and replenish the earth, and subdue it.'"), believed that the natives only had ownership rights over the very few plots that they were actively working at the time the settlers arrived. The land, as John Winthrop put it, "lay open to any that could or would improve it [since] the Natives in New England inclose noe Land, neither have any settled habytation, nor any tame Cattle to improve the Land by."[2] Everything that was not being "subdued"—clam banks, fishing ponds, berry-picking areas, hunting grounds, uncleared forest—could be, and was, allocated to settlers, justifiably (from the English point of view) and without guilt. Unfortunately for the English, the natives did not find any justice in that arrangement.

Subduing the land was something that Europeans had been doing for centuries before the first of them tried to accomplish it in North America, and over the

course of those centuries, the landscape of Europe had been changed profoundly. Where there had once been vast, dense forests, there were now, in Europe, mile after mile of cultivated fields. When the forests disappeared, so too did the game animals—deer and pheasant, ducks and squirrels—that had once inhabited the forests; so too did many of the nuts and berries that had once been a standard part of human diets. By the seventeenth century, Europeans could only feed themselves through agricultural practices; they had lost the ability (which the Native Americans still possessed) to live directly off the land. To Europeans, the forests were dangerous, terrifying places that had to be subdued before civilization, or even survival, could be accomplished.

The forests of the New World were even more terrifying to the European settlers because bands of hostile natives lurked in them. Native Americans warriors traveled in small bands, moving swiftly and soundlessly through forests with which they were quite familiar, using various features of the landscape to provide cover, overtaking their enemies, whenever possible, in surprise attacks. The European settlers called this a "skulking way of war," because they were accustomed to open field combat tactics; for them, cultivated fields were the appropriate places for battles, not forests. European soldiers stood in ranked lines across those fields, loading and firing their guns at each other in unison, hoping to make up in massive fire power what their guns could not achieve by accuracy. To make matters worse for the settlers, in the early decades of the seventeenth century the natives had begun acquiring guns in trade for furs and had turned out to be better marksmen than the settlers, the vast majority of whom had never had military training. The settlers had no military success against the natives until later in the century when they began, reluctantly, to adopt the tactics they had previously disparaged: they formed alliances with Indian tribes who could guide them through the forests, stopped moving in large groups, utilized canoes and snowshoes as quiet forms of transportation, and began training their own citizen militias.

The fact that the earliest European settlers had had no military training also signifies another important difference between them and the native inhabitants of their new world. Over the previous centuries, Europeans had become accustomed to and dependent on a social structure characterized by a high degree of differentiation: in Europe, some people specialized in farming, while other people pursued the crafts or were merchants, soldiers, priests, or physicians. This differentiation was possible at least in part because European agricultural techniques were efficient enough to produce surpluses of food; some people could be spared from food production to pursue other endeavors.

Over the course of the centuries, a social system had developed in Europe in which farmers, the people who produce the commodity that everyone needs to survive, had become dependent on numerous products and services provided by non-farmers. In England, France, Spain, and Holland, there were people who specialized in butchering, baking, and candlestick making—as well as building ships, weaving sailcloth, shoeing horses, spinning flax, weaving wool, grinding grain, and carving stone.

The technological systems of seventeenth-century Europe, and the differentiated social system with which they were intertwined, may seem simple to our twenty-first-century eyes, but they were very complex when compared with Native American systems—and the Europeans who crossed the Atlantic were very dependent on them. Most Europeans could not live as the Indians could, "unencumbered by utensils." (Those few Europeans who enjoyed living in the native style were usually explorers and trappers—loners—not founders of permanent settlements.) In order to farm, a European farmer needed a plow; and in order to maintain the plow, the farmer needed a blacksmith. In order for the blacksmith to be supplied with wrought iron, it had to be purchased from the owner of an iron furnace, who couldn't make wrought iron without employing skilled craftsmen. Neither the farmer nor the furnace owner could have gone about their business without depending on merchants (since iron ore is not evenly distributed in every locale in which people need it), who were themselves dependent on carpenters (to make carts) and teamsters (who loaded and drove carts). There was no level of European life into which such networks of social and technical dependency did not spread.

Europeans could neither feed nor clothe themselves without the help of skilled craftspeople and complex machines. The hard outer shell of most dried grain seeds must be mechanically broken or human stomachs cannot digest it. Native Americans accomplished this task by grinding their corn (after it had been removed from the cob and dried) between two stones, or in a stone or wood device similar to a mortar and pestle. By the seventeenth-century, Europeans had long forgotten how to do this themselves; in the early Middle Ages, some enterprising Europeans had learned how to build water- or horse-powered gristmills for the purpose. These mills represented large investments both of money and labor because they were (for their time) large structures of wood or stone (then very expensive materials) containing millstones, which had to be quarried, transported, cut, and attached to gearing systems, as well as waterwheels, which only skilled craftsmen could build and maintain.

So it was also with clothing. If a Native American boy needed a new set of trousers, he could kill a deer, and the rest of his family could skin it, stretch the skin, and then sew it together. The tools involved were the bows and arrows needed to fell the deer, the sharpened stones needed to skin it, and the awls (made from bone) needed to pierce the skin so that thongs might be threaded through. Most Native Americans possessed the skills that were needed both to fashion those tools and to process those hides.

If an English girl needed a new dress, the process of providing it for her was very different, and no member of her immediate family could have owned all the tools that were necessary, let alone known how to make or repair them. Cloth was purchased from a merchant, who obtained it from a dyer, who purchased it from a fuller (who owned a mill in which cloth was pounded and treated with chemicals to shrink it). The fuller received the cloth from a weaver (who owned and operated a loom), who had received the thread from spinsters (who used spinning wheels

that had to be built by carpenters), who purchased raw wool from sheep that had been raised and shorn by yet other skilled craftspeople. Only then might the dress be sewn together at home, using a needle (purchased from a peddler, who got it from a needle maker) and some thread (which the girl might have spun herself).

When Europeans were transplanted across the Atlantic Ocean, they were cut off from the network of craftspeople on which their lives up until then had depended. Just imagine what it might have been like to break a needle or run out of thread when you are three thousand miles—and several months—away from the nearest spinning wheel or needle maker. Imagine trying to sharpen an ax when you have no access to a grinding wheel and you need the ax to chop down some trees. Worse yet, imagine needing to chop down those trees in order to build something that will shelter you from the elements when you are not a carpenter and haven't the faintest idea how to tether the pieces of wood together so the shelter will remain standing when the winds begin to blow!

The Europeans needed to learn basic survival skills from the Native Americans, and they needed to learn those skills very soon after arriving. Few if any craftspeople were tempted to make the treacherous trip across the ocean. Even if they had been tempted to come, many of their crafts could not have been pursued in the New World because the equipment they needed was too difficult to transport or because the essential raw materials were too difficult to obtain. So the Europeans needed to learn how to build traps to catch wild game, fish, and birds; they also needed to learn how to grow corn, beans, and pumpkins—foods that they had never before tasted. Most had to learn how to hollow out the trunk of a tree so that grains of corn could be pounded into meal; others had to learn to mix those grains with water to create a type of bread. Even those who were not shoemakers learned how to make moccasins out of the skins of wild animals; even those who were not carpenters learned how to shape necessary objects out of wood, particularly canoes. Perhaps most significantly of all, the early settlers learned the virtues of becoming undifferentiated and unspecialized from the natives that they so quickly and unfairly displaced. They learned that survival in the New World required men and women to be adept at many skills: jacks-and-jills-of-all-trades, albeit masters and mistresses of none. And when they passed on that knowledge and those skills to their children, they created what subsequently came to be called the culture of "Yankee ingenuity."

THE COLONIAL ECONOMY

The settlements that eventually became the thirteen colonies were each founded in a different way, in a different time. In the early seventeenth century, Virginia and Massachusetts were started by companies, groups of investors who pooled their resources in order to finance a group of settlers. New York began in the same way, except that the original investors and settlers were Dutch rather than English, but New York was turned into a proprietary colony (belonging to one individual who had his grant from the king) when the English ousted the Dutch in 1664. New Jersey, Pennsylvania, Connecticut, Delaware, and both Carolinas were also

seventeenth-century proprietary colonies, and so was Maryland, created to provide a haven for English Catholics. New Hampshire and Rhode Island were created later in the seventeenth century by emigrants from Massachusetts who found the religious intolerance of the original settlers a bit too much to bear, and Georgia, the very last (organized in 1732), was founded by a company with the express intention of turning a profit for the investors by providing jobs and homes for people who would otherwise have been imprisoned for debt.

The economy that the European settlers created in North America was an economy based on trade across the ocean. Lacking the ability to manufacture the goods that they needed for survival (axes and salt, cooking pots and woolen cloth), the colonists desperately needed some commodity that they could sell on European markets in exchange for those goods. Even after several decades, even after the difficulties of first settlement had been overcome, both hard cash and human labor were still scarce in the colonies, and manufactured goods had to be imported from abroad. By the time the seventeenth century had turned into the eighteenth, Atlantic trade had become the backbone of the colonial economy; without it the entire enterprise of settlement everywhere in North America (including the French colonies, which eventually formed the basis of Canada) would have failed—and failed miserably.

From Jamestown in 1610, from Massachusetts Bay in 1630, and from Georgia a century later, the first products sent back to Europe after the settlers arrived were those that were very nearly raw, products that were easiest to procure with the fewest tools and the least labor. In many places, particularly where the native inhabitants were willing to cooperate, this product was furs—pelts of the animals that inhabited the endless forests of the eastern coastal plain and the Appalachian highlands. Furs were close to a perfect product from the colonists' point of view. Relatively lightweight and pliable, they were easily packed for shipment across the ocean, where they commanded very high prices. Western Europe had been depleted of most of its furbearing animals for a very long time, but the demand for fur remained high since there was no product better able to protect Europeans from the ravages of the cold. Rather than hunt themselves (an enterprise at which they were not very skilled), the settlers preferred to obtain pelts from the local tribes, who were often quite willing to trade beaver skins and deer hides for axes, knives, cloth, guns, mirrors, kettles, beer, rum, and other products of European civilization. Thus the labor costs involved in the fur trade were slight, as long as the labor of the natives was discounted. The fur trade continued to be a major sector of the colonial economy throughout the eighteenth century; 2,000 packhorses loaded with "Indian goods" made their way west from Augusta, Georgia, just in the year 1740 alone, returning with pelts which would bring between £20,000 and £30,000 on the London market (approximately $3 million today). Within decades, the eastern forests were depleted of furbearing animals and trading outposts had to be established farther west—one of the reasons the French and the English were at each other's throats in the territory between the Mississippi and the Appalachians in the middle decades of the eighteenth century.

Aside from furs, the forests of the New World provided the earliest colonizers with several other products, much in demand in Europe, that were relatively easy to extract: potash, pearl ash, pitch, tar, and resin. Unglamorous as these may be, they were used in a host of manufacturing processes; the first two were essential chemicals in the making of soap and glass, as well as the dying and shrinking of cloth; the latter three, in shipbuilding and other forms of carpentry. Wherever there were pine trees (in the Carolinas, for example, or on the sandy soils of Cape Cod), pitch, tar, and resin (frequently lumped together under the heading "naval stores") could be collected by tapping and purified by boiling. Wherever land had to be cleared of trees, potash and pearl ash could be produced as a cash crop, by-products, as it were, of the process of clearing.

Potash was made by constructing a huge pile out of the trees that had been felled, burning it, collecting the resultant ash, loading it into a huge iron pot, and heating the ash until it was semi-molten. The heating process caused carbon, sulfur, and a few other elements in the ash to be driven off (as noxious gases), and the gray caked material that resulted when the pot cooled was nearly pure potassium nitrate. Reheating this once again in the same pot could, if high enough heats could be achieved, break down this compound and produce almost pure potassium, called pearl ash by virtue of its lighter color. Hauled to the nearest merchant, these alkalis could be traded for the supplies needed to get through the first winter, before land could be plowed and the first crop harvested. Naval stores and alkalis were one of several forest products without which the young American economy might not have survived.

Wood itself was another such commodity, whether in the form of whole logs, boards, shingles, or barrel staves. Western Europe had long been starved for wood: in all of England, for example, there was no stretch of forested land more than five miles square in the early seventeenth century, and in parts of southern England (the most populous part of the country), there was virtually no wood at all with the exception of hedges. The earliest explorers and settlers were well aware of the potential value of the North American forests: on June 22, 1607, the Jamestown settlers wrote to the officers of the Virginia Company to tell them that "the soil is most fruitful, laden with good Oake, Ashe, Walnut trees, Poplar, Pine, sweet woods, Cedar, and others yet without names." A few trees had already been felled, and some boards sawed so as to construct a few houses, the colonists reported, and they had already sent back "a taste of clapboard." That taste must have whetted English appetites because it was not long before the garrison in the Jamestown block house was set "for their exercise" to the cutting down of trees and the making with hand tools "of Clapboard and Wainscot"—and not long either before a sawmill had been constructed further up the James River in Henrico.[3] The lumber industry in the colonies expanded rather quickly after that. By 1675 there were fifty sawmills operating just in the province of Massachusetts. Some communities built sawmills even before they built gristmills, which meant that they had to import flour from somewhere else.

Some of these early sawmills were tidal mills, one or two may have been windmills; the vast majority used river falls to run a waterwheel, which, through simple wooden gearing, powered an up-and-down saw blade. The waterwheels were situated so that trees could be cut upstream and floated down to the mill and the sawn boards carried out on boats or barges. At least for the better part of the seventeenth and early eighteenth centuries, most of these mills were built and operated by men who were not English, lumber having been so scarce in England for so many centuries that sawmilling had not flourished there. Where sawmills were to be built and operated, Danish and Swedish emigration was encouraged by the investors—an early example of what later came to be called technology transfer through the emigration of skilled labor.

Lumbering also provides an example of the way in which an implement can be changed by anonymous craftspeople when a new environment creates new opportunities and new demands. The ax that Europeans brought with them when they first crossed the Atlantic consisted of a brittle iron head (the poll) weighing about four pounds onto which a very light steel blade (the bit) was welded, with the whole head inserted in a straight, club-like handle. Over the course of several decades, colonial craftsmen began to improve this instrument, which had remained unchanged in Europe over many centuries. The weight of the poll and bit was evened out so that the center of gravity of the head was located near the centerline of the handle; the handle itself was carved so that it curved, frequently precisely to fit both the height and the grip of the person who was going to wield it. Using an American ax a person could fell three times as many trees as someone using the older, European type.

Between the ax and the sawmill, the eastern forests were very quickly transformed—and in some cases obliterated. The great white pines of the northern forests were cut down for ship masts; the smaller pines became the millions of miles of boards from which houses, barns, forts, and mills were built all over North America, Europe, and the Caribbean. The white and red oaks were transformed into barrels, casks, and trunks for transporting wine, sugar, rum, and flour. The birches became canoes and shingles. The cherries and the maples became furniture, the willows became caning; the chestnuts and the cedars became fences. A good lot of this lumber was exported, but not all of it. Every structure in the colonies was built, wholly or in large part, out of wood; virtually every implement, from printing presses to rakes, was made out of wood; and nearly every household, from Maine to Georgia, burned wood every single day of the year for heating or for cooking until well into the early decades of the nineteenth century. A typical New England household consumed as much as thirty or forty cords of firewood a year, a stack of wood four feet high, four feet wide, and three hundred feet long—better than an acre of forest. Where the Europeans favored half-timbered construction, the Americans moved quickly to full-timbered styles; roofs that had been thatch or slate abroad were shingled in America. American lumbering practices were regarded by European travelers as very wasteful: "an incredible amount of wood is really squandered in this country for fuel," a Swedish visitor remarked in the

1740s, "day and night all winter, or for nearly half of the year, in all rooms, a fire is kept going."[4] Trees were cut down helter-skelter, without any thought being given to the renewal of the forests—hardly a serious manner when the forests themselves seemed endless.

But the forests were not, in fact, endless. Within a few decades, some types of trees—the great white "mast" pines—had disappeared entirely from the forests of the coastal plain, and the balance between species had been profoundly altered. By the end of the eighteenth century, deforestation had transformed the ecology of whole districts, most especially in New England, New York, and Pennsylvania—many habitats for game had disappeared, watercourses had changed, seasonal flooding was more frequent and more devastating, the soil was less able to retain water, summers were hotter and winters colder than they previously had been. The landscape Americans now seek when they travel to Maine or New Hampshire or to the White Mountains, the Catskills, the Poconos, or the Blue Ridge for their vacations is not, by any stretch of the imagination or of nostalgia, the original, densely forested landscape that the settlers encountered when they first arrived.

Aside from furs and forest products, the three items that formed the backbone of the American economy during the first decades of settlement were fish, tobacco, and wheat. Wheat did not grow well in New England, where it was subject to devastation by a fungal disease called "blast," but it did flourish farther south, in parts of New York (particularly Long Island and the Mohawk Valley) and in New Jersey, Delaware, Pennsylvania, and Virginia. Europe experienced periodic shortages of wheat; a drought here or a battle there could, and frequently did, threaten some Europeans with starvation every year. The farmers of New York, Pennsylvania, New Jersey, Delaware, Virginia, and Maryland were happy to provide their European cousins with the staff of life—for a price. They were also happy to provide their compatriots overseas with the "noxious weed" that the Native Americans had taught the Europeans how to roll into tubes and smoke for relaxation.

By 1700, the middle and southern colonies were starting to convert from subsistence to commercial agriculture, with wheat and tobacco as their principal products. Commercial farming was a labor-intensive activity; both wheat and tobacco required considerably more care in plowing, cultivating, irrigating, harvesting, and fertilizing than corn does. For this reason, the middle and southern colonies imported more indentured servants than New England during the seventeenth and much of the eighteenth centuries—until, that is, some commercial farmers (particularly in the southern colonies) realized that slaves provided even less expensive labor than indentured servants.

The cities of the middle colonies—New York, Philadelphia, and Baltimore—became centers of merchant milling by the end of the seventeenth century. Merchant mills were somewhat different enterprises from local gristmills. Colonial farmers brought their grain to a local gristmill to have it ground for their own consumption; the price the miller exacted for this service was some fraction of the grain or some other farm product—cider, perhaps, or a side of pork. When farmers brought their grain to a merchant mill, they expect to sell it to the miller

in exchange for cash. The miller then ground it and packed it into barrels for shipment and sale somewhere else. Merchant mills were very profitable in the colonies, and they were also, as we shall see in the next chapter, a locus for important forms of technological change.

So were fisheries or, more precisely, some of the industries that were stimulated by the massive colonial trade in dried fish, particularly cod. Meat was not a basic staple of European diets in the seventeenth century, but fish was very popular. Fish were relatively easy to catch, very easy to preserve (in salt), and relatively easy to transport (in barrels)—hence, fish were cheap. Fish was also, in those countries that continued to abide by the practices of the Catholic Church, ritually required as a food on some days of the week and for some weeks of the year. Having been worked over for centuries, the prime fishing areas along the European coast were not bearing very well by the seventeenth century—the reason Portuguese, Dutch, French, and English fishing fleets had been scurrying down the coast of Africa, in and around the Baltic, and all over Greenland in search of fish.

Eventually they were bound to try North America. Stretching in a long arc from Long Island to Newfoundland, cooled by an Arctic current, lay one of the finest fishing grounds in the world. In the early decades of the sixteenth century, French and Portuguese fishing fleets established fishing stations in the areas that are today Newfoundland. Roughly a century later, the English who settled in Plymouth and Massachusetts Bay, as well as the Dutch who settled New Amsterdam, also began mining the gold that came from the sea. The abundance and variety of fishes in the waters around Massachusetts astounded the earliest settlers. The Reverend Francis Higginson, who was the first minister of Salem, Massachusetts, told friends and relatives in England: "The aboundance of Sea-Fish are almost beyond beleeving, and sure I should scarce have beleeved it except I had seene it with mine owne eyes." One settler reported that during a few hours of fishing he and his companions "had pestered our ship so with Cod fish, that we threw numbers of them overboard againe."[5] By 1700, New Englanders were exporting over 10 million pounds of fish a year, surpassing the fleets of England in both quantity and quality. By 1770, 665 vessels were employed in the New England fisheries alone, and 4,405 men (a number larger than the total population of several substantial towns) were making their livings as fishermen.

Such extensive fishing (and also whaling) stimulated other colonial industries. Someone, after all, had to build all those boats carrying the whalers and the fisherman out to sea; someone had to weave the sailcloth; someone else had to make the rope that was used to keep the sails in place. The colonists quickly became adept at all of these endeavors; to the dismay of English craftsmen, colonial shipbuilders were soon able to turn out a product that was cheaper (since transportation costs on the raw material were lower) and better adapted to coastal sailing.

Furs, trees, fish, wheat, and tobacco—these were the humble materials on which firm colonial foundations were laid. Some of the colonists may have dreamed of living without religious persecution, some may have dreamed of a life unfettered by poverty, some may even have remotely sensed the potential for

democratic government in the New World—but all realized that first they had to trade something in order to survive in the wilderness. Some made fortunes from furs, trees, fish, wheat, and tobacco (and, of course, land), but every single colonist depended on the trade in those commodities simply for survival. In some cases, that dependence was direct, as when colonists exchanged potash for plowshares so that they could plant the seeds that produced their food. In other cases, it was indirect, as when the mother country, anxious not to interrupt the flow of profitable goods, sent soldiers and armaments to defend the colonists against the often hostile native inhabitants. Either way—direct or indirect—furs, trees, fish, wheat, and tobacco kept both the colonists and the colonies alive.

COLONIAL ECONOMIC POLICY AND TECHNOLOGICAL CHANGE

Most of the social and technological systems that both the Native Americans and the European colonists developed in North America evolved in response to the pressures and opportunities created by new environments. The very first human settlers on the continent used stone and wood spears to kill polar bears, but they eventually figured out how to add leather and make harpoons, which could effectively kill the sea lions and whales that were so abundant in the arctic seas. Centuries later, their descendants living on the temperate plains and woodlands learned how to propel small spears with the tensile forces of bent wood and twisted animal gut, thus adding small game (rabbits, deer, squirrels, pheasants) to their diets.

Later still, the Europeans arrived, and their traditional implements and skills began to change also. Unable to grow wheat easily at first, they learned to make a semi-leavened bread from corn. Unable to depend on the network of crafts they had been accustomed to in Europe, they learned how to do their own butchering, baking, and candle making—and how to repair their implements themselves. Their unwieldy axes, little used in Europe, evolved into elegant and efficient instruments in the New World, adapted to the needs of people who wanted to eliminate and clear the forests as quickly as possible.

But necessity and opportunity, although powerful, are not the only forces that direct and shape technological systems. The European colonists brought with them another social instrument—governmental policy—which can also have profound effects on technological change. The North American tribes, lacking complex governmental arrangements and bureaucrats who devote their lives to creating and implementing economic policies, may not have been aware of the power that governments can have over technology, but the European settlers in North America most certainly were.

In the seventeenth and eighteenth centuries, mercantilism was the economic theory favored by most European monarchs. It was a very simple theory: the function of the king's government was to make the king rich, for when the king was rich he could defend his nation and extend its power, thereby making his subjects

rich, or at least comfortable. The best kind of riches, the mercantilists thought, were the kind the Spanish had taken from South America, gold and silver bullion. Unfortunately, not all countries were lucky enough to be able to tap into the silver mines of Mexico and the gold lodes of Peru. For these unfortunate countries, there was a second best solution—trade. And the very best kind of trade was with your very own countrymen, settled in colonies far distant from your homeland. Colonies could supply you with raw materials that would stimulate industry at home and would, in turn, provide a ready market for things that had been manufactured at home.

To keep the colonial system working to the advantage of the monarch, it was, however, necessary to ensure that all the goods being traded back and forth between colony and homeland were carried on vessels owned by loyal subjects, manned by loyal sailors, and unloaded only at royally approved ports—the better to ensure that in times of peace the regulations would be followed and that in times of war there would be plenty of ships and plenty of skilled sailors to draft into the king's service. Now all of this required something of a bureaucracy to enforce, but the cost of the bureaucracy would certainly be offset by the riches that would flow into the coffers of the king—or so the theory said.

In practice, of course, nothing worked out quite that simply, either for the colonies or for the mother country. Bureaucratic control turned out to be a rather difficult thing to manage three thousand miles across the ocean, and some of the colonists turned out to be quite adept at smuggling; the word "yankee" is actually a corruption of a Dutch word that means "smuggler." After a while, in any event, the rules and regulations started to get so complicated that even a perfect bureaucracy could not have enforced them. As trade between the colonies and the homeland picked up and as the colonial economies became more stable, difficult situations inevitably arose in which it proved impossible either to know whose interests it was best to serve or whether the regulations were accomplishing what they were intended to accomplish. What do you do, for example, when the colonists, who are, after all, loyal subjects, begin producing ships (very good ships as it happens) in direct competition with shipbuilders at home, who also happen to be loyal subjects?

With all the goodwill in the world, the kings of England and their financial advisors could not have resolved such disputes either equitably or simply—and, of course, neither the king nor the officials of his customs agency had all the goodwill (or efficiency) in the world. By the middle decades of the eighteenth century, the mercantile system had become hopelessly complicated, and it continued to become more complicated—and more of an irritant to the colonists—as King George III attempted in the years after 1763 to solve his financial troubles by exercising ever more control over colonial trade. The oft-amended Navigation Acts, the Currency Act, the Sugar Act, and the Stamp Act eventually provoked the colonists to revolt; they also had a crucial, although less spectacular, determining effect on the pattern of technological change in the colonies.

In capitalistic economies such as those of Europe in the seventeenth and eighteenth centuries, wherever an industry flourishes, technological change occurs. When many people are engaged in the same activity, someone will eventually figure out how to change an implement here, or reorganize a system there, so as to give his or her enterprise just a little competitive edge. And where the activity is proving profitable, someone else may come along and invest the funds that the innovator needs to experiment with the new implement or develop the reorganized system, producing not just an idea for technological change but technological change itself. The waterwheel was a European invention, but Americans were building a waterwheel on every stream that could tolerate one. Sooner or later some American was going to figure out how to build one just a little bit better, as we will see in a later chapter. The mills that were powered by waterwheels—the merchant mills that ground wheat and the sawmills that created boards—were extremely profitable ventures (in part because the goods they were producing were in demand overseas) which meant that eventually some investor, while laying out money to build a new mill, was going to consider building it with one of those "just a little bit better" wheels—and the technology of waterpower was going to change.

Yet while mercantilism favored American milling, it did not similarly favor American weaving or, for that matter, American spinning. The rules and regulations of the English international economy were constructed to encourage export of flax, cotton, and wool from the colonies while prohibiting the export of cloth. Cloth had been one of England's principal export commodities for centuries, and according to mercantile theory, the English would have been foolish to allow a cloth-making industry to develop in their colonies. Americans were allowed to spin and weave materials for their own consumption, but not for sale overseas; whatever they needed that they could not supply with their own hands, they were expected to buy from producers in England. This meant that spinning and weaving were both relatively unpopular and relatively unprofitable occupations in the colonies. Thus in the last decades of the eighteenth century, the early years of industrialization, when spinning wheels and looms were changing with dizzying speed in Britain, they were hardly changing at all in the British colonies. The power of even inefficiently enforced governmental policy was such that those colonial industries that were repressed by regulations of the British Board of Trade (textile production was one such industry; iron and steel fabrication was another) did not undergo technological change until several decades after independence had been won.

CONCLUSION: QUICKENING THE PACE OF TECHNOLOGICAL CHANGE

By 1750, the continuance of European settlement in North America seemed assured. Each of the thirteen colonies was, in its own way, flourishing. The growth of foreign trade had led to the development of cities all along the eastern seaboard, from Boston in the North to Charleston in the South. Frontier settlements were still being attacked by bands of Native Americans, and French armies on the

western frontiers were still a source of worry—but most of the time most of the colonists could go about their business peacefully. New immigrants arrived daily: from Scotland and Ireland, from Scandinavia and France, from the Germanies and from the Netherlands. The population was increasing by natural means as well; since colonial mothers were better fed than their European sisters, they tended to have more children, and those children were more likely to survive infancy.

At every turn, civilization was being "implanted" in the colonies, and the wilderness was being "subdued." Fish, furs, trees, wheat, and tobacco still provided the basis for the colonial trading economy, but other products had been added as the colonists had pushed into new territory and as money was invested in new facilities. Wheat was still flowing in an endless stream from the middle colonies, but by the 1750s more of it was leaving as flour and biscuit than as whole grains. Pig and bar iron was leaving the smelter's furnace and traveling across the seas, just as rum was being poured out of the distiller's vats and into barrels destined for the Caribbean. Virginia and Maryland were still producing tobacco, but North Carolina had converted to indigo and South Carolina to rice (each of them also labor-intensive crops). Naval stores remained an important export, but so too did increasingly large quantities of finished wood products: knocked-down houses (intended for quick construction in the Caribbean), clapboards, shingles, and barrel staves.

As the European population of the colonies expanded, so too did the level of domestic demand and the quality of the goods being produced to satisfy it. Craftspeople in Philadelphia were making furniture for houses in Lancaster, while iron furnaces in Lancaster were producing box stoves to heat houses in Philadelphia. Shoemakers in Massachusetts were making footwear that was being sold to plantation owners in North Carolina. Weavers in New York were making cloth that was purchased in Connecticut, and the owners of orchards in Connecticut were pressing cider that was being sold in New York.

After its primitive beginnings, the colonial economy had developed into a rather complex affair by 1750. Only a century and a half earlier, the forests and the beaches of the eastern coastal plain had been occupied by people who cut the bark from trees with stone cudgels, dug root crops out of the ground with sticks, and ground grain in hollowed-out logs. Now there were sawmills and distilleries, gristmills and brickworks. Just a short time earlier, there had been people living directly off the fruits of the ground; now there were people living directly off the fruits of foreign trade. Where once the Europeans had been frightened by terrifying forests and mysterious rivers, they now found cultivated fields and prospering cities.

For several millennia, technological change had occurred slowly in North America. People migrated and adapted to new environments, but there had never been enough of them to profoundly alter those environments, even if their technologies had been capable of it, which they weren't. New technologies had developed in response to new environmental conditions, but never at a pace or to an extent that had prevented the natural environment from repairing itself. Animals had been killed, but their populations had never been completely decimated, so they

were always able to reproduce themselves. Plots of agricultural land, once abandoned, had fairly quickly become indistinguishable from the surrounding forest.

With the advent of Europeans, the pace of change quickened—and the changes began to look both permanent and profound. The Europeans brought with them social and technological systems that had evolved slowly, over many millennia, somewhere else; but in North America, they were totally novel and had totally novel effects. In just over a century, the human population of the eastern coastal plain had increased markedly and its natural environment had been completely altered. Many of the forests had been cleared; most of the furbearing animals had been killed; some species of birds were almost extinct.

At first, the new settlers had had to borrow survival skills and locally adapted implements from the native peoples, but once they had managed to stabilize their colonies and establish regular trade with their home country, they were able to re-create a semblance of the social and technological world of Europe. Some new settlers adapted their old technologies to fit new conditions. Other settlers used the technologies at their disposal (and the support of their government) to alter their new land so that it would more closely resemble, and be of service to, the one from which they had come. Yet others used the same technologies—the books and the deeds, the guns and the axes, the wheat and the cattle—to exploit the abundant natural resources of the new land in new ways, at a new pace, and with new convictions about the righteousness of what they were doing.

NOTES

1. From the diary of Thomas Morton [n.d.], as quoted in William Cronon, *Changes in the Land: Indians, Colonists, and the Ecology of New England* (New York: Hill and Wang, 1983), p. 38.
2. John Winthrop, *Winthrop's Journal*, ed. James Kendall Hosmer (New York: Scribner, 1908), p. 294.
3. All quotes are from "Your Poore Friends to the Council of the Virginia Company," as quoted in Mary Newton Stanard, *The Story of Virginia's First Century* (Philadelphia: Lippincott, 1928), p. 40.
4. Peter Kalm, *Travels in North America* [1753–1761], ed. Adolph B. Benson, Vol. 1 (New York: Dover, 1966), p. 239.
5. Francis Higginson, "New England's Plantation" [1630], *Massachusetts Historical Society Proceedings* 62 (1929): 311.

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CHAPTER 2

Agricultural and Craft Work in the Colonies

The culture that the European colonists created on the Atlantic seaboard of North America is one of the foundational cultures of the United States. Work is an important part—some would say the most important part—of people's lives, and as a result, patterns of work are crucial aspects of all human cultures, yesterday and today. Understanding work means understanding at least two things: tools and social relationships. When tools are linked together to get work done, we call that a "technological system." When people are linked together to get work done we describe that as a "work process." As a consequence, understanding the technological systems and work processes of the colonial period of American history provides a good foundation for an understanding of American culture, not just as it was then, but also as it is today.

Colonial farming, for example, was done with a technological system that linked together implements like plows and hoes and scythes, as well as a work process that linked together people with very different social, legal, and economic statuses. Some of them (usually adult males, called "husbandmen" in eighteenth-century parlance) owned the land that they worked. However, pre-industrial technological systems, made up of implements like plows, hoes, and scythes, were very labor intensive, so husbandmen needed a lot of assistance to make their land productive. Some of those assistants were women: the landowner's spouse (the "huswife") was one, so were his daughters and, possibly, one or more female servants or slaves. Farmers were also assisted by men and boys, some of whom were his sons, some of whom may have been indentured servants (working in exchange for room and board and, possibly, the cost of their passage across the Atlantic). Others may have been temporary laborers employed seasonally or tenants, working the farmer's land, using some portion of what they produced as their rent.

Colonial artisanal work, such as printing and blacksmithing and sawmilling, was also done with pre-industrial technological systems that linked together tools like printing presses and ink, hearths and anvils, water wheels and wooded gears. As with farming, some of the people who used these craft tools actually owned

them while other others were paid wages to participate in the work process; others were working without pay in return for being taught the skills needed to use the tools effectively, while others were members of the tool-owner's family.

A detailed exploration of some of the technological systems and work processes that were common in the colonial period helps to clarify the various ways in which the culture the European settlers built in their new world was so different from the ones they left behind in the old.

COLONIAL FARMING

By 1750, about 80 percent of the colonial economy in North America was agricultural and about 90 percent of all adults living in the colonies farmed for at least part of the year. The new nation, when it came to be created at the end of the eighteenth century, was truly a nation of farmers.

But not all colonial farmers were either socially or economically identical. Some colonial farms were pioneer farms, small plots of land that rarely provided the bare necessities of life. Others were huge plantations; their owners were "white glove" farmers, supervising and managing laborers without getting their own hands dirty. Many adult men—servants, slaves, and day laborers—farmed even though they did not own land and even though the label "farmer" would never have been applied to them. Women and children farmed also, especially the wives, sons, and daughters of farmers; they winnowed wheat, hoed gardens, milked cows, churned butter—farmers in reality, if not in name or social position.

Pioneer farms were enterprises that were just getting off (or into) the ground, which might take, depending on the skill, health, and size of the farming family—and the character of the plot—anywhere from five to twenty years. A pioneering family had to devote much of its time and energy to clearing the land: chopping down trees, pulling out stumps, removing rocks and boulders. Until cleared, the land on a pioneer farm could not provide even a low level of subsistence for a family; pioneers either had to have cash savings or a handy first crop that they could exchange for essential supplies. A pioneering family lived at what contemporaries regarded as a substandard level: in houses made of logs chinked with mud, without a proper hearth, perhaps lacking beds, certainly lacking appropriate changes of clothing and an adequate diet. "In many places," a visitor reported from the backwoods of western South Carolina, "they have nought but a Gourd to drink out of. Not a Place Knive or Spoon, a Glass, Cup, or anything. . . . It is well if they can get some Body Linen, and some have not even that."[1]

The plantation farm, on the other hand, provided a luxurious standard of living for the family that owned it, albeit not for the employees, slaves, or tenants who actually worked it. Most plantations were located in the southern colonies (although there were a few in New York, especially in the Hudson River Valley), and almost all were devoted to cash commodities: tobacco, rice, and indigo in the South; wheat or occasionally cattle in the North. So much land was available and so many slaves or servants were employed that the plantation could grow all the

food that was needed for its own sustenance, spin and weave its own cloth, make and repair its own tools, even in some instances mine and forge its own iron.

A large plantation might be a self-sufficient community—producing everything that was needed to sustain itself, but the people who lived on it were not independent, either of each other or of the marketplace. Many of the tenants, slaves, and servants were specialist farmers, skilled in the unique techniques that each cash crop required: the fertilizing of wheat fields, for example, or the drying of tobacco leaves or the flooding of rice seedlings. Other tenants, slaves, and servants were specialist artisans, who knew how to operate spinning wheels and looms for the production of cloth, or forges for the repair of plows and horseshoes, or gristmills for the grinding of cornmeal or wheat flour.

By the middle of the eighteenth century, however, the vast majority of European Americans lived and worked on moderately sized mixed farms, farms that were neither pioneer farms nor plantations. Mixed farms were enterprises in which the owner and his family, along with a few servants and occasional laborers, tried to produce some of the goods that the family needed to feed and clothe itself, and additional goods that could be traded for other things the family needed. If all went well, such farms were expected to create a decent standard of living for the farming family—neither exceedingly luxurious nor exceedingly deprived—and to provide a bit of a protective cushion during those seasons in which, inevitably, things would not go well at all. A close examination of the technological systems and work processes on these relatively small plots of land will give us some idea of the effort that had to be expended to achieve what was considered, in its time, a middling standard of living.

Colonial farming was done with a set of what appear to us today to be very simple implements; a hoe, a plow, a harrow, and a scythe were all that was needed to plant and harvest the major colonial grain crops: corn, wheat, rye and oats. As simple as they may appear to be, however, these tools required great skill and much experience to be utilized effectively; children were expected to acquire those skills by working alongside their parents. The growing season began in the spring when plows (hitched to an ox or a horse) were used to break and turn over the soil, which had become compacted during the winter, or to uproot and turn over weeds that had developed on a field that had been left fallow.

Plowing was men's work. It was arduous labor, for the farmer and his helpers as well as for the ox; an able man working with a competent beast could not expect to plow more than an acre a day. The colonists practiced extensive rather than intensive agriculture, which means that they preferred to clear and plow fresh land, rather than manure, till, and fallow old land on which the yields were falling. Hence, in any given year, they tended to have more land under plow than European visitors, who were accustomed to more intensive farming, thought appropriate. James T. Lemon, a historian who has carefully examined eighteenth-century Pennsylvania farm records, estimates that an average Pennsylvania farm consisted of approximately 125 acres, of which roughly 30 acres were under plow every spring—a whole month of very difficult work.

After plowing, the fields were harrowed, which leveled the ridges the plow had created—and then the seed was planted by being sown broadcast (which means that it was thrown with a sweeping arm gesture) and the field was harrowed again, to cover the seed with soil. Harrows were as heavy as plows, and using them was work for men assisted by draft animals. During the growing season the crops had to be tended in various ways. Some crops had to be pruned, pinched at the top. Worms had to be periodically picked off leaves and stems. The soil between rows had to be hoed regularly to keep down the weeds. Much of this "light" work was done by women, children, servants, and slaves. Hoes were lighter than plows and harrows, but hoeing had to be done regularly, over the space of months, often in extreme heat.

At harvesting time, some form of sharp blade was utilized to cut down the crops: a scythe (a sharp blade set almost at a right angle to a wooden handle) or a sickle (a curved blade set into a wooden handle) or some form of knife. Harvesting was arduous work, for it had to be done quickly—just when the crop was ripe—and it was done entirely by hand. Many hands were required: all those who resided on the farm, male, female, young and old, as well as extra hands hired just for harvesting. In some New England villages, craftspeople were required by law to lend their labor to their neighbors at harvest time.

The hard work did not stop even after the crop was safely home, for none of the grain crops grown in the colonies could be consumed by human beings without additional processing. All the small grains, like wheat and rye, grow on a stalk from which they must be separated (threshing and winnowing), and all are covered with a husk that must be either removed or broken before they can be cooked (milling). None of this was easy work. For threshing, the straw (dried stalks with kernels attached) was placed on a barn floor and either hit with a jointed device called a flail or trod by draft animals; this part of the work was most commonly done by men. Then the mixture was placed on a large cloth and women would repeatedly toss it into the air, so that the broken stalks (now called the chaff), being lighter than the kernels, would be blown away; this process, depending on the state of the wind on any given day, might take hours before any given batch was relatively clean of chaff.

Following this, the grain was carefully stuffed into sacks to await milling. Wheat was most frequently hauled to a water-powered gristmill, a task that is easy to write about, but much more difficult to do, given the poor (or nonexistent) quality of colonial roads: "I had 14 miles to go in winter to mill with an ox team. . . . No roads were broken and no bridges built across streams. I had to wade two streams and carry the bags on my back. . . . I got only 7 miles the first night, and on the 2nd night I reached the mill"—a not-unusual, four-day trip to provide three or four bushels of wheat, perhaps a month's supply.[2] Where no gristmill existed, colonial farmers had to contrive a mill of their own with two heavy, polished stones and at least one horse or ox.

Corn, which was the grain most commonly used in the colonies, both north and south, was just as difficult to process. Some of it could be eaten fresh after harvesting, straight off the cob, but most of it was destined for consumption several months later, which meant that it had to be dried, husked, decobbed, and then ground. Husking was tedious but not strenuous work, usually done by men, who

sometimes relieved the boredom of their task by turning it into a social event—a husking bee—replete with music and drink. Once husked, kernels were removed from the cob by the use of a simple slicing device, a sharp blade set, slightly at an angle, into a flat board. Dried, decobbed corn could be cooked up (with dried beans) over a slow fire for many hours, creating succotash, but in order to become bread in any form, it had either to be taken to a gristmill or to be pounded at home.

Home pounding of corn was both time-consuming and backbreaking; in colonial Maryland, fines were instituted to prevent parents from forcing their children to pound corn. With a hand quern (a slab of wood, rotated by hand), two or three hours were required to grind a day's supply; with a spring mill (a hand-guided mallet, attached to a green sapling, which was used as a spring), one day of pounding might supply a family for a week. Frederick Law Olmsted, while traveling in the West in the 1850s, observed a winch-operated device that may have had its origins in the colonial period: "Two boys were immediately set to work by their father at grinding corn. The task seemed their usual one, yet one very much too severe for their strength. Taking hold at opposite sides of the winch they ground away outside the door for more than an hour, constantly stopping to take breath."[3] This task had to be repeated every two days.

Figure 2.1 In the absence of a gristmill these pioneer farmers had to pound corn with a spring mill. In the absence of a sawmill they built their cabin out of logs, not boards. Note also, in this late 18th century drawing, the simplicity of their clothing. From, Carl Dreppard, *Pioneer America* (1949). (Courtesy, Ward Melville Library, Stony Brook University)

Yet the men and women of the American colonies did not live by bread alone. Hoes, plows, harrows, flails, scythes, and mills were necessary for the production of grains and for the small quantity of garden crops—potatoes, cabbages, beans, pumpkins, herbs, onions—that the colonists also planted. Other tools were required, however, for other forms of farm production; these average-sized colonial farms are called "mixed" farms precisely because they produced things other than grains and vegetables.

If a family kept domestic animals, for example, then it had to provide food for them in the winter. This meant the necessity of planting several fields with English grasses (the native American grasses were inadequate winter feed for horses and cattle) and regularly cutting the grass during the summer months (with a sickle) and transporting it (with a cart) for storage (in a barn). James Lemon estimated that on a hypothetical Pennsylvania farm of 125 acres, at least 20 acres might be planted in grasses, each of which provided about 1½ tons of hay every year. This went to feed roughly seven head of cattle (three cows, one steer, three calves), three or four horses, eight pigs, and perhaps ten sheep. On top of this, the farm animals consumed roughly 215 bushels of grain (mostly corn and oats) during the year, or the total produce of 22 of the 30 acres planted in grain. The animals themselves and the food they ate, as well as the tools required to harvest their food and the barns in which that food was stored were all part of a single technological system, intended, just like plowing and harrowing, to turn land into food, energy, and profit for the use of human beings.

Furthermore, horses, oxen, and even cows could not be used as draft animals unless they were harnessed. Steers and pigs could not be turned into roasts, steaks, hams, and sausages without butchering knives—and considerable skill at using them. In addition, the household required barrels for salting away the meat and a hearth over which it could be hung for smoking. Men and boys were expected to do most of the work of getting meat prepared for its final cooking; women and girls were responsible for poultry. Collecting milk from cows required, at the very least, a pail and a stool; making butter meant a churn; making cheese, at least a strainer and maybe also a press (butter and cheese, when salted, were convenient ways to preserve milk after it left the cow); this work was done by women and girls.

In addition to food and shelter, farming families needed clothing. Wool and flax were the two substances most commonly found in the bodices and skirts, the aprons and kerchiefs, the shirts and trousers, the leggings and petticoats, the mantles and capes that the colonists wore—not to speak of the pillow covers and bed sheets on which they slept and the rags that they stitched into rugs or with which they diapered their babies. Wool came from one set of domestic animals, sheep; special shears (and a good deal of patience) were needed to remove the wool from the animal (men's work) and special combs (called cards) were required to clean and straighten it (children's work). Spinning wheels turned it into thread (women's work) and looms wove the thread into cloth: men's work if the loom was for wide cloth; women's work if it was narrow). Linen, which was derived from the fibrous stalk of the flax plant, required yet another set of tools. Flax grew exceptionally

well in the colonies; from two acres planted in flax, a farming family might have been able to derive 300 pounds of plants at harvest time, as well as ten bushels of seeds (which, when pressed, yielded another valuable colonial commodity, linseed oil). Flax did not, however, yield up its thread easily; the plant had to be broken apart (which required a special instrument called a brake, a heavy log set into frame in such a way as to crush the stem of the plant when lowered); this was men's work. Then the fibrous inner material had to be combed carefully with a special device called a hackle—a task often assigned to children—all this before any spinning could begin, or any weaving, for that matter.

Spinning and weaving were among the most time-consuming, and tedious, of all occupations. In farm households, the months from December through May were largely devoted to spinning and weaving. We can derive a rough gauge of what a household required from the diary of Elizabeth Fuller, a teenage girl, who in the 1790s recorded having spent the months of January and February spinning and the months of March, April, and May weaving, with the resultant production of 176 yards of narrow cloth. She finished on June 1 and exulted in her diary: "Welcome sweet Liberty."[4] If it was of sufficient width, 176 yards of cloth was probably

Figure 2.2 Making cloth involved some of the most complex, and expensive, preindustrial tools—and the labor of all members of a family was involved. In this late 18th century depiction the man is weaving, the woman is spinning, and the children are using flax stems to weave mats. From, Carl Dreppard, *Pioneer America* (1949). (Courtesy, Ward Melville Library, Stony Brook University)

all that her family needed for the year (although it was unlikely to be of the right density for outer clothing), but the sewing—of shirts and sheets, of petticoats and breeches—was, of course, yet to come, all of it, of course, women's work.

Most colonial farmhouses were not large structures; the stately colonial homes of such notables as Washington and Jefferson, which have been preserved as part of our national heritage, bear about as much resemblance to an ordinary colonial residence as a Rolls Royce bears to a Model T. An ordinary farmhouse essentially consisted of one room, called the hall. If the ceiling were high enough in the hall, a loft might have been added or some partitions might have been built to create one or two new rooms at one end or a lean-to may have been constructed at the back, with a door cut through the rear wall of the house. The hall was the busiest room of the house. Here the women of the family cooked, the family sat down to meals, and some members of the family slept. The loft and side rooms were usually used either for storage (bolts of cloth, bags of cornmeal, ropes of onions) or for sleeping. The lean-to, if there was one, was used for storing milk or cider, also for churning butter.

As small as these homes were, it was still very hard work to keep them heated in the cold months and to provide the wooden fuel that was necessary for cooking every day of the year. The most striking feature of the hall (in fact, its only built-in feature) was the fireplace, inserted in one wall of the room, framed in brick or stone, topped by a wooden beam, which served as the mantle, with a separate small enclosure (the baking oven) off to one side. The fire burning on this hearth rarely was allowed to go out: during the cold months of the year, it was the only source of heat for the house; every day of the year, it was the place at which cooked meals were prepared. Its furnishings were few, but each was essential: andirons were used to keep the logs off the floor of the hearth and improve air circulation; bellows, to encourage the fire; a set of tongs or a fork, to manipulate the logs; a shovel, to remove or rearrange ashes. On a swiveling iron bar inserted in the side wall (called a crane) were hung heavy kettles; perhaps another iron bar was set further up in the chimney for hanging meats to be smoked. The cooking equipment was also modest: one or two hanging kettles, perhaps a footed pot with a cover, a skillet or two, and a few wooden spoons of various sizes completed the housewife's set of tools. Many high school graduates go off to college today with more cooking equipment than an eighteenth-century farmer's wife was likely to see in her lifetime.

Keeping that hearth fire burning was no easy business. Open hearths are notoriously inefficient. Most of the heat goes straight up the chimney and whatever radiates laterally into the room does not radiate very far; anyone who has tried it can report that when it is cold outside you can sit two feet from a fireplace and be flushed with heat in front and freezing behind. To supply an average colonial farmhouse for a year, more than an acre of woodlot had to be cut down, hauled to the farmyard, chopped, and split to fit into the fireplace. The tools involved were simple—several axes of different sizes, a sturdy cart, a good ox, a wedge, and a mallet—but the work was hard, and unending. Everyone in the household

participated, but the heavy part—the cutting, hauling, and chopping—was usually reserved for men and boys; roughly one third of a farmer's time during the year was occupied in fuel-related chores.

Men and boys provided the fuel; women and girls cooked on the open hearths of colonial homes. Without the work of men and boys the women would have had no way to cook; without the work of women and girls, the men would not have had meals to eat. As it was with food, so it was with the production of clothing and with the production of the raw materials to be cooked: the work processes of farming with pre-industrial technological systems on colonial-era mixed farms required the hard, time-consuming, and often tedious labor of many different people, occupying many different statuses within the farming household, possessed of many different gender-based skills, working together.

The simplest job, the description of which might take no more than two sentences in this text, could take hours, days, weeks, or even months to perform. If a housewife made everything from scratch, she had to combine the skills of more than a dozen crafts: flax and wool spinster, weaver, dyer, fuller, tailor, seamstress, knitter, baker, gardener, brewer, dairymaid, chandler (someone who makes candles), and soap maker—all this on top of cooking, tending the sick, caring for infants and small children, winnowing, carrying water, and, occasionally, laundering. Her husband likewise had to be competent at plowing, reaping, carpentry, wood carving, leatherworking, butchery, stonemasonry, wood chopping, carting, milling, and brewing, not to speak of a bit of blacksmithing and shoemaking. Had a young person been set to an apprenticeship at any one of these crafts, he or she would have been expected to take five years, at the very least, for adequate training.

THE MYTH OF SELF-SUFFICIENCY

Open almost any American history textbook, and you will read something about the self-sufficient farmers of the colonies, who could produce everything that they needed for their own support and sustenance—all their bread, all their meat, every inch of cloth, every cord of wood—and who never, as a result, had to purchase anything. Listen to any Fourth of July oration, and you will likely hear something about the "independent" life of our fore parents, people who did not need to rely on welfare systems or paychecks but who could, and did, make their way on their own through dint of hard work, self-employed. Our politicians frequently applaud self-sufficiency, whether it be in energy policy, defense policy, health policy, or even farm policy. Independence is a concept to which Americans attach multiple emotional meanings, some of which derive from our sense of our national past, and some of which derive from our respect for that past. Every time it is said that someone doesn't want to take money from her parents or doesn't want to be a renter forever or hopes soon to start his own business, the rest of us respond sympathetically, at least in part because of what we were taught about the people who settled this country and shaped it in its early years, the farmers who "made this country great."

In truth, however, colonial farmers and their wives, although famous for their versatility, were never self-sufficient. No one could have performed competently at all these tasks; and there were not enough hours in the day for two adults and their children, even if aided by a servant or a handyman, to produce all of what was required to feed, clothe, and house themselves at the standard that we know to be common for eighteenth-century farm families in the colonies.

In fact, colonial farmers specialized. Some owned plows but hired neighbors to do their harrowing. Others grew flax but did not chop their own wood. A farmer who was a reasonably good carpenter might make a chair for another farmhouse and then trade it for the pig that he had not had the time to raise himself. A housewife might keep chickens and trade the eggs with her counterpart three miles away in exchange for the butter that she had neither the equipment nor the time to churn. Some people fattened pigs and steers for eating but sold the meat on the hoof, only to buy it back again salted away in barrels. Some people raised sheep but traded the wool to others who had wheels and looms, perhaps in exchange for cider or cheese. The market economy flourished in the colonial countryside even where there were no merchants or even storekeepers to manage it.

Supplementing this barter economy were the itinerant craftsmen who plied colonial roads, supplying skills and tools that farm households needed. There were, for example, roving shoemakers who would stay for a week and turn the family's hides into boots; neighborhood seamstresses who would come in to do the sewing; midwives who supervised childbirth and cared for the mother and newborn child; knife sharpeners who carried their flintstones on their backs; plowmen who assisted when schedules were tight; stonemasons who mended chimneys or built new ones. Farm men and women may have been jacks-and-jills-of-all-trades, but they clearly preferred, whenever such preferences could be exercised, to have specialists take over some of their work.

Not surprisingly, the wealthier a household was, the more technological systems it could contain and the more people it could employ to participate in its work processes. As a result, complete self-sufficiency was possible only for those who were rich; only colonists who owned plantations, such as Thomas Jefferson and George Washington, could afford, for example, to have their own gristmills, built with their own funds, located on their own lands, operated by their own millers. Economic independence—complete household self-sufficiency—was thus the province of the very rich. Thomas Jefferson deeply believed in the virtues of self-sufficient farming; as a framer of the Constitution, he tried to ensure not only that the interests of the small farmer would be respected but also that the culture of self-sufficiency—which continues to be called "the Jeffersonian ideal"—would become embedded in American political processes.

The concept of self-sufficiency is a crucial component of American culture, but it was a myth—even in its own day. The pre-industrial technological systems of farming in the eighteenth century simply were not up to the challenge; in the world of hoes and harrows, looms and spinning wheels, economic independence for individuals was simply out of the question, unless they were rich. With all

the best intentions, even with horses and oxen to help, even if they lived long lives in perfect health, a colonial family simply could not have produced all that it needed for its own sustenance because the tools at its command were not sufficiently efficient.

Even Jefferson's contemporaries seem to have been aware of the contradiction between what he advocated and the way they lived. Many wished to be spared, as Jefferson was spared, the long hours and backbreaking labor of farming. Many wished to have, as Jefferson had, more comfortable clothing than that which could be spun, woven, and stitched at home. Many hungered after the varied diet that became possible when there was cash to pay for coffee from Brazil or sugar from the Caribbean or wine from Madeira. Those wishes, for what we would now call a higher standard of living and a more comfortable style of life, stimulated the most profound economic and technological transformation of all time: the industrial revolution. Self-sufficiency is attractive to those of us who are nostalgic for what we think were simpler, preindustrial times, but it didn't seem particularly attractive to most of the people who lived in those times. They understood precisely how much hard work, and how much discomfort, was really required.

ARTISANAL WORK IN THE COLONIES

Most of the remaining 10 percent of the adult colonial population were artisans, people trained in one or the other of the crafts: blacksmiths and printers, cordwainers (people who made shoes) and seamstresses, coopers (people who made barrels) and shipwrights, midwives and tanners, joiners (people who made furniture) and millwrights (people who constructed water mills), apothecaries and iron smelters. Although small in numbers, these artisans were big in impact. Artisans manufactured the tools that farmers needed to work the land; they also provided the services and skills that were essential for the growth of cities. The political activities of artisans helped to foment the Revolution; and, as we shall see, the economic activities of artisans laid the groundwork for industrialization.

Some artisans were rural, living and working in the small villages that dotted the countryside from Maine to Georgia. Many of these rural craftspeople were indistinguishable from the farmers who were their neighbors; they owned land and grew some crops, but acquired a lot of what they needed in trade for the services they could render: a barrel of salted pork in exchange for mending a clock, five pounds of butter in trade for two yards of handmade cloth. Rural artisans frequently practiced several trades at once, specializing in none: one Long Island craftsman, for example, advertised himself as a wheelwright, clockmaker, carpenter, cabinetmaker, toolmaker, and a repairer of spinning and weaving equipment as well as guns—all the while collecting fees for the pasturing of other people's cows.

By the middle of the eighteenth century, however, the vast majority of colonial artisans lived in cities. During the colonial period transportation was very expensive; artisans needed to be located in cities so that they could minimize