Contents

Series Foreword x
Acknowledgements xiii

Introduction 1
Organization of the Material 1
The Point of Social Theory 4
Key Themes 5

1 **Theorizing Technology** 8
What is Technology? 8
What Does Technology Do? 12
How has Technology been Theorized? 15
Technology, Systems and Social Interests 20
Our Times: Technology, Complexity and Risk 23
Conclusion 27
Further Reading 27

2 **Marx, Modernity and the Machine** 29
The Material Turn 29
Machine-Made Machines: Modern Industry 31
Machine-Made People: Modern Subjectivity 34
Marx and Technological Determinism 37
Extensions of Marx, I: Critical Theory and the Culture Industry 39
Extensions of Marx, II: David Noble, *The Forces of Production* 43
Conclusion 47
Further Reading 48

3 **Constructing the Modern: Human-Built World** 50
Social Theory in the City 51
The Arcades Project 53
Benjamin on Flânerie and Technology 54
Foucault as Technological Thinker 57

1

Theorizing Technology

Chapter 1 critically examines the central significance of technology in our world. The intention is to lay the groundwork for the substantive chapters that follow, when we will assess particular theorists and theoretical traditions. Here we introduce some general points for the would-be theorist of technology to keep in mind. We think about the nature of technology, what it is, what it does, how social theorists have conceptualized it, and the role social interests play in technological triumph. We consider what might happen when technologies shift settings, contexts and countries. From our example we will see that there is no single trajectory for a technology; rather there are many trajectories and many effects. We therefore suggest positioning technology as ongoing encounter. The mundanity of technology and its complexity are noted. The increased scale and interdependence of technologies are here conceptualized as the rise of sociotechnical systems. We explore some of the consequences of the development of more complex, interdependent and open technologies in relation to notions of expertise and risk. In addition to seeing our technologies as ongoing encounters, we raise the possibility that they might also be ongoing experiments.

What is Technology?

'In a way, everything is technology', so wrote Fernand Braudel (1985a, p. 334), arguably the twentieth century's greatest historian. Just as technology is everything, it is also everywhere, present in all our endeavours, be they exceptional or everyday. Braudel noted technology's role in humanity's great revolutionary moments: gunpowder, the machine, navigation, the printing press. He also saw the part technology has played in those slow accretions which modify what we already know and do (the sailor in the rigging, the peasant following the plough) – the gradual transformations of tools and techniques which add to the stock of accumulated knowledge. Technology helps elucidate history and vice versa. But as the

great historian warned, we should not collapse the history of technology to the level of crude materialism. Artifacts affect history, but they do not necessarily drive it, and they are never divorced from human desires, needs and passions.

Braudel alerts us to the difficulty of defining technology and determining what it does, given its ubiquity. Leo Marx (1997) has even referred to it as a 'hazardous' concept. In doing so he has taken issue with Braudel's way of defining it because the term is drained of any useful meaning. Others have articulated the same concerns, calling technology a 'slippery' term (MacKenzie and Wajcman, 1985, p. 3). In trying to give it some determinacy they draw attention to three separate levels of meaning. The first sees technology as physical things: objects, artifacts, tools, machines and so on. Of course, few theorists are happy to stick to this limited 'hardware' definition (Latour, 1988b, p. 199). These days many of our technologies are virtual, and we must reckon with the salience of software in our world. In Western societies these codes influence ever-more aspects of social life. Software has spread into communication devices, toys, domestic appliances, automobiles, elevators, traffic light and surveillance systems, to name but some. Society is populated with various animated smart devices, so much so that software can be said to be an important actor in the modern world. Computerization has radically altered the 'technical substrate' of society (Thrift, 2005, p. 197). While we are still confronted with fixed, stable and bounded things, we increasingly interact with intangible products and with things in transition. Software gives us time-restricted rights to access content streams, ongoing development, openness and upgrading possibilities. Saskia Sassen (2002, p. 369) identified digitization as the main driver in the transformation of the nature of things. It has increased

> those capacities that make possible the liquefying of what is not liquid … [it] raises the mobility of what we have customarily thought of as not mobile or barely mobile. At its most extreme, this liquefying de-materializes its object. Once de-materialized, it gains hypermobility – instantaneous circulation through digital networks with global span.

We therefore need to be mindful of what Nigel Thrift (2005, p. 10) called 'shifts in the nature of materiality'. New media technologies especially stress interactivity and convergence. They seem to be constantly transforming (we return to this point in Chapter 5). Mobile phones were once just that; senders of disembodied voices across distance. Now they also send text, capture and store images, download and play music, access and surf the web. To say that today's mobile phones are simply phones is to sell them short. While they remain communication devices they are also computational ones. This multiplication of functions also multiplies the potential uses, and the potential effects. Mobiles destroy the tyranny of distance and allow for 24/7 communication, they provide for novel forms of entertainment and new ways of knowing, being and seeing. However, they also present us with new problems: happy slapping, sexting, text bullying, upskirting, another way to get into debt, another target for muggers, and new forms of tracking and surveillance.

The definition of technology as objects (which we have upgraded to actual or virtual objects, fixed or in flux) still requires expansion. Two other definitions are offered: technology as human activities, and technology as knowledge (MacKenzie and Wajcman, 1985, p. 3). Technologies are produced to create certain effects. In order for these to be realized we need to know how to use them. This takes us into the realm of technique. It entails what Raymond Williams (1975, p. 134) said of culture – right knowing and right doing. Even a simple tool can be useless in the hands of an untutored user. While three different definitions of technology have been identified, they all combine in use. For example, you are currently reading this chapter. To do so requires an object (this book), an activity (reading) and knowledge (of the English language). Should any of these three technological elements be removed the enterprise will fail.

We already have a sense of why technology is slippery – many technologies seem to be in a permanent state of transition and a single technology can have multiple uses and meanings. Yet another reason for the slipperiness of technology is that its meaning – what we understand by the word – has changed across time, as has its perceived relationship to terms like science. The origins of the word 'technology' are in the Greek root '*techne*', relating to art or craft (with '-ology' referring to knowledge about *techne*). When technology came into English usage in the seventeenth century it was tied to a particular type of learning, that of the mechanical arts. Even after the Industrial Revolution and well into the nineteenth century 'technology' referred to a type of book. It was only with the dawn of the twentieth century that sociologists like Thorstein Veblen began to use technology to refer to the whole of the mechanical arts. Leo Marx (1997) identifies ideological and substantive drivers for this shift: changing conceptions of the mechanical arts and changing organizational structures. These social changes resulted in the deployment of the word 'technology' in the sense that we understand it today.

The ideological spur came from the perception of new connections between science and the mechanical arts, married to a powerful belief in progress. That belief in progress, while ushered in by Enlightenment thinkers, was given a massive boost by the scale of scientific and technological advance. Refrigeration, steam power, the power printing press, the telegraph and scientific medicine had profound effects in the West. Here we see the emergence of a specific (and particularly common) understanding of technology as applied science. There are some objections to this. In the broad sweep of history science and technology have had separate trajectories. Moreover, the causal chain is just as easily reversed: science itself is

produced by technologies. Technologies are required to facilitate experiments and to measure outcomes. These days the word 'technoscience' is often used to denote their mutual constitution. Leo Marx (1997) singles out the chemical and electrical industries as particularly important sites of scientific and technological convergence at the turn of the twentieth century. This period, which ushered in air travel, automobility, electrification, film, radio and the telephone, is often labelled the Second Industrial Revolution.

Leo Marx (1997) also notes the growing range and effects of various technologies, in addition to their increased scale and interdependence. While the early phases of the Industrial Revolution were marked by individual machines (the spinning jenny, the power loom), across time isolated devices lost in significance to sociotechnical systems, of which the mechanical component may only constitute a small proportion. (The next chapter considers the politics of industrial technology with reference to another Marx – Karl.) Leo Marx's example is the railroad, one of the epitomes of modernity. Here we can revisit our three definitions of technology, and once again we can see how they combine in practice. To be sure, the railroad involves a physical object, the train. But to operate it requires many other objects, activities and knowledge sets. The first necessary physical thing was the track itself. Englishman George Stephenson built the first locomotive in 1814, but it was only with the mass manufacture of iron rails from 1820 onwards that the rail*way* was a possibility (Benjamin, 1999b, p. 563). Other necessary objects included bridges, tunnels, rolling stock, signals and stations. As to activities, there are numerous skilled workers involved in the construction, operation and maintenance of railroads. These activities entail specialist knowledge such as railroad engineering and telegraphy. The scope and complexity of these new systems also necessitated a new 'organizational matrix of the mechanic arts' (L. Marx, 1997). For the American railroads to be possible large corporate business structures with significant capital investment needed to be in place. The institutional framing of railroad operations also included standardization of track gauges and time zones. The combination of different types of railway technologies – objects, practices, knowledges – results in a sociotechnical system. Leo Marx adds a fourth useful definition of technology here: technology as a mode of social organization (see also Winner, 1977, p. 12). Interestingly, social theorists already seemed to be working with such definitions. In 1941 Herbert Marcuse wrote 'Some Social Implications of Modern Technology'. He defined technology 'as a mode of production, as the totality of instruments, devices and contrivances which characterize the machine age [and] at the same time a mode of organizing and perpetuating (or changing) social relationships, a manifestation of prevalent thought and behavior patterns, an instrument for control and domination' (Marcuse, 1995, p. 124).

To summarize, we are defining technology as:

- objects (virtual or actual)
- activities
- knowledge
- modes of organization
- sociotechnical systems.

What Does Technology Do?

Most dictionary definitions of technology stress its utility. We use technologies to improve our existence, to make our lives easier, to save time. Technology, then, appears to be the solution to a problem. We use technology to enhance ourselves, to magnify our force or efficacy, usually for purposes of environmental adaptation or control. This prompted media theorist Marshall McLuhan (2005) to discuss technologies as prostheses. Simply put, technologies are extensions of our bodies, physical forces and senses. (We expand on these points in Chapter 7.) How have we primarily extended ourselves in the world? Thrift (2005, p. 155) argues that the two main technological extensions of the human body have been through the inventions of writing/print and machines. We might think of these two extensions in terms of software and hardware. Until recently they have had separate existences, but thanks to advances in computer programming the two are converging. As Thrift puts it, software is 'becoming so pervasive and complex that it is beginning to take on many features of an organism' (2005, p. 155). Technologies, in this sense, can be said to act. Four ways in which information communication technology (ICT) assumes agency in the so-called New Economy are outlined:

1 The issue of sunk costs – massive investment in ICTs means that they *have* to be used;
2 The expectation of use produced by this – good companies use ICT;
3 It provides a new way of perceiving the world;
4 Software forbids some things and allows others – this is seen as the virtual and effective equivalent of barriers and tolls, walls and fences.

The idea of non-human agency is still controversial, but if we think of agency in terms of creating effects it is less threatening. This, after all, is the *point* of technology.

Another related way of thinking about the point of technology is by reference to mediation. Technologies mediate between the physical world and culture, between matter and meaning (Lemonnier, 1993, p. 10). This

meshes with the notion of technologies as agents. We use technology to act on and in the world, and technologies reciprocate. 'What humans are and what their world is receive their form by artifactual mediation. Mediation does not simply take place *between* a subject and an object, but rather *coshapes* subjectivity and objectivity' (Verbeek, 2005, p. 130). In other words, we should not think of technologies as neutral intermediaries interposed between humans and the physical world, but as full-blown mediators affecting what it is to be human in the world. Peter-Paul Verbeek uses the simple example of wearing glasses. When he wears his glasses he is different. Glasses give him additional competencies and experiences. Without his glasses activities like writing are impoverished and other activities, like driving and piano playing, are utterly impossible. For more on mediation see Chapter 6.

Peter-Paul Verbeek (2005, p. 114) also wrote of the train coshaping the presence of landscape. We can expand upon this point by drawing on the work of historian Wolfgang Schivelbusch (1986, pp. 52–69). This provides us with an opportunity to develop McLuhan's ideas about technology and sense perception. In pre-industrial times the fastest collective transport was the horse-drawn coach. The steam train accelerated, and significantly altered, the experience of travel. The train was seen as a projectile hurtling through, even destroying, time and space. Humanity had experienced nothing like it. Passengers conceived of themselves as packets, separated from the landscapes they traversed, propelled from A to B. Recalling McLuhan's arguments about technology and sense extension, we find the new railways altered the sense ratio and thus perception. Stagecoaches permitted subjective connection with landscape, a direct experience of the immediate environment. Railways offered a more objective perspective, a mechanization of the senses, a run through geographic space. Trains destroyed depth perception. The increased velocity caused the foreground to vanish. Old ways of observing were obsolete. You could still fixate on what was closest, but it came at the price of nausea and fatigue. Sensory retraining was required. This demanded a focus on the distance where things pass at a more leisurely pace. The existing ratio of proximity and distance in equal proportions was duly recalibrated. The new technologically-enabled, *mediated*, perceptions of time and space were at first shocking. Neither strictly in the landscape any more, nor in the company of intimates of equal social standing, when compared to coach travel this was first felt as a form of estrangement. But people adjusted. The increased speed and the new spatiality gave rise to a novel mode of apprehension, a moving vision. Things previously perceived as separate were now connected in a seamless, albeit fleeting, unfurling. What had emerged was the panoramic sensibility.

We have noted that we relate to, with and through technologies, that they are mediators, elements of our human being. Philosopher Martin

Heidegger (1977) offers further insight here. Joost Van Loon (2002, p. 90) says that Heidegger's work treats 'the notion of technology as a culmination of modern thought, a mode of being in which modernity reveals and conceals itself most fully'. For Heidegger the fixation on objects existing only to be used conceals the fundamental truth of technology. The essence of technology – what technology actually does – is not to be found in narrowly instrumental terms as means or in anthropological expressions as human action. Heidegger draws on philosophical wisdom since the time of Aristotle. He tells us that philosophy identifies four causes: content (matter), form, end and effect. These are united by a bringing-forth, a process involving a coming to presence or, as Heidegger (1977, p. 12) prefers, revealing. This revealing is the very essence of technology. Technology, then, is a form of knowing. Its import is metaphysical, but metaphysical in two distinct senses: the denial of truth as disclosure, and the sense that every disclosure also conceals (Heidegger, 1969). What marks modern technologies as distinctive is the particular type of revealing they entail. All seek to challenge nature, to unlock, transform and store its energy. The world appears as resource, as standing-reserve (Heidegger, 1977, p. 17). Heidegger uses the word 'enframing' to describe modern technology's way of revealing the world as standing-reserve. The crucial point about enframing is not that it is a method of unveiling but that it is a method of disclosure that forgets that truth itself is a disclosure. Enframing excludes all other methods of unveiling. One of Heidegger's most famous examples concerns a hydroelectric power plant on the River Rhine. The plant sets the river to work. In earlier times bridges and mills might be built into the river, now the reverse holds: the river is built into the plant, its current challenged to deliver energy. Its hydraulic pressure turns the plant's turbines which power the machines that generate the electricity: 'even the Rhine itself appears as something at our command' (Heidegger, 1977, p. 16).

Technologies in the broadest sense (as objects, activities, knowledge, organizations and, in combination, as systems) therefore do very important things. Drawing on Heidegger, Van Loon (2002, p. 91) tells us that technology 'shows us something: it discloses a specific trajectory of a particular matter, through its formation in production, its purposeful utility in action, but also its consequences, both manifest and latent'. Technologies go to the very core of our being, shaping how we are in the world, and how the world appears to us. They frame our relationship to the environment and to each other, impacting upon our perception, cognition and interactions. At the level of the individual they make us human, and at the level of the collective they make society possible. Michel Callon and Bruno Latour (1992, p. 359) are of the opinion that 'there is no thinkable social life without the participation – in all the meanings of the word – of non-humans, and especially machines and artefacts'. Such points are elaborated throughout the book, but are particularly emphasized in Chapters 6 and 8.

To recap, technologies:

- help us adapt to or control environments
- solve problems (and create new ones)
- extend human forces and senses
- mediate between the physical world and the cultural one
- are modes of being and knowing, revealing and enframing
- are agents.

How has Technology been Theorized?

There have been a wide variety of ways of theorizing technology, change and agency. We can impose a sense of order on them by separating them into three broad schools:

- anti-humanist ones that privilege the role of technology in social explanations,
- humanist ones that privilege the role of society, and
- posthumanist ones that refuse to privilege either.

The anti-humanist approach is often referred to as 'technological determinism', where technology is taken to be the decisive force. Being the prime actor it shapes social relations and causes social change. The humanist approach is sometimes referred to as 'social constructionism'. This has tended to be the province of most social theory and of mainstream sociology. Here humans take centre stage. They are the main actors. In preference to any form of determinism the posthumanist school simultaneously considers people, technologies, companion species, non-human organic agents and environmental forces. Here agency is not located at either end of an axis labelled technology and society; instead it is distributed widely amongst all those seen as actors (see Chapter 8).

The technological determinist position has been referred to as anti-humanist because humans are a secondary consideration to technology. We might say that from this perspective it is all about the object, as opposed to other definitions such as technology as activity, technology as knowledge, technology as organization. Indeed, all of these other elements are seen as the *effects* of material artifacts. Technology structures the social. From this perspective technology is viewed autonomously, it seems to exist outside of social relations. It is a-social. It is only when the technology is introduced into society that politics come into play. All of this can be illustrated by the following quotation: 'They say that no totalitarian regime, no matter how great its political, military, or even its economic strength, can survive above a certain threshold in the density of the telephone network.

Once this threshold has been crossed, police control is no longer possible, and the totalitarian straightjacket cannot hold' (Derrida in Derrida and Stiegler, 2002, p. 72). In this example the telephone network is introduced into totalitarian society and destroys authoritarian government. It necessarily creates democracy. While technologies have strong effects (as in the example, the telephone determines an entire political system), there are no *internal* politics to artifacts. Technological determinists tend to assume that technologies exist in the form that they do because it is rational, indeed inevitable, that they do so.

There are several objections to technological determinism, prime amongst them is that you cannot abstract technology from its social context. Technologies are social through and through. They are designed, manufactured, marketed, accessed and used by humans. For these reasons they can never exist outside of society. People like Bijker and Pinch have alerted us to the internal politics of technological construction (see Chapter 5), and social issues like the ownership and control of technology are important, if not decisive. As our definitions of technology made clear, it is not just about things, but about action, knowledge, organization and systems. We also need to think about the vitally important category of use. Is a single technology used in a single way? Few scholars would say 'yes'. Multiple cultures of use can develop around the same device. Europe and North America show marked differences in patterns of uptake and types of use regarding laptops, mobile phones and PDAs (Thrift, 2005, p. 163). The same technology can be called different things in different national settings. This can speak to very different perceptions of the same technology. In the US the 'cellular' phone references technological infrastructure, in the UK the 'mobile' stresses liberation from a fixed location, while in Japan the 'keitai' (roughly 'something you carry with you') speaks neither to technological possibility nor new-found freedoms but rather to an 'intimate technosocial tethering' (Ito, 2005, p. 1). Moreover, while some of the applications and uses of technologies are anticipated by the manufacturers, the history of technology shows us that they can frequently be used for unintended and unofficial ends, as in hacking.

While it is all too easy to conflate technology with complex high-technology, Ruth Schwartz Cowan reminds us that even simple devices can be deeply problematic when transposed from their original cultural context of use to another. The original rules may no longer apply. The humble baby bottle serves as a good example. Cowan (1979, p. 52), a feminist historian of technology, has taken male technology writers to task for focussing on the complex and spectacular, in a phrase, on Big Boys' Toys:

> The indices to the standard histories of technology ... do not contain a single reference ... to such a significant cultural artifact as the baby bottle. Here is a simple implement which, along with its attendant delivery systems (!), has revolutionized a basic biological process, transformed a fundamental human experience for vast numbers of infants and mothers, and been one of the more controversial exports of western technology to underdeveloped countries – yet it finds no place in our histories of technology.

In the developing world this overlooked technology is an entirely different entity. The basic operating assumptions – that constant access to clean drinking water is guaranteed, that the bottles and teats can be properly sterilized, that the product is easily affordable and will not be watered down or withheld, that consumers are literate and can follow written instructions, and that written instructions will be in a language appropriate for the market – do not necessarily hold. The latter problem is routinely reported by organizations like the International Baby Food Action Network.

To be successful this technology requires a background infrastructure of education, health and water delivery systems – a sociotechnical complex. Only when this system is properly working can we say that consumers make informed decisions. Formal education, especially for females, is far from certain in developing countries. Subsequent education from healthcare professionals may also be compromised by the heavy lobbying of representatives of the baby formula industries eager to push their products. Aggressive marketing tactics have also been reported. New mothers are given free samples which continue up until the point at which lactation stops. Mothers are then locked in to using the technology. Dr Anahit Demirchyan, UNICEF's Armenian coordinator of the Baby Friendly Hospital Initiative, claimed that the distribution of baby formula as humanitarian aid nearly ended their breastfeeding programmes (International Baby Food Action Network). Given the educational uncertainties in developing countries it is by no means definite that those using baby bottles know that breast milk provides babies with antibodies and nutrients that infant formula does not. Conversely, as the 300 000 victims of the Sanlu Group's melamine-tainted baby formula in the Peoples' Republic of China in 2008 show (Barbosa, 2009), the notion that baby formula is as safe as breast milk can also be erroneous. This is compounded by hygiene and sanitation issues: what is the quality of the water that is mixed with the baby formula? Clean drinking water is a pressing problem for a massive proportion of the planet's population: 1.1 billion people lack water security and 2.4 billion are without basic sanitation (World Health Organization, 2009). What is essentially a lifestyle decision in the West can be a life-chance gamble for the Rest, because in countries where diarrhoea is a killer this can be the difference between life and death. World Health Organization (2009) statistics put the yearly deaths from diarrhoea at 2.2 million people, most of whom are under five years old. This accounts for 4 per cent of all annual global deaths.

As the above example showed, there is no single trajectory for a technology, or single effect. This helps to explain why technological determinism has fallen from favour. Largely discredited by the humanists, it has become a term of abuse. For humanists, it is all about the subject. Humans are centre stage. The chain of causation is thus reversed: technology is an effect, not a cause. Society structures every aspect of technology. This also challenges the technologically-determinist idea of technological autonomy. The notion that technology is a-social is rejected. Humanists oppose the ideas that technology exists as it does because it is rational and logical that it does so, and that politics only come into play after a technology is introduced into society. For them, elements of society are already impressed into technology. Technologies have embedded social relations. They incorporate competing aesthetic, design, economic, engineering, production and marketing interests. These various interests are often hotly contested. Consequently, instead of the idea of a pure technology we need to pay heed to the 'politics of artifacts' (see Chapter 4), and against the cast-iron control posited by the technological determinists we need to speak of contingency.

The insights of humanists are useful. Recent work in social constructionism has been informed by empirical case studies (see Chapter 5). It is markedly more nuanced than the older technologically-determinist literature. That said, such approaches are not beyond criticism. At the extreme end of social constructionism (what we could call social determinism) material artifacts are forgotten altogether. Everything focusses on the social. The functionality and physicality of technologies disappears. Materiality is relegated to a residual category. Technologies are merely social constructions. This means that they exert no agency of their own, they have no effects. Their significance is only symbolic. As Bruno Latour (2000, p. 112) put it, the 'thingness' of things is forgotten. This is a problem. While society is the creation of humans and is doubtlessly constructed, it is 'not just *socially* constructed' (Latour, 1994b, p. 793). Indeed, 'for a few million years, [people] now have extended their social relations to other actants with which, with whom, they have swapped many properties, and with which, with whom, they form a *collective*'. The other actants Latour has in mind here are our technologies. Technologies function beyond the symbolic realm. They give society durability. For Latour and like-minded actor-network theory thinkers, society is best conceived as a series of sociotechnical assemblages (see Chapter 6).

Thus far we are still stuck with the same binary oppositions: technology versus society. The debate is over which leads which, the technological or the social. Even Braudel (1985b, p. 68) went down this road, asking if technology was civilization's body or soul. He decided on the former. But is it correct to pose an either/or proposition? An emergent posthumanist literature argues not. Neither the social determinism of humanists nor the anti-humanism of technological determinism pass muster, as we are always

faced with a sociotechnical order. Instead, posthumanists advocate distributed agency, which is to say the idea that humans *and* technologies (and a host of others) have agency and create their own effects. Such accounts are about objects and subjects (and objects acting as subjects, and vice versa). Here humans are decentred: 'There are no humans in the world. Or rather, humans are fabricated – in language, through discursive formations, in their various liaisons with technological and natural actors, across networks that are heterogeneously comprised of humans and non-humans who are themselves so comprised' (Michael, 2000, p. 1). Posthumanists therefore transgress the technology/society binary and stress co-agency, collective production and interaction, or what Verbeek called 'coshaping'. This seems to be a useful theoretical advance in as much as it retains the technological determinists' insistence on materiality (the 'thingness of things') and the social constructionists' take on the symbolic significance of technology, accepting the agency of technologies and humans simultaneously. Technical properties and social meanings are entertained. Both, after all, are vital.

To help us understand the admittedly challenging posthumanist position we will use Mike Michael's example of the couch potato. (We will discuss posthumanism in more detail in Chapter 8, particularly in relation to 'living technologies'.) In a way, the couch potato is also a living technology. The television-watching creature that never strays far from the sofa is best seen as a collective; a heterogeneous mixing of soft human and soft furnishing with hard television and hard remote control. It is a human/couch/television/remote hybrid. All are necessary elements. Without a place to lounge you fail to qualify as a couch potato, ditto without a remote – you will have to make the walk to the television set to adjust channel or alter volume all by yourself. The remote control therefore acts in important ways. We cede a complex of bodily functions to it. It works as our legs and arms. It does our walking for us. However, it does not substitute for the body entirely because we still need our fingers to press its buttons.

Who gets to do the pressing is also of great concern. And again we have a merging of the functional and the symbolic, technical property and social meaning, the material and the social, 'body and soul'. It is illuminating to see how a household technology gets domesticated. Who has possession of the TV remote? Who decides what will be watched? What is the etiquette? Is channel surfing permissible? Does the possessor of the remote accept requests? Will he or she relinquish it on demand? Michael cites David Morley's case studies of television viewing. Overwhelmingly Morley found the 'man of the house' in control and making all of the real decisions. The remote was used as yet another tool to reinforce the privileged position of the senior male, prompting Morley to urge us to think of remotes as congealed power relations. Thus the most modest of artifacts – as with our baby bottle example – can be seen to have considerable significances.

The remote extends the human senses, it receives a delegation of bodily actions and it is a repository (and producer) of family power relations. No innocent bystander in these family dramas, the television remote is also an actor: it 'also mediates – symbolizes, crystallizes and materially affects – these relations' (Michael, 2000, p. 105).

In sum, theorists have approached technology in three broad ways:

- by privileging technology
- by privileging society
- by thinking about the mutual entanglement of technology, society and other things besides.

In thinking about technology it is a good idea to be mindful of issues like:

- ownership
- control
- access
- use
- unintended consequences.

Technology, Systems and Social Interests

People, things, activities, knowledges and organizational structures are all part of the human story. As our previous sections made clear, we need to think beyond things in isolation to things in combination, to what we have been calling sociotechnical systems, and to what Manuel De Landa (1997, p. 77) calls 'meshworks of mutually supporting innovations'. De Landa makes the point with reference to the Industrial Revolution, the age of coal, cotton, iron and steam. Why did it happen in Britain in the nineteenth century and not Germany in fifteenth-century Lübeck or Cologne with their mining industries and system of large-scale credit, or in Italy given Milan's booming textiles and its links to commercialized agriculture? De Landa's conclusion is that technological artifacts in and of themselves do not suffice. The successful positively-reinforcing interactions of institutions, skills, processes and systems are vital. Britain could sustain its industrial take-off while Germany and Italy could not because it had upskilled its population through industrial espionage and the importation of expert labour. This created a reservoir of skill. Big business and the new technological artifacts were additionally catalyzed by a national market, a secure financial system of banking and credit, long-established global networks of trade (including colonial acquisitions), and an expanding agricultural sector which could in turn feed the growing population which was the very source of labour and skills.

An important lesson is to be drawn: technologies can not be abstracted from the environments which they help to create. This systemic focus helps us to understand why technical efficiency is not enough. Contrary to common sense, the best-designed technology does not necessarily win. Writing on Alexander Graham Bell's invention of the telephone, Bruce Sterling (1994, p. 6) tells us that it succeeded, not because it was an obvious technical improvement upon rival systems like telegraphy, 'but ... due to a combination of political decisions, canny infighting in court, inspired industrial leadership, receptive local conditions, and out-right good luck'. He says that the same holds for more recent communications systems. There is nothing inherent in any technology to guarantee success. Matsushita's VHS triumphed over Sony's Betamax format video-cassette recorder, yet it was widely held that the latter was technically superior. If our spotlight focussed on the technological artifacts alone this would make no sense. But if we broaden our vision beyond technologies as objects to see the wider context of the consumer electronics market (and the heavy competition between Japanese and Pacific Rim producers) we can see why Betamax lost market share: a number of Sony's rivals supported Matsushita and refused to release films in Sony's format. This is sometimes referred to as the bandwagon effect. In this case they ensured that VHS was locked in as the industry standard (Du Gay et al., 1997, p. 76). We could also add the knock-on network effects as video renters and retailers observed the increasing demand for VHS. Noticing this they stopped stocking Betamax machines and video cassettes for which profitability was declining. Here we need to remind ourselves that politics are not only a matter of concern during the production of material artifacts – *they could be different* (Bijker and Law, 1992b, p. 3) – but also in terms of advertising, marketing, distribution and uptake. Power, capital and the ability to persuade are ongoing considerations, and they are central to technological triumph.

The ways in which 'our' decisions about the technologies we adopt are actually shaped by a series of prior decisions is known as path dependency. This impresses upon us the importance of events removed from us by time (history) and the potentially self-reinforcing nature of events (positive or negative feedback, or what we just called the bandwagon effect). This explains why your computer keyboard begins with the letters QWERTY when the alphabet begins ABC. They are 'governed by other laws than those of chance' as Foucault (2002, p. 96) wrote. Today's computer keyboards are arranged as they are because of the typewriter layout of the 1890s. The early typewriters were temperamental creatures. Typebars would jam if the keys were hit in quick succession. To minimize this inconvenience frequently used letters were spaced out across the keyboard. The result of this experimental work was the QWERTY keyboard, produced by Remington. This had the additional marketing merit that the product name could be typed easily by travelling salespersons wanting to impress: the word 'typewriter' uses only the keyboard's top row. Engineering advances soon meant that typewriters did not need the QWERTY keyboard layout. However, it strengthened its dominance against rival layouts and became the standard because keyboard design was part of a bigger, technically entwined organizational matrix (David, 1985, p. 334). The operators were used to the QWERTY layout, as were the training establishments geared to their instruction, particularly so following the advent of touch-type training which was tied specifically to Remington's machine. The need for software (training, technique) and hardware (keyboard) compatibility became paramount. Typists did not want to waste time learning several different keyboard arrangements and employers did not want to waste money buying different models of typewriter.

Finally, the stress on dynamics, relations and exchanges – on seeing things in their combination – is valuable because it moves us away from thinking about the isolated genius, the lone heroic (usually male) inventor, and technology as fixed and stable entity. Instead, as David Spitz and Starling Hunter (2003, p. 1) suggest, we should conceptualize technology as 'ongoing encounter'. Who created the file-sharing program Napster? The standard answer is Shawn Fanning, an eighteen-year-old college drop-out. But, Fanning had help. He was assisted by his friend Sean Parker for the beta release of the software. That they could even develop something like Napster also presupposed the existence of a properly working background infrastructure. The existence of the internet is a given. In addition, they required the existence of the MP3 digital audio encoding format. Fanning also confessed to direct influence from internet relay chat (IRC) rooms. 'In fact, the closer "his" concept came to "thing-ness" the more social it became' (Spitz and Hunter, 2003, p. 5). Websites announced the beta release, which had been modified by early users, and Download.com hosted the program. Opinion is divided as to whether or not Napster even worked at this point in time. Its final success was due to a combination of factors: Fanning, Parker and their investors, a community of engaged users who helped eliminate bugs and improve upon the product, the existence of MP3s, IRC and peer-to-peer networks, Download.com and legal loopholes created by the Digital Millennium Copyright Act (Spitz and Hunter, 2003, p. 6). Once again we see that the actors are people and things, and that success rests on the combination of people, skill sets, artifacts and modes of organization. Such actor networks are the topic of discussion in Chapter 6.

To extend our knowledge of technology we should:

- think beyond the lone genius inventor
- include considerations of power, capital and the ability to persuade – they are all important factors in technological success

- look to the positively reinforcing interactions that sustain sociotechnical systems
- appreciate previous events (that past informs the present) and their potentially reinforcing nature (positive or negative feedback).

Our Times: Technology, Complexity and Risk

It is commonplace to argue that our technologies are more open, more fluid, more interdependent, and more complex than ever before. In consequence, we struggle to comprehend them. Jean Baudrillard (2005, p. 124) asserts that we are all 'Sunday drivers', entirely mystified by our technologies. Jacques Derrida (Derrida and Stiegler, 2002, p. 57) raises the same concern: we lack the ability to comprehend the very technologies that constitute our environment. We are useless in the face of modern technologies. For Derrida this is a root cause of today's existential struggles. While this state of affairs is worrying in itself, anxiety levels are further increased by the growing recourse to technology as the solution to seemingly any problem (Bauman, 1993, p. 187). In everyday talk this is referred to as the 'technological fix', the ready resort to technology, indeed the proffering of technology as the only source of legitimate action.

While we have noted the problem-solving nature of technology, and our baby bottle example introduced its problem-creating potential, we have no idea if a technology is a help or a hindrance until we see it used in a concrete context. Disjunctures between intention and outcome present with technologies as with everything else. The unintended consequences of human activity are long familiar to sociologists. Peter Berger elaborates, telling us that sociologists understand history as something more than the triumph of collective will or the rule of great ideas. For example, the notion of unanticipated outcomes is a recurring motif in the work of early sociologist, Max Weber. In *The Protestant Ethic and the Spirit of Capitalism* Weber noted the linkages between religious and economic practice. Calvin's doctrine of predestination led people to act ascetically in all aspects of life, especially economic life. This, he argued, gave rise to the ethos of capitalism, something that the founders of the Calvinist Reformation never envisaged. 'In other words, Weber's work … gives us a vivid picture of the *irony* of human actions' (emphasis in original) (Berger, 1968, p. 52). Technological examples of this abound. When the British Royal Commission on the Automobile convened in 1908, the biggest predicted problem was dust from unmetalled roads (Collingridge, 1980, pp. 16–17). No one predicted that it would supercharge teenage sexuality, destroy the inner city, kill and maim more people than firearms or give us a range of contemporary ailments from gridlock to road rage. Edward Tenner (1996) calls the unforeseen negative aspects of technology their 'revenge effects'.

Suffering, like privilege, is distributed unevenly, and sociologists also ask which groups bear the brunt of these revenge effects. Sticking with our automobile example Ian Roberts (2003) asserts that it is the young rather than the old, the poor rather than the rich, the people of the global south rather than the north, the pedestrian rather than the driver that pay the price: 'Every day about 3,000 people die and 30,000 people are seriously injured on the world's roads in traffic crashes. More than 85% of deaths are in low and middle-income countries, with pedestrians, cyclists and bus passengers bearing most of the burden. Most of the victims will never own a car, and many are children'.

Bryan Wynne (1988) offers us no comfort. His work shows us that even the experts might be at a loss to determine the consequences of any technologically-mediated activity, and these days most activities are technologically-mediated, which explains the growing interest of technology in social theory. Wynne considers several cases – the Challenger space shuttle disaster, the handling of highly toxic methyl isocyanate (MIC), fire aboard a passenger jet, leaks of radioactive gas at a nuclear power plant, and a methane explosion at a water pumping station – none of which he takes to be exceptional. He argues that experts work under greater ambiguity than is ordinarily supposed, particularly when they are involved with diffuse multi-sited systems. The bulk of our technologies are precisely these complex and interlinked systems (they are 'extensive' and 'open-textured' in his terminology). It is commonly believed that we have rules and then practices. The idea that we normally have a system in which devices, power sources and people operate with a shared logic of rational, rule-bound expected behaviour is refuted. Gaps exist between technology in theory (design and rational planning: what it *should* do) and technology in practice (use and emergent rule-making: what it *actually* does). The latter is never a final accomplishment; it always remains an ongoing process or what Spitz and Hunter called an ongoing encounter. These practices of contextualization and informal rule development impact upon the technology, complicating notions of risk. As Wynne sees it, technologies are 'normalized' through unanticipated developments, and accidents are the events which bring normal technology into question.

In the case of the Challenger space shuttle, NASA was fully aware that some components and subsystems were not in proper working order. This had been the case with previous missions, none of which came to a catastrophic end. The Challenger explosion was caused by leaking O-ring seals on the solid rocket boosters. Earlier launches demonstrated thermal stressing of the O-rings and leak paths in the surrounding insulation. In fact it was widely agreed that the O-rings had never performed as they should. They were frequently burned or broken and they were liable to leak. Their performance was acceptable as opposed to optimal. Many other components were not working to script. The result was that notions of safety

shifted. What was taken to be safe was negotiated informally in-house. Observable failures were a matter of ongoing debate, but it was agreed (wrongly in hindsight) that all failures were within acceptable limits.

Wynne identifies three elements of technological normalization: institutional, contextual and systemic. First, as the work of organizational sociologists has demonstrated, organizations develop working routines and rules that are frequently at odds with official organizational norms. The NASA example is pertinent here. Second, technologies work in concrete and complex circumstances, including ones for which they were never originally designed (our baby bottle discussion serves as a good example of this). Slippage can occur between various contexts of use as technologies are adapted for local conditions. Third, slippage is exacerbated in the case of large-scale systems where contextualization may only be partial. For example, parts are absorbed (or not) into the local regulatory structures and because of this the overall operating system is fragmented. When we have cross-cutting rationalities we have the potential for yet further problems. Wynne cites the case of a French factory that was storing and distributing MIC, the chemical responsible for thousands of deaths in Bhopal when it leaked from a Union Carbide plant. Bhopal is regarded as one of the world's worst industrial disasters. Stringent safety procedures for dealing with the chemical were introduced in its aftermath. While the factory was exercising due care, at another point in the sociotechnical system (the port in Marseilles) the MIC was being processed as if it were any other substance. The dockworkers were used to standardized productivity-based pay and so they were unloading it as quickly as possible when extreme care was required. In conclusion, Wynne (1988, p. 149) thinks that we should see 'technology as a form of large-scale "real-time" experiment' which enmeshes us all. Put another way, it is an accident waiting to happen.

While all eras have known natural disaster, the industrial epoch ushers in the time of the mass accident, these being the very consequence of our technological achievements. Indeed, '[o]ne might say that the more civilized the schedule and the more efficient the technology, the more catastrophic its destruction when it collapses. There is an exact ratio between the level of technology with which nature is controlled, and the degree of severity of its accidents' (Schivelbusch, 1986, p. 131). Paul Virilio (2003a) has pushed this thinking even further: to his mind a full understanding of our history and our technology is not possible without coming to terms with the accident. Whenever we invent a new technology we also invent the possibility of unintended and unfortunate outcomes. The invention of the ship creates the shipwreck, the invention of the airplane the plane crash. Invention spawns catastrophe. Virilio feels that this proliferation of disaster has created conditions of deep unease. The twentieth century was marked by mass-produced disasters, with signal events like the sinking of the unsinkable Titanic (1912) and the meltdown of Chernobyl's nuclear reactor (1986) which had been celebrated under the title of 'Total Safety' in the previous month's edition of *Soviet Life*. Industrial accidents – whether on land, water or in the atmosphere – continue, and these are supplemented by new postindustrial accidents in genetic and information technology. Such events move us towards what Virilio calls the 'generalized accident'. This condition is best symbolized by the attacks on the World Trade Center on 11 September 2001:

> Indeed, not to use weapons, not military instruments, but simple vehicles of air transport to destroy buildings, while being prepared to perish in the operation, is to set up a fatal confusion between the attack and the accident and to use the 'quality' of the deliberate accident to the detriment of the quality of the aeroplane and the 'quantity' of innocent lives sacrificed, thus exceeding all limits previously set by religious or philosophical ethics. (Virilio, 2003a)

Ulrich Beck makes related points. His thinking about risk society also includes 'risk technologies'. Beck (2004, pp. 30–1) notes the shift from local to global technological risks with the transition from first to second modernity. He defined first modernity as: social relations founded on the collective, full employment, a bounded nation-state and the relentless exploitation of nature. Under first modernity the effects of risk were limited to clearly defined temporal and spatial domains (Beck, 2004, p. 115). Second modernity is marked by the opposite traits: individualization and fragmentation, growing unemployment, globalization and environmental catastrophe (Beck, 2000, p. 18). Gene technology, human genetics and nano-technology are all examples of global risks. '[B]ecause such risks are systematic, they change the concept of risk, from one of probability to one of radical uncertainty' (Beck, 2004, p. 31). They are difficult to contain or demarcate, generic and porous. In these respects the Chernobyl reactor meltdown is the exemplar of contemporary risk. It affected a poorly-defined community spread over an ill-defined territory over an imprecise time period (Beck, 2004, pp. 115–17). Chernobyl burst through all earlier attempts at defining risk. Its consequences were unbounded. This is 'modernity radicalized' (Beck, 2004, p. 115). New risks, then, gather communities separated by time and space. They are unpredictable, uncontrollable, unavoidable and uninsurable (Beck, 2004, p. 131). Beck (1997, p. 23) believes that these risks and their very real dangers now drive the motor of social change.

Technology is a major source of social anxiety:

- modern technologies are extensive and open-textured, even experts may struggle to master them
- the intended outcomes for technology might not work out in reality

- technologies are real-time experiments, they have revenge effects, they are accidents waiting to happen
- ours is a world of technologically-induced global risk.

Conclusion

We began by discussing the ubiquity of technology, it seems to be everything. To understand this 'hazardous' concept we suggested thinking about it in four ways: as artifacts, activities, knowledge and modes of organization. We also noted the connections between various forms of technology, stressing the ensemble, the sociotechnical system. How a sociotechnical system works out, indeed *if* it works out, will depend in large measure upon background infrastructures and cultures of use. This in turn is shaped by social interests (current and historic), the operations of power, and the context in which the technology is concretized. We need to be mindful of the politics of technological construction, ownership, operation and regulation. Any technology could have evolved differently. The form that technology takes is the outcome of contestation, including that between social classes (considered in the next chapter) and between the limitless human imagination and those constraints imposed by the laws of nature.

Further Reading

The most comprehensive hard-copy overview of the field is Rayvon Fouché's (2008) edited 4-volume series *Technology Studies* (London: Sage) containing 62 applied and theoretical pieces by authorities in the field. Authors include: Ruth Schwartz Cowan, Jacques Ellul, Jürgen Habermas, Donna Haraway, Martin Heidegger and Steve Woolgar. The series is organized around several themes: theorizing technology, technological change, technological politics, and technology and culture.

It is perhaps overstating the case to argue that Humphrey Jennings' (1995) *Pandaemonium* (London: Papermac) should be seen as England's *Arcades Project* (see Chapter 3) but it does deserve to be regarded as a classic in its own right. Jennings furnishes us with first-hand accounts of the Industrial Age, or, as he phrases it in the book's subtitle, *The Coming of the Machine As Seen by Contemporary Observers*. Chronologically ordered, the earliest entry in the book dates from 1660 and the latest is from 1886. The organizing themes are: observations and reports, exploitation, revolution and confusion.

David Edgerton's (2006) *The Shock of the Old* (London: Profile) is the best book-length study of the mundanity of technology.

Thomas P. Hughes is obligatory reading for those wanting to gain purchase on the idea of technologies as sociotechnical systems. See his 1983 work *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: Johns Hopkins University).

Nelly Oudshoorn and Trevor Pinch's (2003) book *How Users Matter: The Co-construction of Users and Technologies* (Cambridge, MA: MIT Press) brings together a number of authors. These case studies show the agency of users, highlighting their ability to affect all aspects of technology from design right through to application.

Those interested in gender, technology and development are well served by a Sage journal of that name.

Two articles that deal with technology and development in relation to the digital divide are Tim Bunnell's (2002) 'Multimedia Utopia? A Geographical Critique of High-Tech Development in Malaysia's Multimedia Super Corridor', *Antipode*, 34(2): 265–95, and Melissa Gilbert et al.'s (2008) 'Theorizing the Digital Divide: Information and Communication Technology use Frameworks among Poor Women Using a Telemedicine System', *Geoforum*, 39(2): 912-25.

Michael Adas' (1989) *Machines as the Measure of Men: Science, Technology and Ideologies of Western Dominance* (Ithaca: Cornell University Press) offers a historic analysis of race and technology in the context of Western colonialism.

Contemporary accounts of race, racism and technology can be found in Paul Gilroy's (2001) 'Driving While Black', in Daniel Miller's (ed.) *Car Cultures* (Oxford: Berg), pp. 84–104, and Thuy Linh N. Tu et al.'s (2001) reader *Technicolor: Race, Technology, and Everyday Life* (New York: New York University Press).

Judy Wajcman's (2004) *TechnoFeminism* (Cambridge: Polity) is a good starting point for entry into the topic of technology and gender. It includes a discussion of feminism, technology studies and gender in the virtual world. Linda Layne et al.'s (2010) *Feminist Technology* (Champaign: University of Illinois Press) takes a critical look at technologies that are specifically designed for, and sold to, women.

Steve Redhead's (2004) *The Paul Virilio Reader* (Edinburgh: Edinburgh University Press) is a good starting point for those interested in Virilio's thoughts on technology. It collects 20 of Virilio's works from across his career, finishing with 'The Museum of Accidents'.

2

Marx, Modernity and the Machine

For most sociologists Karl Marx's work marks the beginning of serious systematic social theory. He regarded technologies as indices of social and economic relations. Marx was amongst the first to think through the consequences of the Industrial Revolution. He had admiration for the things that technology could do and contempt for what it was used to do. Machines were dictating the pace and pattern of modern economic life. Where workers had once been in charge of tools, machines now took charge of them. Under capitalism technological innovation was strongly connected to worker domination. Indeed, technologies helped to reproduce a social order that benefitted the ruling class by exploiting the working class. Marx's political project was to harness technology for truly human ends, not for narrow class advantage. In this chapter we begin by acknowledging Marx's novel intervention in modern social thought before looking at the topics of industrial technology, subjectivity in machine culture and technological determinism. Following this we look at two theoretical traditions that extend the work of Marx: the Frankfurt School who apply his insights on industrial production to the realm of cultural production and consumption, and the labour process school. Here we take a single study, David Noble's examination of the introduction of numerical control technology into the American manufacturing industry.

The Material Turn

Karl Marx's writings were heavily influenced by Enlightenment thought. The stimulus for the Enlightenment was born of advances in the physical sciences and the belief that a better society could be built: the future, as opposed to the past with its lingering traditions and superstitions, should