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THE ETHICS OF INVENTION

Technology and the Human Future

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Chapter 1

THE POWER OF TECHNOLOGY

Our inventions change the world, and the reinvented world changes us. Human life on Earth today looks radically different from just a century ago, thanks in good part to technologies invented in the intervening years. Once firmly earthbound, with only legs and wheels to carry us on land and ships to cross the waters, we have now taken to flight in droves, with more than eight million passengers criss-crossing continents each day in a few airborne hours. If Richard Branson, founder of Virgin Galactic, achieves his dream of building the world's first commercial "spaceline," ordinary people may soon become astronauts. Communication, too, has broken free from shackles of time and distance. When I left India in the mid-1950s, it took three weeks for letters to go back and forth from Kolkata, where I was born, to Scarsdale, New York, where my family first settled. Mail would not arrive reliably. Stamps would be stolen and packages not delivered. Today, an electronic message sent at night from the eastern United States brings an instant reply from a friend in Europe or Asia whose day is just beginning. Facebook connects more than a billion users worldwide with a single mouse click or two.[1] Last but not least, we have cracked the secrets of living and nonliving matter with the decoding of the human genome and the ability to create and deploy a world of novel human-made materials.

Speed, connectivity, and convenience matter a lot, but for most of Earth's seven billion people the quality of life matters more. Here, too, a century of accelerating technological invention has changed us. Work is safer. Air and water in many parts of the world are measurably cleaner. We live appreciably longer. The World Health Organization (WHO) tells us that global "average life expectancy at birth in 1955 was just 48 years; in 1995 it was 65 years; in 2025 it will reach 73 years."[2] Technological innovations account for the trend; better sanitation, drinkable water, vaccines, antibiotics, and more abundant and wholesome food. People not only live longer but enjoy their lives more, through increased access to travel, recreation, varieties of food, and, above all, improvements in health care. If asked whether we would rather be living in 1916 or in 2016, few today would opt for a hundred years ago, even if the world back then had not been racked by war.

Adding up to what some call a second industrial revolution, the technological advances of the past century have propelled wealthy nations to the status of knowledge societies. We have, or are poised to have, unprecedented amounts of information about people's genetic makeup, social habits, and purchasing behavior, and those data are expected to enable new forms of commerce and collective action. State census bureaus are no longer the only bodies that can compile masses of data. Search engines like Google and Yahoo have also become voracious data gatherers, rivaling governments. Even individuals can use devices like Fitbit or the Apple watch to monitor and record volumes of information about their daily activities. Digital technologies have made it possible to combine previously incommensurable forms of data, creating useful convergences between physical, biological, and digital records. What we know about a person today is no longer just a matter of physical descriptors, such as height, weight, ethnicity, and hair color. Nor can people be located through only a few static markers, such as an address and a phone number. Instead, biometric information has proliferated. Passports, for example, can be linked to information gleaned from fingerprints and iris scans collected from anyone who crosses a national border. Apple incorporated a digital fingerprint sensor into its smartphones in the 2010s to replace numerical passcodes and to offer greater security.

The information explosion, spurred by exponential growth in computing capability, now powers economic and social development. The Internet has put unprecedented informational resources at people's fingertips and functions in this respect as an aid to democracy on many levels: for patients wishing to research new drugs and therapies, for small business owners attempting to reach stable markets, or for citizens seeking to pool knowledge about local problems and pressure the authorities to act. Almost everything that people do in high-tech societies leaves informational traces, and these can be consolidated to form astonishingly accurate pictures of their demographic profiles and even their unexpressed desires. From medical environments to commercial ones, the concept of "big data" has begun to expand people's imaginations about what they can learn and how information can open up new markets or provide better public services. In this era, as many governments now recognize, knowledge itself has become an increasingly precious commodity, needing to be mined, stored, and developed like any rare natural resource. The big data age is a frontier for business opportunities, and youthful tech entrepreneurs are the iconic figures driving the new gold rush.

Today's information and communication technologies offer remarkable scope for anyone who can creatively tap into the newly abundant sources of data. Airbnb and Uber took advantage of unused capacity in private homes and private vehicles to turn willing property owners into hoteliers and taxi drivers. When this sharing economy works, everyone benefits because unused capacity is put to use and unmet needs are met more efficiently at lower cost. Families that could not afford to pay for hotels can enjoy dream vacations together without breaking the bank. Enterprises like Uber and Zipcar can help lower the number of cars on the road, thereby reducing fossil fuel use and greenhouse gas emissions. Many of these developments have opened up new frontiers of hope, even in economically depressed regions of the world. Indeed, technology and optimism fit together like hand in glove because both play upon open and unwritten futures, promising release from present ills.

Technological civilization, however, is not just a bed of roses. Offsetting invention's alluring promises are three hard and thorny problems that will frame the remainder of this book. The first is risk, of potentially catastrophic dimensions. If human beings today face existential risks—threats that could annihilate intelligent life on Earth[3]—then these are due to the very same innovations that have made our lives more easy, enjoyable, and productive. Our appetite for fossil fuels, in particular, has created a warming planet where massively disruptive changes in weather patterns, food supplies, and population movements loom uncomfortably close. The threat of total nuclear war has receded a little since the fall of the Iron Curtain, but devastating localized nuclear conflicts remain well within the zone of possibility. Highly successful efforts to manage infectious diseases have produced unruly strains of antimicrobial-resistant organisms that could multiply and cause pandemics. Britain's first "mad cow" crisis of the 1980s offered a sobering preview of the unexpected ways in which poorly regulated agricultural practices can interact with animal and human biology to spread disease.[4] While health and environmental risks dominate our imagination, innovation also disrupts old ways of working and doing business, creating economic risks for those left behind. Taxi companies' bitter opposition to Uber, especially in Europe, reflects an anxiety recently expressed to me on a late-night cab ride in Boston: that the taxi driver is an endangered species.

The second persistent problem is inequality. The benefits of technology remain unevenly distributed, and invention may even widen some of the gaps. Take life expectancy for example. According to the 2013 United Nations World Mortality Report, average life expectancy at birth in rich countries was over seventy-seven years, but in the least-developed countries it was only sixty years, or seventeen years less.[5] Infant mortality rates dropped dramatically between 1990 and 2015, but by WHO estimates rates in Africa remained almost five times higher than those in Europe.[6] Patterns of resource use show similar discrepancies. World Population Balance, a nongovernmental organization dedicated to eliminating poverty, reports that the average American consumed seventeen times as much energy as the average Indian in 2015.[7] In the age of the Internet and instant communication, the U.S. Census Bureau documents wide variation in broadband access within the United States, with 80 percent having such a connection in Massachusetts versus less than 60 percent in Mississippi.[8] The same technologies can be found from Kansas to Kabul, but people experience them differently depending on where they live, how much they earn, how well they are educated, and what they do for a living.

The third problem concerns the meaning and value of nature and, more specifically, human nature. Technological invention upsets continuity. It changes who we are as well as how we live with other lives on Earth, and on this front, too, change is not always felt as beneficial. For more than a century, writers ranging from the German sociologist Max Weber to the American environmentalist Bill McKibben have bemoaned our loss of capacity to wonder at a denatured world, mechanized and disenchanted by technology and threatened by the unstoppable march of progress. The frontiers of disenchantment have widened. Endless new discoveries, especially in the life sciences and technologies, tempt humanity to play out scripts of self-fashioning and control that could transform nature and human nature into manipulable machines. Today's deep ecologists, committed to defending the intrinsic value of nature, want to turn the clock back on some of our most pervasive inventions, such as cars and chemicals. England's Dark Mountain Project, founded and led by the eco-activist Paul Kingsnorth, mobilized around a nightmare of "ecocide," of industrial humanity "destroying much of life on Earth in order to feed its ever-advancing appetites."[9] This collective of writers and creative artists is committed to promoting "uncivilization," through art and literature that might redirect humanity toward less destructive ends.

A more immediate result of technological advancement, other critics claim, is fragmentation and loss of community, in short, the weakening of the social ties that make human lives meaningful. The Harvard political scientist Robert Putnam deplores the America of "bowling alone."[10] This is an America where, in his view, people stay home watching television instead of getting involved in church or civic activities, an America in which women eager for equality and financial independence have left mothering, school teaching, and other community-centered occupations for higher-paid jobs in law offices and corporate boardrooms. Such claims may seem

preposterous to today's twenty-somethings who feel connected to increasingly more varied communities through social media. Yet the MIT psychologist Sherry Turkle describes today's youth in America as "alone together,"[11] absorbed in individual, solitary worlds of smartphones and other communication devices, unable to break free and form meaningful, multidimensional, real-world connections.

Technology, in short, has made huge strides in recent decades, but those developments raise ethical, legal, and social quandaries that call for deeper analysis and wiser response. Most visible perhaps is responsibility for risk. Whose duty is it in today's complex societies to foresee or forestall the negative impacts of technology, and do we possess the necessary tools and instruments for forecasting and preventing harm? Inequality raises an equally urgent set of questions. How are technological developments affecting existing gaps in wealth and power, and what steps can be taken to ensure that innovation will not worsen those disparities? A third group of concerns focuses on eroding morally significant commitments to nature and, above all, human nature. Technological developments threaten to destroy cherished landscapes, biological diversity, indeed, the very concept of a natural way of life. New technologies such as gene modification, artificial intelligence, and robotics have the potential to infringe on human dignity and compromise core values of being human. Cutting across all these worries is the pragmatic question whether institutions designed mainly to regulate the physical and environmental risks of technology are up to the task of reflecting deeply enough on the ethics of invention. To examine the complex relationships between our technologies, our societies, and our institutions, and the implications of those relationships for ethics, rights, and human dignity, is the primary purpose of this book.

FREEDOM AND CONSTRAINT

The word "technology" is as capacious as it is unspecific. It covers an astonishing diversity of tools and instruments, products, processes, materials, and systems. A composite of Greek *techne* (skill) and *logos* (study of), "technology" in its earliest usage, back in the seventeenth century, meant the study of skilled craft. Only in the 1930s did the word begin to refer to objects produced through the application of *techne*.[12] Today, the first images the word conjures up are most likely drawn from the world of electronics: computers, cell phones, tablets, software, anything backed by the chips and circuits that make up the silicon world of high-tech societies. But it is well to recall that technologies also include the arsenals of armies, the throbbing dynamos of the manufacturing industry, the plastic forms of genetically modified organisms, the ingenious gadgets of robotics, the invisible products of nanotechnology, the vehicles and infrastructures of contemporary mobility, the lenses of telescopy and microscopy, the rays and scanners of biomedicine, and the entire universe of complex, artificial materials from which almost everything we touch and use is made.

Caught in the routines of daily life, we hardly notice the countless instruments and invisible networks that control what we see, hear, taste, smell, do, and even know and believe. Yet, along with the capacity to enlarge our minds and extend our physical reach, things as ordinary as traffic lights, let alone more sophisticated devices such as cars, computers, cell phones, and contraceptive pills, also govern our desires and, to some degree, channel our thoughts and actions.

In all of its guises, actual or aspirational, technology functions as an instrument of governance. A central theme of this book is that technology, comprising a huge multiplicity of things, rules us much as laws do. It shapes not only the physical world but also the ethical, legal, and social environments in which we live and act. Technology enables some activities while rendering others difficult or impossible. Like rules of the road, it prescribes what we may do without complication and what we do at peril or high social cost. Statins lower blood cholesterol levels and improve cardiovascular health, but people taking statins must be careful to stay away from grapefruits and grapefruit juice. Mac users buy ease and elegance but cannot get behind the computer's built-in design features as easily as PC users can. Purchasers of electric cars drive more climate-friendly vehicles, but they must reckon with the reality that charging stations are few and far between by comparison with gasoline pumps. Food omnivores in rich countries enjoy an unimagined wealth of fresh produce sourced from around the world, but their eating habits leave larger carbon footprints and tax the environment far more than the diets of poor people or committed locavores.[13]

Modern technological systems rival legal constitutions in their power to order and govern society. Both enable and constrain basic human possibilities, and both establish rights and obligations among major social actors. In contemporary societies, moreover, law and technology are thoroughly intertwined. A red traffic light, for example, is a legal and material hybrid whose regulatory power depends on an enforceable traffic code that equates red with stop. Many of modern technology's brightest promises could not be realized without support from the law, such as laws governing contracts, liability, and intellectual property. Conversely, law relies on technology at many points to ensure that its rules will have force and effect, for example, cameras that capture vehicles speeding or police officers shooting. As yet, however, there is no systematic body of thought, comparable to centuries of legal and political theory, to articulate the principles by which technologies are empowered to rule us. Nor are the predictive and regulatory instruments invented over the past half century necessarily strong enough to control how technology will define humanity's common future.

HOW TECHNOLOGY RULES US

It would be hard to overstate how pervasively technological inventions rule our actions and expectations. A mundane example may make the point. Until the summer of 2007, I walked across the T-intersection near my office in Cambridge, Massachusetts, without the benefit of a stoplight. Cars streamed steadily along two roads, each a major artery into and out of Harvard Square. I had to gauge how fast they were coming and when a break was wide enough to permit safe crossing. Sometimes traffic was annoyingly heavy and I had to wait many minutes; other times I hardly had to pause before stepping out into the road, though knowing that an aggressive Massachusetts driver might appear from nowhere as I was hurrying across. I made personal decisions about when to stop and when to go, with only my knowledge of local roads and drivers to guide me.

Today, that intersection is regulated. I have to wait up to three changes of the stoplights before a walk sign lets me cross, but then I can count on a full nineteen seconds to make it safely to the other side. For that brief span, recurring on a predictable cycle, pedestrians own the crossing. Cars stand still as drivers watch the seconds ticking down, waiting for red to turn green. The crossing now feels almost sedate. Jaywalking, a student birthright in this venerable college town, remains an option for those in a rush, but what used to be a matter of judgment is now

almost a moral question. Should I wait and abide by the law? Should I cross illegally against the light, possibly slowing down a car, getting hit by a bike, or setting a dangerous precedent for other walkers? Inanimate lights backed by invisible experts and unseen electrical circuits have stepped in to discipline behavior that was once risky, individual, and free.

Those traffic lights are a reminder that technologies incorporate both expert and political judgments that are inaccessible to everyday users. Who decided that the crossing needed a light or that nineteen seconds was the right number to keep pedestrians safe and cars moving fast enough? Did Cambridge city officials consult the public? Did they draw the number out of a hat, did they commission their own experts, or did they outsource the design of traffic signals to a consulting company that specializes in such work? The questions multiply. How did the experts, whoever they were, model traffic behavior at the intersection and determine how to allocate time between cars and people? What data did they use, and how reliable was their information? Did they assume all walkers are equally able-bodied, or did they allow extra time for infirm or disabled persons? Normally, we might never think to ask these questions—not unless accidents at the intersection reveal that the experts had made sad mistakes and someone should be called to account.

That observation brings us to the second major theme of this book: governing technology wisely and democratically requires us to look behind the surfaces of machines, at the judgments and choices that shaped how lines were drawn between what is allowed and what is not. Curiously, social theorists have spent a great deal more energy thinking about how to make good laws than about how to design good technological objects, like traffic lights. That asymmetry is puzzling. In democratic societies, uncontrolled delegation of power is seen as a basic threat to freedom. Both legislation and technological design involve delegation, in the first case to lawmakers, in the second to scientists, engineers, and manufacturers. Yet, historically, we have cared a lot more about handing over power to humans than to technological systems. History matters, of course. Philosophers and social scientists have for centuries worried about abuses of monarchical power. The potentially coercive power of technology is a more recent phenomenon. But if we want to retain our human freedoms, our legal and political sophistication needs to evolve along with our technologies. To reclaim human rights in a world governed by technology, we must understand how power is delegated to technological systems. Only then can the delegations be monitored and supervised so as to satisfy our desire for ordered liberty and informed self-governance.

Just as similarities between law and technology are important, so also are the differences. Law on the whole regulates relations between human beings and between people and social institutions. Technology, too, affects interpersonal relations, as for instance when telephones allow salespeople or lobbyists to penetrate private spaces that would be off-limits to physical intruders. But whereas law's efficacy depends on human action and interpretation, technology functions by dividing agency between mindless inanimate objects and mindful animate beings, with far-reaching consequences for responsibility and control. To continue with the traffic light example, a fatal accident at a regulated intersection raises issues of negligence and liability different from those raised by an accident at a crossing without lights. Running a red light is evidence of wrongdoing in and of itself because we have chosen to attribute legal force to the color red. At an intersection without a light, determining who is at fault would require other kinds of evidence, such as the judgment of fallible human bystanders. When to make, and not to make, such potent regulatory delegations to objects remains a deeply ethical question.

AGAINST CONVENTIONAL WISDOM

More than just arrays of inanimate tools, or even large interconnected systems that facilitate getting things done, new and emerging technologies redraw the boundaries between self and other and nature and artifice. Technological inventions penetrate our bodies, minds, and social interactions, altering how we relate to others, both human and nonhuman. These changes are not merely material—better cars, computers, or medicines—but transformative of human identity and relationships. They affect the meaning of existence. Our ability to manipulate biological matter, for example, has reframed how we think about life and death, property and privacy, liberty and autonomy. DuPont's 1930s advertising slogan "Better things for better living—through chemistry" sounds hopelessly naïve in an era when life itself, from human bodies to the living planetary environment, has become an object of design.

Taking this transformative potential into account, this book rejects three widely held but flawed ideas about the relations between technology and society. These are technological determinism, technocracy, and unintended consequences. Singly and together, these ideas underpin much of what people commonly believe about the role of technology in society. Each idea offers useful pointers for thinking about how to govern technology well, but each is limited and ultimately misleading. Most dangerously, each represents technology as politically neutral and outside the scope of democratic oversight. In this respect, all three notions assert the inevitability of technological progress and the futility of trying to resist, let alone stop, slow, or redirect it. Challenging those presumptions is an essential step in making technology more governable: put differently, these powerful myths need to be set aside in order to reclaim technology for democracy.

The Determinist Fallacy

The idea of "technological determinism" permeates discussions of technological change, even though the term itself may not be familiar to everyone who shares the conventional wisdom. This is the theory that technology, once invented, possesses an unstoppable momentum, reshaping society to fit its insatiable demands. Technological determinism is a common theme in science fiction, where the machine escapes human control and acquires a will of its own. The murderous computer HAL in Arthur C. Clarke's 1968 novel *2001: A Space Odyssey* captured the popular imagination with just this quality of malign intent.[14] Savvy enough to lip-read human speech, but lacking human compassion, HAL kills most of the astronauts accompanying him in the spaceship when he "hears" their plan to disconnect his programmed, amoral mind.

In 2000, Bill Joy, influential cofounder and former chief scientist of Sun Microsystems, wrote a widely noticed article in *Wired* magazine entitled "Why the Future Doesn't Need Us."[15] He argued that the hugely powerful technologies of the twenty-first century—genetics, nanotechnology, and robotics, or GNR as he called them—should be taken far more seriously than most of us do take them because of their annihilating potential. Joy saw a difference between this new era and former times because of the

self-replicating potential of the new GNR technologies and the relative ordinariness of the materials needed to produce them. Small groups of individuals with the right know-how could unleash "knowledge-enabled mass destruction." Joy imagined the ultimate dystopian future:

> I think it is no exaggeration to say we are on the cusp of the further perfection of extreme evil, an evil whose possibility spreads well beyond that which weapons of mass destruction bequeathed to the nation-states, on to a surprising and terrible empowerment of extreme individuals.[16]

At first glance, Joy's vision seems not entirely deterministic in that he leaves room for human action and intention, at least by "extreme individuals." But at a deeper level he seems certain that properties intrinsic in the technologies themselves will render the "perfection of extreme evil" a virtual certainty if we continue heedlessly to develop those technologies. Reading this essay by a gifted computer scientist, it is hard to believe that human beings can maintain control over their machines except through inhuman restraint, by not developing the enticing capabilities that also threaten our destruction. Yet there was nothing natural or preordained about HAL's twisted intelligence in *2001.* The murderous computer was the product of earlier, self-conscious human intentions, ambitions, errors, and miscalculations. To treat instruments like HAL as autonomous, possessing an independent capacity to act or to shape action, belittles the ingenuity that designed them and strips away responsibility from the human creators of these marvelous but ungovernable machines.

How can we assess the risks of technology in advance, and is it really true, as Joy fears, that once we launch on the dizzying adventure of technological innovation there can be no turning back? Is there no middle ground for responsible, ethical, technological progress between unbridled enthusiasm and anachronistic Luddism? Joy's essay does not take us to that place, but we can find other handholds on the smooth wall of progress.

Let us return to traffic lights for a moment. In the United States today, we think of each kind of traffic as having a controlled right to an intersection, either through a principled right-of-way that allows some actors always to go before others—as pedestrians on a zebra stripe—or a sequentially regulated right of access for different types of traffic, as at the newly installed lights near my office. This understanding of rights on roadways was itself a novelty less than a hundred years ago.[17] Under English common law, all street users were considered equal, but pedestrians had to yield to motorists as cars took over the urban landscape. Cars caused congestion that could be cured only by giving motorists the right-of-way everywhere except at intersections. Beginning in Texas in the 1920s, traffic signals quickly replaced the more costly human police force. Their rapid spread throughout the world, as devices that carry the same meaning and enforce roughly the same behavior everywhere, is one of the great success stories of modern technological innovation. Once lights were in place, jaywalking became the marked behavior, risky everywhere and punishable with stiff fines in some American states.

But lights, too, have their limitations. They can be overwhelmed by the sheer volume of traffic, and sometimes they are incapable of preventing accidents. At the turn of the twenty-first century, the Dutch road engineer Hans Monderman came up with what seemed like a radically different solution to the problem of mixed traffic on busy roads. His solution was a concept known as "shared space." Monderman's idea was to simplify,

not complicate, the technological infrastructure, in short, to do away with lights, signs, barriers, and all other confusing markers. Instead, he proposed that roads and intersections be crafted to encourage users to look out for their own and others' safety. Lights, rails, stripes, and even raised curbs gave way to simpler, more "village-like" designs that encouraged drivers to be more careful. Instead of using material structures to separate different users of the road, Monderman relied on social instincts of respect and care to calm his intersections.

In a 2004 interview with *Wired* magazine, Monderman commented on a traffic circle in the town of Drachten that once had been a nightmare for nonmotorists:

> I love it! Pedestrians and cyclists used to avoid this place, but now, as you see, the cars look out for the cyclists, the cyclists look out for the pedestrians, and everyone looks out for each other. You can't expect traffic signs and street markings to encourage that sort of behavior. You have to build it into the design of the road.[18]

So successful were Monderman's traffic experiments that versions were introduced in metropolitan business districts ranging from London to Berlin. In effect, he had turned the clock back to a kinder, gentler era when all users enjoyed equal rights to the road. It was a small example of how thoughtful, critical reflection on the assumptions underlying a technological system can have enormously liberating effects on those who use the technology, even users who never stopped to ask whether alternatives to inbuilt structures are even imaginable.

If we so often blind ourselves to the power and intent that created our designed and regulated modes of living, it may be because the very word "technology" tempts us to think that the mechanical productions of human ingenuity are independent of their social and cultural foundations. Leo Marx, the eminent American cultural historian, noted that the shift in the word's meaning, from the study of skill to the products of skill, was highly consequential for later thought. It enabled us to conceive of technology "as an ostensibly discrete entity—one capable of becoming a virtually autonomous, all-encompassing agent of change."[19]

That sense of autonomy, however, is illusory and dangerous. A more thoughtful view holds that technologies, far from being independent of human desire and intention, are subservient to social forces all the way through. As Langdon Winner, a prominent critic of technological determinism, pithily put it in a 1980 essay, "artifacts have politics."[20] Many reasons have been put forward for questioning a strictly deterministic position with regard to technologies created by human societies. On the production side, the technologies we make inevitably grow out of historical and cultural circumstances that condition the kinds of needs that societies face, or think they face. Knowledge of the inner workings of the atom did not have to lead to the making of the atomic bomb. That consequence came about because warring states harnessed physicists' theoretical knowledge to make the most destructive weapons that money could buy. Politics influences the uses and adaptations of technology even after products enter the market. Smartphones and social utilities did not cause the Arab uprisings of 2011, although it was fashionable for a time to call them the Twitter revolutions. Rather, existing networks of protest, including the barbarous Islamic State, found phones, video cameras, and services like Twitter useful in giving voice to discontent that had been simmering for years under the region's lids of authoritarian, sectarian politics. These observations have led analysts to rethink technology as

both a site and an object of politics. Human values enter into the design of technology. And, further downstream, human values continue to shape the ways in which technologies are put to use, and sometimes even repudiated as in Monderman's calming traffic circles.

The Myth of Technocracy

The idea of "technocracy" recognizes that technological inventions are managed and controlled by human actors, but presumes that only those with specialist knowledge and skills can rise to the task. Who, after all, could imagine approving a new drug without medical knowledge of its impacts on health, or licensing a nuclear power plant without engineering expertise, or running a central bank without training in finance and economics? The belief that modern life is too complicated to be managed by ordinary people has long roots in Europe, dating back to the ideas of the French aristocrat and early socialist thinker Henri de Saint Simon at the beginning of the nineteenth century.[21] Saint Simonisme, as his philosophy was called, stressed the need for a scientific approach to the management of society and a correspondingly authoritative position for trained experts. In the United States at the turn of the twentieth century, the Progressive Era cradled similar beliefs in the inevitability of progress based on science and technology, and the necessary role of experts as advisers at every level of government. By the end of the Second World War, a new dynamic had come into play. Scientists, nurtured by abundant public funding during the war and often relishing their role in affairs of state, lobbied hard to insert more and better science into public decisions. Advisory bodies and positions proliferated, creating in effect a "fifth branch" of the government, beside the traditional legislative, executive, and judicial branches, supplementing the influential "fourth branch" of expert regulatory agencies.[22]

Faith in technocrats and dependence on their skills, however, walked side by side with skepticism and disenchantment. Harold Laski, an influential British economist and political scientist in the twentieth century's brief interwar period, wrote about the limitations of expertise in a 1931 pamphlet that prefigured later doubts and reflections:

> Too often, also, [expertise] lacks humility; and this breeds in its possessors a failure in proportion which makes them fail to see the obvious which is before their very noses. It has, also, a certain caste spirit about it, so that experts tend to neglect all evidence which does not come from those who belong to their own ranks. Above all, perhaps, and this most urgently where human problems are concerned, the expert fails to see that every judgment he makes not purely factual in nature brings with it a scheme of values which has no special validity about it.[23]

Unlike other intellectuals of his day, including some of his American Progressive Era friends, Laski also presciently cautioned against relying too much on eugenics and intelligence tests. Supreme Court Justice Oliver Wendell Holmes, whose increasingly liberal views on the First Amendment were partly shaped by his correspondence with Laski, notoriously supported eugenic sterilization in the 1927 case of *Buck v. Bell.*[24] The excesses of the Holocaust, in which German biologists lent scientific support to Nazi racial doctrines, proved Laski's skepticism to have been tragically well-founded.

Many more recent examples of technological failure, some discussed in detail in later chapters, bear out Laski's long-ago

charge that experts overestimate the degree of certainty behind their positions and blind themselves to knowledge and criticism coming from outside their own closed ranks. Although the National Aeronautics and Space Administration (NASA) conducted a highly public inquiry into the 1986 loss of the space shuttle *Challenger*, it did not discover the problems inside the agency that hindered the detection and communication of early warning signs. Only after the loss of a second shuttle, the *Columbia* in 2003, and then only upon consulting with the sociologist Diane Vaughan,[25] did NASA acknowledge deficiencies in its expert institutional culture. In the award-winning documentary *Inside Job*, the director Charles Ferguson detailed how a small circle of well-placed economic advisers, including the "unquestionably brilliant"[26] Lawrence Summers, advocated for financial deregulation and dismissed early warning calls as "Luddite" in the lead-up to the 2008 financial crisis. These examples offer strong arguments for greater transparency and public oversight in expert decisionmaking.

Intended and Unintended Consequences

A third idea that often runs in parallel with technological determinism and technocracy is that of "unintended consequences." It is well known that technologies fail, but it is less obvious who should be blamed for failures and under what circumstances. Indeed, the more dramatic the failure, the less likely we are to accept that it was imagined, let alone intended, by those who designed the object or system. When a toaster breaks down or a car stalls on a freezing morning, we call someone to repair the malfunction; or, knowing that things, like people, have appointed life spans, we grumble a little and buy a replacement for the one that has outlived its usefulness. If an appliance stops working before the end of its warranty period or its expected functional life, we declare it a lemon and ask the seller for our money back. If the malfunction is serious or has caused injury, we may lodge a consumer complaint or go to court to seek redress. Most mishaps in the shared lives of humans and machines are so commonplace that they hardly cause a ripple in society's basic rhythms. We see them almost as natural events, the predictable end points of an aging process that afflicts nonliving as well as living systems.

If technological mishaps, accidents, and disasters seem unintended, it is because the process of designing technologies is rarely exposed to full public view. Anyone who has toured a steel mill, a chocolate factory, or a meatpacking concern knows that visitors must observe strict rules in exchange for even limited transparency. There are places they cannot look and doors they may not open. Once in a while production errors spill into the open with consequences that can be highly embarrassing for the designers, but these are the exception, not the rule. One such episode unfolded in July 2010, when Apple launched its iPhone 4 with great fanfare, selling three million devices in just three weeks. It turned out that, held in a certain way, the phones lost connectivity and refused to function as telephones. The blogs went wild, mocking the legendary company's loss of face and lampooning a product that had taken the market by storm. The event quickly earned a derisive name: Antennagate. It took a smoothly choreographed performance by Apple's late cofounder and chief visionary, the master salesman Steve Jobs, to silence the critics.

Jobs's public meeting and publicity video stressed one theme over and over: "We're not perfect. Phones aren't perfect."[27] Not perfect, perhaps, but as good as it humanly gets, he argued, and in the case of the iPhone 4 far better than any competing gadget

on the market. Jobs backed up his claims with a deluge of data on all of the effort that had gone into testing the iPhone antenna's performance. As one blogger noted, it was a bravura performance designed to convince viewers "that the iPhone 4 wasn't just thrown together by some cavemen in a cubicle."[28] If imperfections remained, that was the unavoidable state of a world in which neither humans nor machines can be totally foolproof and fail-safe. Importantly, however, Jobs accepted responsibility on the company's behalf, emphasizing that Apple's people were working overtime to correct the problem and repeating his mantra that Apple wanted all its users to be happy. As a gesture of appeasement, he offered free iPhone covers to compensate early buyers for any inconvenience they had experienced.

The theme of unintended consequences spins technological failures in an altogether different direction. This story line is not the same as Steve Jobs's confession of human and mechanical fallibility. Jobs insisted that Apple's engineers were thinking as hard as possible about a problem and trying to solve it in advance, even if perfect mastery eluded them. By the same token, they would rethink and rejigger their designs if a rare mistake happened. The language of unintended consequences, by contrast, implies that it is neither possible nor needful to think ahead about the kinds of things that eventually go wrong. The phrase is usually invoked after dire or catastrophic events, such as the discovery of the "ozone hole" caused by a few decades of releasing chlorofluorocarbons into the stratosphere, or major industrial disasters such as the lethal 1984 gas leak in Bhopal, India, that killed thousands, or the near-ruinous collapse of global financial markets in 2008. These are moments that reduce us to helplessness, not knowing quite how to respond, let alone how to mitigate the damage. Claiming that such massive breakdowns were unintended assuages the collective sense of paralysis and guilt. It likens the fatal event to a natural disaster or, in insurers' terms, an act of God. It implicitly absolves known actors of responsibility for what went wrong or for picking up the pieces.

The idea of unintended consequences, however, leaves troubling questions hanging. Does it mean that the designers' original intent was not executed as planned, or that things happened outside the scope of their intent because no one could have known in advance how the technology would be used? The two interpretations carry quite different legal and moral implications. In the first case, there may be technology users who can and should be held responsible—like the negligent engineer Robert Martin Sanchez, whose on-the-job texting caused a deadly train accident in Los Angeles in September 2008, killing him and twenty-four others. It is reasonable to think that the telephone's designers did not intend their invention to be used by someone in a job requiring a high degree of sustained attentiveness. Remedies might include changes in law and regulations to enforce higher standards of care by users as well as manufacturers. In the second case, there may be no identifiable people to blame—for instance, when climate scientists discovered decades after the automobile's mass adoption that emissions from cars burning fossil fuel are a major contributor to climate change. The failures here were of imagination, anticipation, oversight, and perhaps uncurbed appetite, none easily cured through preventive policy or improved technological design.

Unfortunately, the two scenarios, though logically distinct, are often hard to disentangle in practice. Part of the problem lies in the fuzziness of the word "unintended." What, after all, are a technology's *intended* consequences? Can the answer be determined only after a failure, in which case it is not very useful for designers or regulators who need to think proactively about possible mishaps? And is there a built-in bias in the use of the term, in the sense that good consequences are always thought to be intended and only bad outcomes are retrospectively labeled unintended? In that case, the talk of unintended consequences serves mainly to reassure us about the fundamentally progressive and beneficent character of technological change. It expresses the hope that no one would intentionally build the potential for catastrophe into devices that are supposed to serve humankind for beneficent purposes.

A second problem is that the term "unintended" seems to fix intention—at least morally relevant intention—at a specific moment in time, though technology in use is never static. The story of the texting train engineer Sanchez illustrates how technologies acquire complex and changing relationships with society long after they have been released into the world. Phones and trains, texting and commuting, may exist in different conceptual spheres for most of us much of the time—as they clearly did for the managers of the Los Angeles commuter rail system before the fatal accident of 2008. But human beings are ingenious, imaginative, and creative users of the devices that the modern world puts within their reach. Whose responsibility is it to track those changing uses? The tragic event in Los Angeles drew attention to a particular synergy that no one had planned for in advance but that supervisors might have found to be quite widespread if they had troubled to look. If one engineer was guilty of such carelessness, then the chances were that others were also behaving in similar ways. Indeed, Kathryn O'Leary Higgins, who chaired the federal inquiry into the fatal crash, declared the use of cell phones by train crews to be a national problem: "This was one day, one train, one crew. It raises for me the question of what the heck else is going on out there?"[29]

STANDPOINT AND METHOD

Technological innovation is as wide-ranging as human diversity itself, and any attempt to make sense of it analytically requires some framing choices. For me, those choices are driven in part by disciplinary training and in part by personal experiences of the world. Much of the empirical material covered in this book derives from my deep familiarity, as a legal scholar, with controversies at the nexus of science, technology, and law. To these examples, I also bring a secondary training in the field of science and technology studies (STS), a relatively new academic discipline dedicated to understanding how the social practices of science and technology relate to those of other institutions in society, such as law. STS analysis demands, in particular, close attention to the ways in which technical and social uncertainties are resolved, and to what gets lost or simplified in the effort to produce believable accounts of the world. Of particular interest to STS are the decisions that sideline doubt and declare that a technological system will function safely and effectively enough. That perspective has produced a robust literature on expert processes, such as risk assessment, that informs the ethical and moral questions raised in this book.

A second methodological orientation comes from my long immersion in cross-national comparisons of science and technology policy and environmental regulation. Those investigations have revealed that countries fully committed to rational, science-based decisionmaking and vigorous protection of public health and safety nevertheless often impose different degrees

and kinds of controls on technological systems.[30] Germany is highly antinuclear but France on the whole is more favorably disposed. Neither has access to oil fields or uranium mines within its borders, and their policy discrepancies cannot be explained wholly on the ground of economic and geopolitical interests. American publics, too, do not like nuclear power, at least when the power plant might be situated in their backyards, although most U.S. experts and entrepreneurs are convinced that nuclear power is a viable, indeed essential, safe alternative to fossil fuels.[31] Such divergences point to the importance of history and political culture in ethical reasoning about technological futures—another perspective that informs this book.

The examples I use throughout the book also reflect personal choices and experiences at multiple levels. Many cases involve either the environment or the life sciences and technologies, because these are among my longstanding areas of research interest and because ethical and legal problems were articulated in these contexts sooner than in the digital arena, where issues such as privacy and surveillance are still in flux. I also draw on cases from South Asia, especially India, that reflect a mix of personal and intellectual concerns. India and the United States offer striking similarities and differences that bear on the themes of risk, inequality, and human dignity. Both nations are committed to technological development, both are democratic societies, and both have nurtured respectable traditions of social mobilization and freedom of speech. India, however, is markedly poorer than the United States and more than once has been the site of major technological mishaps and disasters. Juxtapositions of debates in the two countries highlight the challenges of responsible and ethical innovation in an unequal world.

THE RESPONSIBILITY GAP

It would be foolish at best and dangerously innocent at worst to deny the advantages of the human-made instruments and infrastructures that make up the environments of modernity. Yet, whether we treat technology as a passive backdrop for a society that evolves according to unconstrained human choice or attribute to technology superhuman power to shape our destinies, we risk making conceptual errors that threaten our well-being. Centuries of invention have not only made human lives more pampered, independent, and productive; they have also perpetuated forms of oppression and domination for which classical political and social theory barely has names, let alone principles of good government. Unless we understand better how technologies affect basic forms of social interaction, including structures of hierarchy and inequality, words like "democracy" and "citizenship" lose their meaning as compass points for a free society.

The doctrines of technological determinism, technocracy, and unintended consequences tend to remove values, politics, and responsibility out of discussions about technology. Little of moral consequence is left to debate if machines possess their own logics that push society along inevitable pathways. In that case, technocrats argue, rule by experts is the only viable option, since all we want is to ensure that technologies function well, and engineering design and the assessment of technological risks are much too complicated to be left to ordinary people. Further, given the complexities of all large technological systems, there is no realistic alternative to living with uncertain futures containing unforeseeable threats. Viewed through the lens of unintended consequences, many aspects of technology simply cannot be known or effectively guarded against in advance. How could Henry Ford possibly have foreseen climate change when he developed the Model T? Surely it is better for societies to be inventive and creative, take risks in stride, and learn to do better if and when bad things happen!

These arguments can lead to fatalism and despair about those aspects of modern lives that are threatened or constrained by technology. We have seen, however, that conventional wisdom is faulty. Theories that represent technology as intrinsically apolitical or ungovernable have generated countervailing insights that neither technologies nor technical experts stand outside the scope of politics, moral analysis, or governance. The challenge for modern societies is to develop sufficiently powerful and systematic understandings of technology for us to know where the possibilities lie for meaningful political action and responsible governance. The bargains struck in enhancing human capability do not have to be Faustian, ratified between unequal bargaining partners under conditions of blind ignorance or irreducible uncertainty.

But what are the most promising means to ensure that technology will not slip from human control, and what tools, conceptual or practical, can we deploy to hold our proliferating inanimate creations in check? The remainder of this book takes up these questions by looking at the problems of risk, inequality, and human dignity that must be addressed if societies are to live more responsibly with their technological inventions. Chapter 2 looks at the risks that accompany almost all technological innovation, asking where they originate and how they are governed. How do technological risks arise, who assesses them, by what criteria of evidence and proof, and under what sorts of supervision or control? Chapters 3 and 4 address the theme of inequality and the structural foundations of injustice in technologically advanced societies. Chapter 3 examines some dramatic failures in technological systems and inquires how more ethical systems of governance could be devised in a world where risks and expertise are unevenly distributed across national boundaries and responsibility for prediction and compensation is hard to pin down. Chapter 4 traces the controversies over genetic modifications of plants and animals, uncovering the transnational ethical and political dilemmas that arise when scientists tamper with nature on global scales. The next three chapters look in different ways at the evolving role of individual liberty and autonomy in emerging technological systems. Chapter 5 considers the ethical and moral implications of changes in biomedical sciences and technologies, examining the institutions and processes through which decisions are made about the limits of manipulating human biology. Chapter 6 delves into the rapidly expanding world of information and social media, mapping the challenges to privacy and freedom of thought that have arisen in the early decades of the digital revolution. Chapter 7 turns to the vexed question of intellectual property and the rules that govern the tensions between the ideal of free inquiry and the reality of proprietary knowledge. The two final chapters explore questions of control and governance. Chapter 8 reviews various mechanisms that have been devised for engaging publics to play more active roles in the design and management of their technological futures. Chapter 9 returns to the book's opening and ultimate question: how can we restore democratic control over technological forces that appear too rapid, too unpredictable, or too complex to be subject to classical notions of good government?

Chapter 2

RISK AND RESPONSIBILITY

In its simplest definition, technology is a means to an end—or, in the modern era, the application of expert knowledge to achieve practical goals. This understanding of technology, however, obscures a glaring limitation. It implies that the "ends" of invention are known in advance; ingenuity comes into play mainly to accomplish already determined ends. No doubt this was true in the primal stages of human development, when our ancestors were interested mainly in foraging for food and sheltering or defending themselves against weather and enemies. Animals had to be caught on the run or on the fly, so slingshots and arrows were invented; rivers and lakes had to be crossed, so bridges were built and hollowed-out tree trunks floated. Display cases full of the dusty handiwork of ancient toolmakers can be seen in any museum of prehistory—a seemingly inexhaustible supply of sharpened flints, shaped ax heads, stone mortars and pestles, and crude farming implements.

Modern technologies, however, are rarely so one-dimensional. They defy any simple, one-to-one correspondence between means and ends. One reason is that the ends of technology in society are never static, and technological systems evolve much as biological organisms do, along with the societies in