CHAPTER 1

THE BIG STORIES

"Technology is a gift of God. After the gift of life it is perhaps the greatest of God's gifts. It is the mother of civilizations, of arts and of sciences."

—Freeman Dyson

What have been the most important developments in human history?

As anyone investigating this question soon learns, it's difficult to answer. For one thing, when does 'human history' even begin? Anatomically and behaviorally modern *Homo sapiens*, equipped with language, fanned out from their African homeland some sixty thousand years ago.[1] By 25,000 BCE[2] they had wiped out the Neanderthals and other hominids, and thereafter faced no competition from other big-brained, upright-walking species.

We might consider 25,000 BCE a reasonable time to start tracking the big stories of humankind, were it not for the development-retarding ice age earth was experiencing at the time.[3] In his book *Why the West Rules—For Now*, anthropologist Ian Morris starts tracking human societal progress in 14,000 BCE, when the world clearly started getting warmer.

Another reason it's a hard question to answer is that it's not clear what criteria we should use: what constitutes a truly important development? Most of us share a sense that it would be an event or advance that significantly changes the course of things—one that 'bends the curve' of human history. Many have argued that the domestication of animals did just this, and is one of our earliest important achievements.

The dog might well have been domesticated before 14,000 BCE,

but the horse was not; eight thousand more years would pass before we started breeding them and keeping them in corrals. The ox, too, had been tamed by that time (ca. 6,000 BCE) and hitched to a plow. Domestication of work animals hastened the transition from foraging to farming, an important development already underway by 8,000 BCE.[4]

Agriculture ensures plentiful and reliable food sources, which in turn enable larger human settlements and, eventually, cities. Cities in turn make tempting targets for plunder and conquest. A list of important human developments should therefore include great wars and the empires they yielded. The Mongol, Roman, Arab, and Ottoman empires—to name just four—were transformative; they affected kingdoms, commerce, and customs over immense areas.

Of course, some important developments have nothing to do with animals, plants, or fighting men; some are simply ideas. Philosopher Karl Jaspers notes that Buddha (563–483 BCE), Confucius (551–479 BCE), and Socrates (469–399 BCE) all lived quite close to one another in time (but not in place). In his analysis these men are the central thinkers of an 'Axial Age' spanning 800–200 BCE. Jaspers calls this age "a deep breath bringing the most lucid consciousness" and holds that its philosophers brought transformative schools of thought to three major civilizations: Indian, Chinese, and European.[5]

The Buddha also founded one of the world's major religions, and common sense demands that any list of major human developments include the establishment of other major faiths like Hinduism, Judaism, Christianity, and Islam. Each has influenced the lives and ideals of hundreds of millions of people.[6]

Many of these religions' ideas and revelations were spread by the written word, itself a fundamental innovation in human history. Debate rages about precisely when, where, and how writing was invented, but a

safe estimate puts it in Mesopotamia around 3,200 BCE. Written symbols to facilitate counting also existed then, but they did not include the concept of zero, as basic as that seems to us now. The modern numbering system, which we call Arabic, arrived around 830 CE.[7]

The list of important developments goes on and on. The Athenians began to practice democracy around 500 BCE. The Black Death reduced Europe's population by at least 30 percent during the latter half of the 1300s. Columbus sailed the ocean blue in 1492, beginning interactions between the New World and the Old that would transform both.

The History of Humanity in One Graph

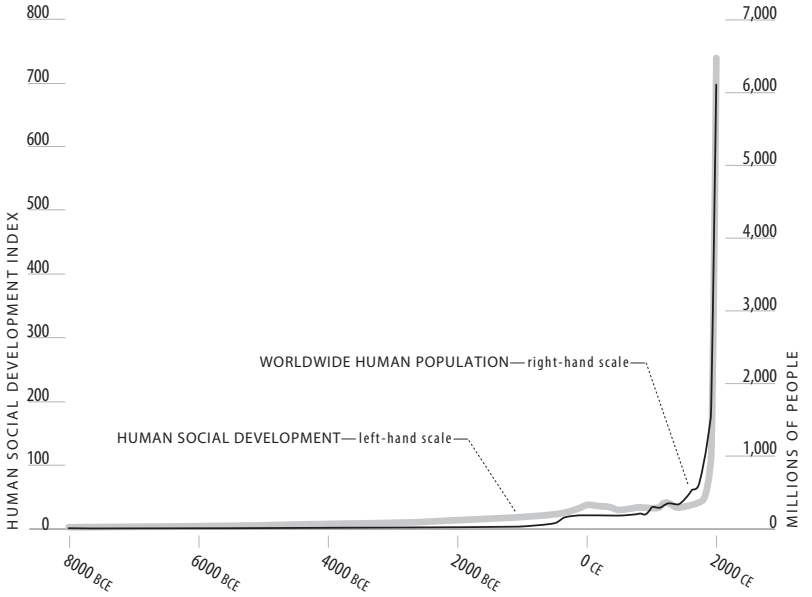
How can we ever get clarity about which of these developments is the *most* important? All of the candidates listed above have passionate advocates—people who argue forcefully and persuasively for one development's sovereignty over all the others. And in *Why the West Rules—For Now* Morris confronts a more fundamental debate: whether any attempt to rank or compare human events and developments is meaningful or legitimate. Many anthropologists and other social scientists say it is not. Morris disagrees, and his book boldly attempts to quantify human development. As he writes, "reducing the ocean of facts to simple numerical scores has drawbacks but it also has the one great merit of forcing everyone to confront the same evidence—with surprising results."[8] In other words, if we want to know which developments bent the curve of human history, it makes sense to try to draw that curve.

Morris has done thoughtful and careful work to quantify what he terms *social development* ("a group's ability to master its physical and intellectual environment to get things done") over time.* As Morris

* Morris defines human social development as consisting of four attributes: energy capture (per-person calories obtained from the environment for food, home and commerce, industry and agriculture, and transporta-

suggests, the results are surprising. In fact, they're astonishing. They show that none of the developments discussed so far has mattered very much, at least in comparison to something else—something that bent the curve of human history like nothing before or since. Here's the graph, with total worldwide human population graphed over time along with social development; as you can see, the two lines are nearly identical:

FIGURE 1.1 Numerically Speaking, Most of Human History Is Boring.



tion), organization (the size of the largest city), war-making capacity (number of troops, power and speed of weapons, logistical capabilities, and other similar factors), and information technology (the sophistication of available tools for sharing and processing information, and the extent of their use). Each of these is converted into a number that varies over time from zero to 250. Overall social development is simply the sum of these four numbers. Because he was interested in comparisons between the West (Europe, Mesopotamia, and North America at various times, depending on which was most advanced) and the East (China and Japan), he calculated social development separately for each area from 14,000 BCE to 2000 CE. In 2000, the East was higher only in organization (since Tokyo was the world's largest city) and had a social development score of 564.83. The West's score in 2000 was 906.37. We average the two scores.

For many thousands of years, humanity was a very gradual upward trajectory. Progress was achingly slow, almost invisible. Animals and farms, wars and empires, philosophies and religions all failed to exert much influence. But just over two hundred years ago, something sudden and profound arrived and bent the curve of human history—of population and social development—almost ninety degrees.

Engines of Progress

By now you've probably guessed what it was. This is a book about the impact of technology, after all, so it's a safe bet that we're opening it this way in order to demonstrate how important technology has been. And the sudden change in the graph in the late eighteenth century corresponds to a development we've heard a lot about: the Industrial Revolution, which was the sum of several nearly simultaneous developments in mechanical engineering, chemistry, metallurgy, and other disciplines. So you've most likely figured out that these technological developments underlie the sudden, sharp, and sustained jump in human progress.

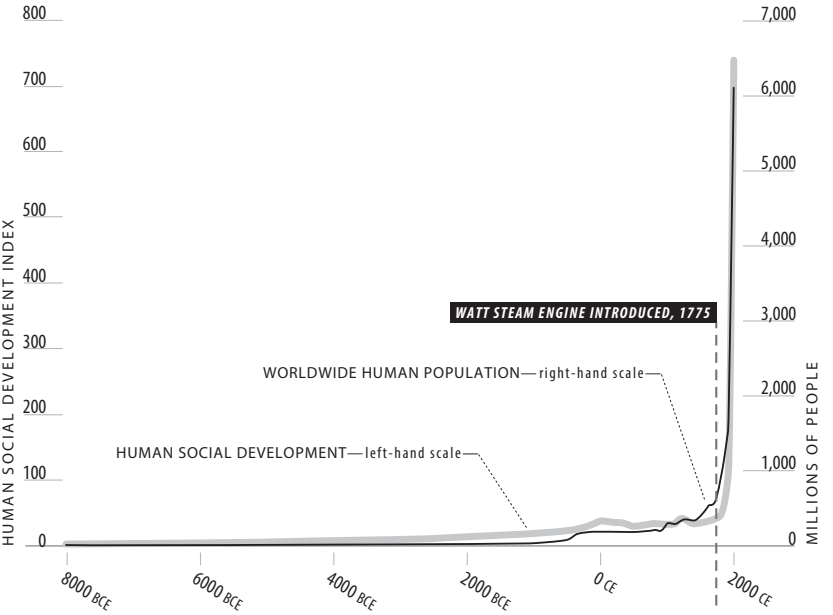
If so, your guess is exactly right. And we can be even more precise about *which* technology was most important. It was the steam engine or, to be more precise, one developed and improved by James Watt and his colleagues in the second half of the eighteenth century.

Prior to Watt, steam engines were highly inefficient, harnessing only about one percent of the energy released by burning coal. Watt's brilliant tinkering between 1765 and 1776 increased this more than threefold.[9] As Morris writes, this made all the difference: "Even though [the steam] revolution took several decades to unfold . . . it was nonetheless the biggest and fastest transformation in the entire history of the world."[10]

The Industrial Revolution, of course, is not only the story of steam power, but steam started it all. More than anything else, it allowed us to overcome the limitations of muscle power, human and animal,

and generate massive amounts of useful energy at will. This led to factories and mass production, to railways and mass transportation. It led, in other words, to modern life. The Industrial Revolution ushered in humanity's first machine age—the first time our progress was driven primarily by technological innovation—and it was the most profound time of transformation our world has ever seen.* The ability to generate massive amounts of mechanical power was so important that, in Morris's words, it "made mockery of all the drama of the world's earlier history."[11]

FIGURE 1.2 What Bent the Curve of Human History? The Industrial Revolution.



Now comes the second machine age. Computers and other digital advances are doing for mental power—the ability to use our brains

* We refer to the Industrial Revolution as the first machine age. However, "the machine age" is also a label used by some economic historians to refer to a period of rapid technological progress spanning the late nineteenth and early twentieth centuries. This same period is called by others the Second Industrial Revolution, which is how we'll refer to it in later chapters.

to understand and shape our environments—what the steam engine and its descendants did for muscle power. They're allowing us to blow past previous limitations and taking us into new territory. How exactly this transition will play out remains unknown, but whether or not the new machine age bends the curve as dramatically as Watt's steam engine, it is a very big deal indeed. This book explains how and why.

For now, a very short and simple answer: mental power is at least as important for progress and development—for mastering our physical and intellectual environment to get things done—as physical power. So a vast and unprecedented boost to mental power should be a great boost to humanity, just as the ealier boost to physical power so clearly was.

Playing Catch-Up

We wrote this book because we got confused. For years we have studied the impact of digital technologies like computers, software, and communications networks, and we thought we had a decent understanding of their capabilities and limitations. But over the past few years, they started surprising us. Computers started diagnosing diseases, listening and speaking to us, and writing high-quality prose, while robots started scurrying around warehouses and driving cars with minimal or no guidance. Digital technologies had been laughably bad at a lot of these things for a long time—then they suddenly got very good. How did this happen? And what were the implications of this progress, which was astonishing and yet came to be considered a matter of course?

We decided to team up and see if we could answer these questions. We did the normal things business academics do: read lots of papers and books, looked at many different kinds of data, and batted around ideas and hypotheses with each other. This was necessary and valuable, but the real learning, and the real fun, started when we

went out into the world. We spoke with inventors, investors, entrepreneurs, engineers, scientists, and many others who make technology and put it to work.

Thanks to their openness and generosity, we had some futuristic experiences in today's incredible environment of digital innovation. We've ridden in a driverless car, watched a computer beat teams of Harvard and MIT students in a game of *Jeopardy!*, trained an industrial robot by grabbing its wrist and guiding it through a series of steps, handled a beautiful metal bowl that was made in a 3D printer, and had countless other mind-melting encounters with technology.

Where We Are

This work led us to three broad conclusions.

The first is that we're living in a time of astonishing progress with digital technologies—those that have computer hardware, software, and networks at their core. These technologies are not brand-new; businesses have been buying computers for more than half a century, and *Time* magazine declared the personal computer its "Machine of the Year" in 1982. But just as it took generations to improve the steam engine to the point that it could power the Industrial Revolution, it's also taken time to refine our digital engines.

We'll show why and how the full force of these technologies has recently been achieved and give examples of its power. "Full," though, doesn't mean "mature." Computers are going to continue to improve and to do new and unprecedented things. By "full force," we mean simply that the key building blocks are already in place for digital technologies to be as important and transformational to society and the economy as the steam engine. In short, we're at an inflection point—a point where the curve starts to bend a lot—because of computers. We are entering a second machine age.

Our second conclusion is that the transformations brought about by digital technology will be profoundly beneficial ones. We're head-

ing into an era that won't just be different; it will be better, because we'll be able to increase both the variety and the volume of our consumption. When we phrase it that way—in the dry vocabulary of economics—it almost sounds unappealing. Who wants to consume more and more all the time? But we don't just consume calories and gasoline. We also consume information from books and friends, entertainment from superstars and amateurs, expertise from teachers and doctors, and countless other things that are not made of atoms. Technology can bring us more choice and even freedom.

When these things are digitized—when they're converted into bits that can be stored on a computer and sent over a network—they acquire some weird and wonderful properties. They're subject to different economics, where abundance is the norm rather than scarcity. As we'll show, digital goods are not like physical ones, and these differences matter.

Of course, physical goods are still essential, and most of us would like them to have greater volume, variety, and quality. Whether or not we want to eat more, we'd like to eat better or different meals. Whether or not we want to burn more fossil fuels, we'd like to visit more places with less hassle. Computers are helping accomplish these goals, and many others. Digitization is improving the physical world, and these improvements are only going to become more important. Among economic historians there's wide agreement that, as Martin Weitzman puts it, "the long-term growth of an advanced economy is dominated by the behavior of technical progress."[12] As we'll show, technical progress is improving exponentially.

Our third conclusion is less optimistic: digitization is going to bring with it some thorny challenges. This in itself should not be too surprising or alarming; even the most beneficial developments have unpleasant consequences that must be managed. The Industrial Revolution was accompanied by soot-filled London skies and horrific exploitation of child labor. What will be their modern equivalents? Rapid and accelerating digitization is likely to bring economic

rather than environmental disruption, stemming from the fact that as computers get more powerful, companies have less need for some kinds of workers. Technological progress is going to leave behind some people, perhaps even a lot of people, as it races ahead. As we'll demonstrate, there's never been a better time to be a worker with special skills or the right education, because these people can use technology to create and capture value. However, there's never been a worse time to be a worker with only 'ordinary' skills and abilities to offer, because computers, robots, and other digital technologies are acquiring these skills and abilities at an extraordinary rate.

Over time, the people of England and other countries concluded that some aspects of the Industrial Revolution were unacceptable and took steps to end them (democratic government and technological progress both helped with this). Child labor no longer exists in the UK, and London air contains less smoke and sulfur dioxide now than at any time since at least the late 1500s.[13] The challenges of the digital revolution can also be met, but first we have to be clear on what they are. It's important to discuss the likely negative consequences of the second machine age and start a dialogue about how to mitigate them—we are confident that they're not insurmountable. But they won't fix themselves, either. We'll offer our thoughts on this important topic in the chapters to come.

So this is a book about the second machine age unfolding right now—an inflection point in the history of our economies and societies because of digitization. It's an inflection point in the right direction—bounty instead of scarcity, freedom instead of constraint—but one that will bring with it some difficult challenges and choices.

This book is divided into three sections. The first, composed of chapters 1 through 6, describes the fundamental characteristics of the second machine age. These chapters give many examples of recent technological progress that seem like the stuff of science fiction, explain why they're happening now (after all, we've had computers for decades), and reveal why we should be confident that the

scale and pace of innovation in computers, robots, and other digital gear is only going to accelerate in the future.

The second part, consisting of chapters 7 through 11, explores bounty and spread, the two economic consequences of this progress. Bounty is the increase in volume, variety, and quality and the decrease in cost of the many offerings brought on by modern technological progress. It's the best economic news in the world today. Spread, however, is not so great; it's ever-bigger differences among people in economic success—in wealth, income, mobility, and other important measures. Spread has been increasing in recent years. This is a troubling development for many reasons, and one that will accelerate in the second machine age unless we intervene.

The final section—chapters 12 through 15—discusses what interventions will be appropriate and effective for this age. Our economic goals should be to maximize the bounty while mitigating the negative effects of the spread. We'll offer our ideas about how to best accomplish these aims, both in the short term and in the more distant future, when progress really has brought us into a world so technologically advanced that it seems to be the stuff of science fiction. As we stress in our concluding chapter, the choices we make from now on will determine what kind of world that is.

NOTES

Chapter 1 THE BIG STORIES

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3. Ibid., p. 71.
4. Ibid., p. 112.
5. Karl Jaspers, *The Origin and Goal of History. Translated From the German by Michael Bullock* (London: Routledge K. Paul, 1953), p. 51.
6. "Major Religions of the World Ranked by Number of Adherents," 2007, http://www.adherents.com/Religions_By_Adherents.html/.
7. Anne Rooney, *The History of Mathematics* (New York: The Rosen Publishing Group, 2012), p. 18.
8. Morris, *Why the West Rules—For Now*, p. 142.
9. Louis C. Hunter and Eleutherian Mills-Hagley Foundation, *A History of Industrial Power in the United States, 1780–1930: Steam Power* (Charlottesville, VA: University Press of Virginia, 1979), 601–30.
10. Morris, *Why the West Rules—For Now*, p. 497.
11. Ibid., p. 492.
12. Martin L. Weitzman, "Recombinant Growth," *Quarterly Journal of Economics* 113, no. 2 (1998): 331–60.
13. Bjørn Lomborg, *The Skeptical Environmentalist: Measuring the Real State of the World* (Cambridge, UK: Cambridge University Press, 2001), p. 165.

Chapter 2 THE SKILLS OF THE NEW MACHINES

1. Frank Levy and Richard J. Murnane, *The New Division of Labor: How Computers Are Creating the Next Job Market* (Princeton, NJ: Princeton University Press, 2004).
2. Michael Polanyi, *The Tacit Dimension* (Chicago, IL: University of Chicago Press, 2009), p. 4.