CHAPTER 1

The Anthropology of Technology: The Formation of a Field

Introduction

Maja Hojer Bruun and Ayo Wahlberg

> Technology, defined anthropologically, is not material culture but rather a *total* social phenomenon in the sense used by Mauss, a phenomenon that marries the material, the social and the symbolic in a complex web of associations.
> —Bryan Pfaffenberger, *Fetishised Objects and Humanised Nature: Towards an Anthropology of Technology*, 1988, p. 249

> Technology embraces all aspects of the process of action upon matter, whether it is scratching one's nose, planting sweet potatoes, or making jumbo jets … technologies are—like myths, marriage prohibitions, or exchange systems—social productions in themselves.
> —Pierre Lemonnier, *Elements for an Anthropology of Technology*, 1992, pp. 1–2, 11

> The shift from the classical concept of *tekhnê* to the modern concept of technology has brought about a profound change in the way we think about the relation between human beings and their activity. The image of the artisan, immersed with the whole of his being in a sensuous engagement with the material, has given way to that of the operative whose job it is to set in motion an exterior system of productive forces, according to principles of mechanical functioning that are entirely indifferent to particular human aptitudes and sensibilities.
> —Tim Ingold, *Eight themes in the Anthropology of Technology*, 1997, pp. 130–131

M. H. Bruun (✉)
Department of Educational Anthropology, Aarhus University, Aarhus, Denmark
e-mail: mhbruun@edu.au.dk

A. Wahlberg
Department of Anthropology, University of Copenhagen, Copenhagen, Denmark
e-mail: ayo.wahlberg@anthro.ku.dk

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> Once seen as producing worldwide homogenization and generalized acculturation, cosmopolitan science and technology are now viewed in terms of their real or potential contribution to the formation of hybrid cultures and to processes of self-affirmation of their selective and partially autonomous adoption. … [N]ew languages are needed that allow different groups of people (experts, social movements, citizens' groups) to reorient the dominant understanding of technology.
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> —Arturo Escobar, *Welcome to Cyberia: Notes on the Anthropology of Cyberculture*, 1994, pp. 215, 221

Anthropos and *techne* are inseparable when it comes to the study of humans and their societies. From its very origins as a discipline, anthropology has recorded and researched human-technology interfaces in efforts to account for and understand forms of social organisation and practice as well as systems of belief and meaning throughout the world. Whether approached in terms of the tools and dexterous capabilities that were seen to separate humans from other species or the technical systems that allowed for subsistence and the reproduction of society, human ingenuity and practice involving the development and use of various kinds of technologies has been a definitive object of ethnographic inquiry.

Today, two decades into the twenty-first century, anthropological approaches to studying technology are thriving. In this Handbook, we have brought together 39 chapters to demonstrate that while there is no single 'anthropology of technology', there is a set of approaches that constitutes a field of enquiry. This field is informed by just over a century of anthropological thought, the history of which illuminates as much the changing landscapes of technological advance as it does the anthropological theories that have been used to make sense of technologies in development and use. We begin this chapter by cataloguing a plethora of definitions of technology, each of which has informed this collection in different ways. From there, we provide readers with a historical exposé that takes us from early evolutionary studies of technology via critiques of it by those who championed diffusionist understandings to more contemporary notions of socio-technical systems and infrastructures. With the advantage of digital search technologies and global journals, our view of the history of the place of technology in the discipline is shaped by technology itself. Once we have situated the anthropology of technology historically, we move on to explain the logic of how we have structured the chapters that follow. Finally, we end this introduction by recapitulating why it remains so relevant and important to mobilise anthropological studies of technology at the present time.

The Handbook is organised around what we see as some of the most important characteristics of anthropological studies of technology, often in dialogue with work in archaeology, sociology, history, political science, and, not least, science and technology studies (STS). Our four thematic sections are dedicated to: (1) the diverse knowledge practices that technologies involve and on which they depend; (2) the communities, collectives, and categories that emerge

around technologies; (3) anthropology's contribution to proliferating debates on ethics, values, and morality in relation to technology; and (4) infrastructures that highlight how all technologies are embedded in broader political economies and socio-historical processes that shape and often reinforce inequality and discrimination while also generating diversity. Importantly, all sections and chapters share a commitment to fieldwork, perhaps not always in a conventional sense but always with a focused attention to experiences, embodiments, practices, and materialities in the daily lives of those people and institutions involved in the development, manufacturing, deployment, and/or use of particular technologies. While the Handbook's four thematic sections all have separate introductions, in this opening chapter the perspectives, fields, and approaches covered in the Handbook's first section are woven into our account of the gradual formation of 'anthropology of technology' as a field of enquiry.

Technology and Techniques

Colloquially, technologies are understood as artefacts. This foregrounds their material existence, origin, creation, and use. In classic ethnographies of the introduction and adoption of new or 'foreign' technologies in new settings (e.g. Sharp 1968[1952]; Godelier and Garanger 1979), artefacts like stone and steel axes are singled out and described, at times in deterministic, evolutionary ways. To this day, in popular accounts, technologies are often disembedded from the social and from human bodies, as they come to 'stand out' materially. Perhaps this is because there are still too few narrative repertoires that allow for the weaving together of technology and social relations into integrated wholes, since it would require us to abandon modernity's divide between technology and society (cf. Latour 1993). Or is it because there *is* something immanent in technologies that either lends them special, magic powers (Gell 1992), or makes them disappear, like Heidegger's (1973[1927]) ready-to-hand hammer, which only appears when it breaks down, Merleau-Ponty's (2002[1945]) blind stick or invisible infrastructures (Star and Ruhleder 1996)?

While sociologists or historians of technology usually study the development of a product or innovation in modern science or engineering (e.g. Bijker et al. 1987; Bijker and Law 1992; Bijker 1995; Hughes 1983), and most technical sciences do not consider anything else as technology, anthropologists have worked according to a wider concept. This breadth is reflected in our Handbook, with chapters covering basket-weaving techniques, reproductive technologies, technologies of beauty, and technologies of government. Anthropologists and archaeologists have always shared an interest in the most mundane and taken-for-granted *things* of everyday life, and studied these as technology or material culture: typically baskets, pots, hoes, arrows, or other tools, not to forget pipettes, smart phones, and cars. At the same time, however, anthropologists have recorded a multiplicity of contemporary human technological practices involving all kinds of ephemeral activities and perishable materials that do not leave traces for archaeological excavation. What counts as

technology in particular contexts and for whom are some of the open questions that are brought to various fields of study and fieldwork sites.

Anthropologists have provided several useful definitions of technology that emphasise that if we are to understand technologies, we must go beyond the artefacts and include human bodies, skills, traditions, practices, processes, and socio-technical systems when conceptualising them. We selected four contrasting quotes to open this volume for the distinct perspectives on technology that they offer, founded in three distinct anthropological traditions in France, the United Kingdom, and the United States. These distinctions can be partially understood through the way the terms 'technique' and 'technology' are used in French and English.

In his 1994 encyclopaedia entry on technology, François Sigaut discusses the terms systematically and defines techniques (the preferred term in French anthropology) by referring to Marcel Mauss's proposition: 'We call techniques an ensemble of movements or actions, in general and for the most part manual, which are organized and traditional, and which work together towards the achievement of a goal known to be physical or chemical or organic' (Mauss 2006[1941/1948], p. 149). Those aspects of technology that relate to bodily movements and material actions implicated in techniques often escape the attention of Anglo-American scholars because of the modernist connotations of 'technology' in English (Sigaut 1994; cf. Schlanger 2006). Here, the concept of technology usually refers to the achievements of modern engineering, 'in short, those techniques that are informed by a relatively scientific content and methods' (Sigaut 1994, p. 422).[1] This understanding of technology, as Nathan Schlanger (2006) points out, leads to a hierarchical, or hierarchising, difference between the 'technical' and the 'technological'. In this hierarchy, 'techniques' and 'technical' skills apply to phenomena that are traditional, small-scale, or tacit, while 'technology' refers to phenomena deemed modern, complex, and sophisticated. In this sense, 'technology' did not exist in so-called pre-modern societies, only 'tools' and technical skills. Think, for example, of the difference between basketry techniques and ballistic technology.

Mauss was the first to suggest that there is something fundamentally non-technical about technology. He argued that technology needed to be put back on the research agenda of the social sciences after its confinement to a marginal position during the formation of the modern sciences of the social (Schlanger 2006). Although Mauss had already in his work on religion and magic compared magic and techniques, both of which are *actes traditionelles efficaces* (Mauss 1903; passim in Schlanger 2006, p. 15), it was only after his personal experiences as a soldier during the First World War, and the general recognition of the powers of modern war technologies that followed from the war, that he formulated an explicit programme for the social study of technology. His essay on techniques of the body (2007[1935]) remains the most widely known. Here his point was that there are techniques which do not require extra-somatic instruments, while they always require the body: 'The body is man's first and most natural instrument' (2007[1935], p. 56). Just as importantly, however, as

Sigaut noted, Mauss pointed out that techniques are an ensemble of movements or actions that are organised (sometimes translated as 'effective') and traditional, which here means that they must be learned, taught, and transmitted in collective contexts, either as habitus or through oral transmission. Moreover, techniques are goal oriented, and 'they are felt by the author as *actions of a mechanical, physical, or psycho-chemical order* and … they are pursued with that aim in view' (2007[1935], p. 56). This is the Maussian legacy on which the French anthropologist Pierre Lemonnier (1992, 1993, 2012) builds in his anthropological theories of technology. He argues that techniques *as material actions* are always themselves social phenomena and are always systemic in that all techniques involve the five interacting elements of matter, energy, objects, gestures, and knowledge. This in turn obliges the ethnographer to follow and document the material and social processes that form, for example, through gardening, hunting, farming, building eel-traps, canoes, or smartphones (Lemonnier 2012).

Somewhat in contrast, Tim Ingold has argued that, rather than techniques of the individual body, anthropologists should empirically foreground *skills* through an 'ecological approach, which situates the practitioner … in the context of an active engagement with the constituents of his or her surroundings' (Ingold 1997, p. 110). For Ingold, skills involve the qualities of care, judgement, and dexterity. Hence, he argues that we must attend, conceptually and methodologically, not to techniques (of the body) but to 'making'. A mix of improvisation and imitation, making arises within the form-generating potentials of complex processes of skilled movement. At the same time, as we saw in one of the epigraphs to this introduction, like Sigaut and Schlanger, Ingold too affirms that 'technology' has come to denote modern society's control over nature, adding that to use the term technology is not only to denote a thing but to make a claim: 'technology [is] the means by which a rational understanding of [the] external world is turned to account for the benefit of society' (2000, p. 312). He points out that the images invoked by contemporary uses of the concept of technology—of operators rather than artisans and of exterior mechanisms rather than embodied skills—impact profoundly on the way we allow ourselves to think about technology and technology's role in society (see also Bunn this volume).

Coming from American cultural anthropology, and with an Anglo-Saxon understanding of technology as operative systems, Bryan Pfaffenberger (1988) has argued that anthropologists should focus on interwoven socio-technical systems and systems of meaning. In his 1992 *Annual Review of Anthropology* article on the anthropology of technology, Pfaffenberger introduces the then 'emergent field known as science and technology studies (STS)' (1992a, p. 493) to a broader anthropological audience. In doing so, he draws a parallel between Mauss's 'total social phenomena' and Thomas Hughes's 'sociotechnical system' (1987). While Hughes and other Social Construction of Technological Systems (SCOT) scholars (see Bijker et al. 1987) had already showed that a successful technological innovation depends on the 'seamless'

(i.e. indissolubly linked) integration of technical, social, economic, and political aspects, Pfaffenberger argued that socio-technical systems are *also* embedded in culture, in ritual and mythic narratives. In this view, 'to construct a technology is not merely to deploy materials and techniques; it is also to construct social and economic alliances, to invent new legal principles for social relations, and to provide powerful new vehicles for culturally-provided myths' (Pfaffenberger 1992a, p. 249).While Pfaffenberger formulated a programme for a new STS-inspired anthropology of technology, others would in a sense invert this programme when taking anthropology to STS, generating a string of post-structural analyses of emerging technologies (e.g. Escobar 1994; Martin 1994; Rabinow 1996; Franklin 1997; Downey and Dumit 1997a). In the 1960s to 1970s, the interdisciplinary field of science and technology studies was dominated by the history, philosophy, and sociology of science. However, by the late 1970s and throughout the 1980s, two turns in STS brought this field together with anthropological studies of technology. A series of ethnographic studies of and in laboratories (Knorr 1977; Latour and Woolgar 1979; Traweek 1988), introduced anthropological methods to STS, along with methodological approaches to the cultures, practices, and social relations in the making of scientific facts that have gained influence over the years to form a 'practice turn' or 'empirical turn' in STS (e.g. Mol 2002). In the same period, a 'turn to technology' occurred in STS (Pinch and Bijker 1984; MacKenzie and Wajcman 1985; Akrich 1992; De Laet and Mol 2000) that also drew anthropologists interested in technology (e.g. Pfaffenberger 1988, 1992a). As the chapters in this handbook show, many scholars working with different anthropologies of technology are equally committed to both anthropology and STS, and many debates and research environments overlap.

Working at the intersections of anthropology and STS, Arturo Escobar went on to reformulate anthropological definitions of technology when arguing 'that human and social reality is as much a product of machines as of human activity, that we should grant agency to machines, and that the proper task for an anthropology of science and technology is to examine ethnographically how technology serves as agent of social and cultural production', while at the same time insisting that anthropologists 'start paying attention to Third World technological innovation' (Escobar 1994, pp. 216, 221). Finally, Pfaffenberger's notion of a socio-technical system would also, as we will see, go on to inform anthropological conceptualisations of infrastructure systems (Larkin 2013; Harvey et al. 2017; Anand et al. 2018; Abram et al. 2019).

These different anthropological approaches to conceptualising technology are often seen as in contradistinction to each other. However, it is our contention that it is exactly this multiplicity of approaches that has contributed to the thriving anthropologies of technology that are on display in the chapters that follow. What these approaches to the anthropological study of technology enable is a kind of analytical and methodological scaling on the part of the ethnographer, who can choose to focus on the embodied skills, on the practices/material actions, or on the larger socio-technical systems which *together*

make up technologies in different parts of the world. Let us now turn to a historical account of how anthropological understandings and ethnographic studies of technology have changed over the past century.

Evolution Versus Diffusion

Any history of the way anthropologists have studied technologies must grapple with its colonial and racist legacy, not least since technology was given a specific marking role in the early evolutionary theories developed by nineteenth-century anthropologists. In *Ancient Society*, Lewis Henry Morgan (1877) shows how material technologies were considered both engine and marker of civilisation when he posits a 'natural as well as necessary sequence of progress' through a savage (subdivided into lower, middle, and upper), a barbarian (also subdivided into lower, middle, and upper), and finally a civilised stage. Distinguishing each of these stages, he argued, was an evolving complexity in discoveries, inventions, and arts of subsistence, starting with 'knowledge of the use of fire', through 'the invention of the Bow and Arrow', 'the cultivation of maize and plants by Irrigation', and 'the invention of the process of Smelting Iron', culminating in 'the invention of a Phonetic Alphabet' (Morgan 1877, p. 3, 12; see Ingold 1997). Throughout the nineteenth century, European and American natural historians, archaeologists, and anthropologists endeavoured to 'divide mankind into large families and subdivisions [in order] … to establish a description of them, in as concise terms as the Botanist, when he examines the plants of a certain region' (Ethnological Society of London 1848, p. 3; see Blumenbach 1865; Lubbock 1875; Ratzel 1896), not least by collecting and cataloguing the 'material culture' they encountered during their travels in the form of artefacts, tools, and decorative objects. The classificatory principle underlying such cataloguing suggested development from simple artefacts towards more and more complex technologies. Perhaps most famously, British archaeologist and anthropologist Augustus Pitt Rivers would apply this evolutionary 'doctrine of development of species' in his extensive 'development-series' museum collection displays of 'implements, appliances, and products of human life, such as boats, looms, dress, musical instruments, magical and religious symbols, artistic decoration, and writing' (Tyler 1901, p. 269).

While dominant and pervasive, the evolutionary schema of the late nineteenth and early twentieth centuries did not go unchallenged in its own time. As early as 1885, Haitian anthropologist Anténor Firmin firmly rejected its overtly racist premises when setting out his vision for a 'positivist anthropology' in *The Equality of the Human Races*. Marking an 'epistemological break' in anthropological thought and laying the groundwork for modern ethnography, Firmin argued that 'all men are endowed with the same qualities and the same faults, without distinction of color or anatomical form', thus defining anthropology as 'the study of Man in his physical, intellectual and moral dimensions as he is found in any of the different races which constitute the human species' (Firmin 2000[1885], p. 405, cited in Fluehr-Lobban 2000, pp. 449,

451). Firmin received his legal training in Haiti, only moving to France following political unrest in 1883 where he became a member of the Société d'Anthropologie de Paris. While his rejection of evolutionary thought was initially silenced by colleagues at the Société (see Magloire-Danton 2005, pp. 194–195), by 1902, in a lecture on the history of religions, fellow anthropologist Marcel Mauss would publicly concur, stating that 'there are no uncivilized peoples, only peoples with different civilizations' (1902, p. 43).

In the United States, German-born anthropologist Franz Boas would likewise reject evolutionary theory, arguing that 'articulate language, the use of implements, and the power of reasoning belong to all members of the human species as opposed to the higher animals' (Boas 1921, p. 247). He based this claim on anthropological studies among Inuit groups on Baffin Island (1883–1884) and the Kwakiutl people (1886–1890) of the Pacific Northwest Coast in Canada. And finally, in Britain, Cambridge neurologist William H.R. Rivers, who famously stumbled into anthropology upon accepting Alfred C. Haddon's invitation to join his Torres Strait Islands expedition in 1893, also ended up rejecting evolutionary theory halfway through writing his two-volume analysis of Melanesian society. Rivers pointed out that he had travelled to Melanesia 'as a firm adherent of the current English school, being almost exclusively interested in the evolution of belief, custom and institution, paying little attention to the complexity of individual cultures … [until] at a definite point in my argument, I was led to see that Melanesian society is complex' (Rivers 1914, pp. 1–2). And so, by the early twentieth century, the task of Euro-American socio-cultural anthropology was no longer to hierarchise different human societies according to 'growing intelligence through inventions and discoveries' (Morgan 1877, p. 12); rather, it was to describe ethnographically the *different* 'modes of life' that could be found in societies throughout the world, all of which were complex in their own ways.

How then could differences and similarities in the modes of subsistence, artefacts, techniques, religions, or kinship systems that were observed be accounted for? If technologies formed an index that organised and represented evolutionary logics, as evolutionary theory lost credibility, new theories were required to account for differences and similarities. Morgan had already acknowledged partial resemblances between cultures at the turn of the century, but Rivers went further, arguing that resemblances were much more a matter of *diffusion* than of *evolution*. Following travels in Melanesia, Polynesia, Egypt, and India, he had learned, not only that supposedly 'simple' societies were in fact complex, as he had put it, but also that 'the transitions which have been taken to be evidence of independent processes of evolution' can instead be 'ascribed to the mixture of cultures and of peoples' through travel and contact that led to 'direct transmission from one people to another' (Rivers 1914, pp. 388, 387). Likewise, Franz Boas argued that similarities in the fishhooks, food pounders, and chisels found along the Pacific coast region 'from Costa Rica to Alaska', as well as in 'Hawaii and other sections of marginal Polynesia ranging even to New Zealand', suggested that 'from time-to-time small groups

of Polynesians and possibly other Pacific Islanders deliberately or accidentally reached our shores and were effectually absorbed in the native Indian population' (Boas 1938, pp. 211–212). Hence, a novel classificatory principle was required which pointed to the modes of contact between different societies facilitated by political alliances, forms of transportation, or exchange of goods leading to the diffusion of various technologies, ideas, and social and cultural institutions.[2]

From Artefacts to Processes

As modern fieldwork methods took hold in the early twentieth century, ethnography not only provided the impetus to revise evolutionary theory but also shifted attention from artefacts to the social processes and broader systems that gave rise to them. Perhaps most famously, in his study of the Kula exchange system in Melanesia, Bronislaw Malinowski describes the complex operations and craftsmanship that go into the building of *masawa* (sea-going canoes) as a key technology allowing for interaction and exchange between peoples in the Trobriand Islands. Malinowski focused, however, on the association of canoe-making with magic and broader systems of economic exchange and belief, as he regarded technologies in a holistic fashion as much more than technical effort (Bubandt and Otto 2010). For Malinowski and his British contemporaries, it was important to study human societies as whole systems; as he wrote, 'an Ethnographer who sets out to study only religion, or only technology, or only social organisation cuts out an artificial field for inquiry, and he will be seriously handicapped in his work' (Malinowski 1922, p. 17). These observations notwithstanding, artefacts and technologies would meld into the background as systems of kinship, economic exchange, religious belief, or political authority were brought to the fore in structural-functionalist analysis.

In distinct contrast, a French tradition that took its point of departure in the body took hold, as already noted, following the publication of Mauss's influential 1935 essay on 'The Techniques of the Body' in which he argued, 'man's first and most natural technical object, and at the same time technical means, is his body' (Mauss 2007[1935], p. 56). Drawing on ethnographic examples from different parts of the world covering everyday practices of swimming, digging, or walking, Mauss invokes the 'social nature of the "habitus"', arguing that 'a manual knack can only be learnt slowly. Every technique properly so-called has its own form [and] each society has its own special habits' (Mauss 2007[1935], p. 52). In *Gesture and Speech*, French archaeologist and anthropologist André Leroi-Gourhan would, consequently, link such body techniques to material instruments such as potter's wheels, wood lathes, and carts. In bringing social, biological, and archaeological anthropology together, Leroi-Gourhan proposed a set of 'fundamental criteria of humanity', the most important of which were 'erect posture, a short face and a free hand during locomotion' (1993[1964], p. 19). From these, he goes on to argue that 'freedom of the hand almost necessarily implies a technical activity different from

that of apes, and a hand that is free during locomotion, together with a short face and the absence of fangs, commands the use of artificial organs, that is, of implements' (1993[1964], p. 20). These implements or tools, in turn, are 'only a testimony of the exteriorisation of an efficient gesture … it is the materialization of the interaction of matter with the means to transform it', leading Leroi-Gourhan to propose the notion of an operational sequence (*chaîne opératoire*) (Leroi-Gourhan 1943, 1945, 1993, cited in Audouze 2002, pp. 287–288; see Coupaye this volume). While Leroi-Gourhan's *longue-duree* evolutionary analysis in *Gesture and Speech* also included a third section on what he called 'values and rhythms' focusing on speech, writing, memory, and art, it was especially Mauss's, Haudricourt's, and Leroi-Gourhan's approach to studying *manual action in technical activities* that was continued at the Centre National de la Recherche Scientifique (CNRS) under the auspices of Hélène Balfet and Robert Cresswell and, later, Pierre Lemonnier and, since 1976, through the French journal *Techniques et Culture*.

From the late 1960s to the 1980s, processual perspectives on technology were also taken up as part of the debates around cultural ecology, cultural materialism, and the anthropological neo-Marxism of the time. While the founding figures of cultural ecology, Julian Steward (1955) and Leslie White (1959), had in some ways receded into the past, a new generation of scholars expanded upon Marxist materialism. They produced analyses that illustrated the significance of economic, material, and technological relations in determining social structures, and the dialectic between social relations and technical forces of production in the forming of different modes of production (primitive-communal or pre-capitalist, feudal, capitalist, communist, and so on). These studies had a comparative and historical sweep, and the issues at stake were the origins of the state (e.g. Goody 1971), the technological foundations of war, despotism and slavery, and the connection between technology, land use, and population growth. To take just two influential examples that tied technology and power together, Karl August Wittfogel (1957; see also Fei 1992[1947]) argued that the need to manage water led to hydraulic despotism, and Ester Boserup, in her studies of agrarian change (1965), identified a correlation in increased population density with the shift from the hoe to the plough. To mention a few scholars from this generation, the structural Marxism of Maurice Godelier (1975, 1986[1982]) sought to understand the relations between the environment, technology, and society by studying the power of Baruya Great Men through their control of warring, hunting, shamanism, and rites of initiation. Marshall Sahlins (1972), among others, discussed 'the domestic mode of production' of households in so-called primitive societies where kinship, culture, and religion are ingrained in economic and technological forces. Finally, Marvin Harris (1979) coined the term 'cultural materialism' and argued that culture is essentially a product of material forces, claiming, for example, that religious taboos prohibiting eating cattle in India have a material basis in that cattle are reserved for agricultural production.

While artefacts have long joined the interests of anthropologists with those of archaeologists, we can see a shift in terminology during the twentieth century from 'technology' through to the conceptualisation of 'material culture'. Malinowski had condemned what he called 'the purely *technological* enthusiasm of material culture ethnologists' and, with the emergence of fieldwork-based anthropology, the study of technology and material culture fell out of fashion and was relegated to museums (Pfaffenberger 1992a, p. 491). This coincided with the increasing dematerialisation of the concept of culture in American cultural anthropology where 'what is culture is the *idea* behind the artifact' (Kroeber & Kluckhohn cited in Pfaffenberger 1992a, p. 492). Writing from his work with the vast Pitt Rivers Museum, British archaeologist Dan Hicks (2010) has observed that while archaeologists maintained an interest in material objects and 'technology', the invention during the early twentieth century of the idea of 'material culture' in anthropology, as a separate interest, marks a shift in mainstream anthropology away from technologies (see also Bille this volume).

An increase in attention towards material culture in the UK during the late 1970s and early 1980s, however, created something of a rapprochement between the disciplines of archaeology and social anthropology, not least as the interdisciplinary *Journal of Material Culture* was established in the wake of a shared material-cultural turn focused on 'the relationship between people and things irrespective of time and space' (Miller and Tilley 1996, p. 5). Ethnoarchaeology (Hodder 1982) developed as a comparative form of archaeological study to understand the past through contemporary material practices and ethnographic methods, bringing anthropologists and archaeologists together. Daniel Miller, himself a trained ethnoarchaeologist, conveyed the significance of objects and materials in everyday social life as he examined the social symbolism of material culture in the contemporary world through several extensive studies (e.g. Miller 1997, 1998, 2005). While cultural materialists had focused on different modes of production, Miller focused his theories on *consumption* (1987), arguing that consumption is one of the processes of objectification whereby things gain meaning in modern everyday life. For example, in Miller's theory of shopping (1998), consumption is not to be understood as destruction but as a creative process and the transformation or enrolment of commodities into social relations, so that shopping is viewed as a 'technology of love', a way to show care and concern (Miller 2006, p. 350). *Both* production and consumption thus came to be seen as technological processes.

In these ways, far from the invention and artefact-oriented conceptualisations of technology that underpinned evolutionary ideas about stages of civilisational development in the nineteenth century, twentieth-century ethnographers had recast technologies into important elements within the processes and systems that undergirded *different* societies.

1980s and 1990s: Programmes for an Anthropology of Technology

By the 1980s and into the 1990s, as mass production, transportation, global communication, and migration intensified (Douglas and Isherwood 1979; Appadurai 1986, 1996; Hannerz 1996; Tsing 2000), efforts to theorise a new anthropology of technology for an age of globalisation took hold. Several initiatives emerged as different clusters of anthropologists began organising seminars, formulating programmes, and putting forth publications aimed at promoting the project (Lemonnier 1986, 1992; Pfaffenberger 1988, 1992a; Gell 1988, 1992; Gibson and Ingold 1993; Escobar 1994; Ingold 1997; Harvey 1997; Downey and Dumit 1997a; Schiffer 2001). Each of these initiatives would further distance itself from the determinist evolutionary theories that still haunted discussions of technology, tackling the legacy of divides between 'modern' and 'pre-modern' that had seeped into public discourse. The classic anthropological themes of tools and tool use were taken up again, in re-evaluations of the role and notion of 'the material', embedding materials thoroughly in the social and inserting new connections and new roles into anthropological conceptualisations of technology. In hindsight, we can see how anthropological interest in technology in fact waxed and waned throughout the twentieth century.

This interest notwithstanding, technologies have regularly been seen to occupy a secondary or peripheral status within anthropology, and scholars have sought to diagnose reasons for its 'neglect' (Sigaut 1994, p. 420) and 'underdevelopment' (Ingold 1997, p. 106) as an anthropological field of study. As we saw earlier, according to Ingold, it had to do with modernity's general cutting loose of technology from society and culture, thereby placing it *outside* society (Ingold 2000). One of the key reasons these commentators could duly complain about technology's relative neglect was the absence of a thriving subfield: technology was rarely included as a core component of curricula, in contrast to, say, kinship, medicine, religion, economic exchange, or political systems. Indeed, Bryan Pfaffenberger decried a 'lack of interest in technology' (Pfaffenberger 1988, p. 237), suggesting that the peripheral status of the study of technology and material culture in anthropology was due to modernist anthropology's immaterial understanding of culture. Pfaffenberger attributed this in part to Malinowski's quest for the professionalisation of the discipline. In response to his desire to shift anthropology away from decontextualised amateur collections set up to compare material objects, socio-cultural anthropology increasingly separated itself from archaeology and material culture studies. Much can be explained by the isolation of the French *Techniques et Culture* school (see Coupaye this volume), the splitting off of material culture studies as a rather independent interdisciplinary field (see Bille this volume) and the discontinuities and distinctions in the use of the concepts of technology and techniques we discussed earlier. All of this, however, would change, as a flurry of lectures, symposiums, and seminars were organised in the closing decades of

the twentieth century resulting in a number of publications central to anthropology of technology.

Between 1983 and 1986, building on his series of lectures ('The Ethnology of Technology') delivered as Chargé de Conférence at the Ecole des Hautes Etudes en Sciences Sociales in Paris, Pierre Lemonnier suggested that 'a veritable anthropology of technology is … taking shape' (1986, p. 147). That these lectures were delivered in Paris was no coincidence as, ever since the early 1970s, as noted earlier, Lemonnier had been part of a cluster of researchers at the Centre National de la Recherche Scientifique (CNRS) who were engaged in the study of techniques. Lemonnier formulated an empirically demanding programme for a comparative anthropology of technology based on the concepts of material actions, technological systems, and technological choices (1986, 1992, 1993, 2012). 'Technological choices', a concept gleaned from Lévi-Strauss, addresses questions that arise from the observation that many techniques are far from 'rational', 'efficient', or the 'best possible' and that, among several technological possibilities, societies seize, adopt, or develop only some features while dismissing others (Lemonnier 1993). Building on the French tradition of Mauss, Haudricourt and Leroi-Gourhan, Bruno Latour and Pierre Lemonnier (1994) endeavoured to integrate the various paradigms of technology at an interdisciplinary symposium in the early 1990s alongside primatologists, archaeologists, ethnologists, philosophers, and science studies scholars. While Latour went on to develop actor-network theory (Latour 2005), Lemonnier continued Mauss's programme and summarised and refined his work in the field of *technologie culturelle* in *Mundane Objects: Materiality and Non-Verbal Communication* (2012), emphasising that material actions and mundane artefacts are at the very core of human existence. It is through close ethnographic attention to material techniques, Lemonnier posits, that anthropologists can understand basic human logics, social relationships, and societies.[3]

Across the Atlantic in the United States, anthropologists looked to philosophy to bring together the material and operational aspects of technology. Drawing on both German philosopher Martin Heidegger's (1977[1953]) essay on 'the Question Concerning Technology' as well as French historian and philosopher Michel Foucault's (1990[1976]) writings on the emergence of technologies and rationalities of government, anthropologists were tackling technology anew. Heidegger had highlighted what he called an 'instrumental and anthropological definition of technology' which suggested:

> Technology is a means to an end …, a human activity. … The manufacture and utilization of equipment, tools, and machines, the manufactured and used things themselves, and the needs and ends that they serve, all belong to what technology is. The whole complex of these contrivances is technology. Technology itself is a contrivance, or, in Latin, an *instrumentum*. (Heidegger 1977[1953], pp. 4–5)

It was at the University of California, Berkeley, that the exegesis of Heidegger's writings by American philosopher, Professor Hubert Dreyfus (1995), went on to have a big impact on the way his concepts and critique of technology were received and understood by North American scholars (see Dreyfus and Rabinow 1982). It was also Berkeley where Foucault would spend time in the 1980s, conceptualising what he famously called 'biopower'. Diagnosing the emergence of novel technologies and techniques of government in eighteenth- and nineteenth-century Europe, he sought to describe 'endeavours to administer, optimize, and multiply [life], subjecting it to precise controls and comprehensive regulations' (Foucault 1990, p. 137). As we will see, Foucault's concepts went on to shape those anthropologies of technology that have focused on biomedicine and biotechnology, not least as developed by Paul Rabinow (Rabinow 1996; see Escobar 1994; Wahlberg this volume).

By the end of the 1980s, a series of influential articles would be published, each emerging from distinct theoretical traditions and each leaving a significant imprint on how anthropological studies of technology would proceed from that point. Firstly, as seen in one of the opening epigraphs of our introduction, Pfaffenberger's 1988 article, 'Fetishised Objects and Humanised Nature: Towards an Anthropology of Technology', introduced a definition of technology in terms of a *total* socio-technical system understood as 'humanised nature':

> any behaviour that is technological is also, and at the same time, political, social and symbolic. It has a legal dimension, it has a history, it entails a set of social relationships and it has a meaning. (Pfaffenberger 1988, p. 244)

With this definition, Pfaffenberger—a Berkeley anthropology graduate working at the School of Engineering and Applied Science at the University of Virginia—sought to bring STS and anthropology into dialogue, not just anthropology's fieldwork methodology but also anthropological theory, adapting, for example, Victor Turner's (1974) concept of social dramas as technological dramas. More than material actions, technological activities 'bring to life a deeply desired vision of social life, often with a degree of fervor that can only be termed millenarian' (Pfaffenberger 1992b, p. 506).

Secondly, in his article on "Technology and Magic" (also published in 1988), Alfred Gell (1988, 1992), based at the London School of Economics, built on the work of Malinowski in arguing that technologies do not only pertain to material production and reproduction, but also to magic, enchantment, and art. With this approach to technology, Gell clearly departs from the Maussian approach where techniques are always physical actions on the material world. For Gell, 'technologies of enchantment' comprise 'all those technical strategies, especially art, music, dances, rhetoric, gifts, etc. which human beings employ in order to secure the acquiescence of other people in their intentions or projects' (Gell 1988, p. 7). Gell suggests that magic haunts technical activity like a shadow and that magical technology is the reverse side of productive technology (Gell 1992). Although it is rare to see magic discussed

explicitly in relation to modern technology, magical thinking and magical ideas are always concomitant with the production of modern technology, for example, in the apotheosis of 'innovation' or the mythologies created through advertisements that serve to entice consumers to buy the products of new technology (Gell 1988, p. 9). In a similar vein, Peter Pels (2010) has noted how frequently the term magic is applied in relation to computer technologies and finds that folk theories of the magic of computers reflect a fetishised way of looking at the world. It is not just that computers are seen as magical machines, but programming is turned into a magical activity, and computer programmers and hackers are often described as magicians or 'wizards' (e.g. Hafner and Lyon 1996). In their conceptualisation of 'technologies of the imagination', Sneath et al. (2009) draw on Gell's 'technologies of enchantment' (1992), and Ingold's (1997) processes of 'exaptation', to examine the imaginative efficacy of technology: for example, when 'avatar' personae that internet users create in chat rooms give rise to particular ethical notions of the users' selves (Humphrey 2009).

Thirdly, and also in 1988, feminist science studies scholar Donna Haraway published her landmark essay, 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective', in which she rejected the notion of 'objectivity' in 'scientific and technological, late-industrial, militarized, racist, and male-dominant societies' in favour of 'a doctrine of embodied objectivity that accommodates paradoxical and critical feminist science projects: Feminist objectivity means quite simply situated knowledges' (Haraway 1988, p. 581). Building on Haraway's work in particular, Gary Downey, Joseph Dumit, and a number of like-minded American anthropologists doing ethnography at the intersections of anthropology and STS began organising panel sessions on 'Science and Technology' at the annual conferences of the American Anthropological Association. These sessions led to the formation of CASTAC (The Committee for the Anthropology of Science, Technology & Computing) and culminated in a weeklong seminar organised by Downey and Dumit at the School of American Research in Santa Fe, New Mexico, in October 1993, with contributions from Donna Haraway, Emily Martin, Paul Rabinow, Rayna Rapp, Sharon Traweek, Deborah Heath, David Hess, and Sarah Williams. In the introduction to the resulting publication, *Cyborgs & Citadels: Anthropological Interventions in Emerging Sciences and Technologies*, Downey and Dumit (1997b) argue for 'new ways of locating and intervening in emerging sciences, technologies and medicines through cultural perspectives and ethnographic fieldwork' given the ubiquity of biomedical, information, and communication technologies in everyday lives (pp. 5–8).

In this iteration of an anthropology of technology, ethnographic engagements with techniques and embodied skills like gardening, canoe-making, or weaving (see Bunn this volume) were supplemented with ethnographic interest in the 'hi-tech' worlds of, for example, genomic sequencing, cancer clinical trials, fertility treatment, prenatal screening, robotics, engineering, or digital finance. Downey and Dumit point to an urgency in the anthropological study

of emerging technologies since, 'We cannot say No to the experience of science, technology, and medicine collectively as a disciplining center that polices other meanings and orders power relations in contemporary life' (Downey and Dumit 1997b, p. 5; see also Escobar 1994). On the one hand, this requires ethnographies in the 'Citadel', which is to say the laboratories, clinics, and workspaces of bioscientists, physicists, computer programmers, engineers, and biomedical doctors (cf. Latour and Woolgar 1979), while on the other (and in keeping with 'classic' ethnographic interest in everyday lives), it requires that the resulting technologies (e.g. DNA testing, reproductive treatments, water meters, robots, or surveillance algorithms) be followed as they come to be routinised, taken up, and (re)appropriated in daily use. Indeed, Emily Martin (1994), Paul Rabinow (1996), Sarah Franklin (1997), and Rayna Rapp (1999) had all been carrying out forms of assemblage ethnography (see Wahlberg this volume) at and across these intersections in their respective ethnographic studies of immunity, genomic sequencing, assisted reproduction, and prenatal testing technologies throughout the 1990s, showing how scientific knowledge, laws, regulations, media reporting, biomedical technologies, and the people developing, practicing, and using them were all imbricated in the making of these phenomena. As feminist technoscience studies (see Lie this volume), many of these ethnographies empirically demonstrated that 'there is no such thing as a pure and politically innocent "basic" science that can be transformed into technological applications to be "applied" in "good" or "bad" ways at a comfortable distance from the "clean" hands of the researcher engaged in the former'; rather science and technology are always 'entangled in societal interests' (Åsberg and Lykke 2010, p. 299), as Pfaffenberger had also insisted. Indeed, anthropological and STS studies showed how different technologies and technological activities are gendered and coded and re-coded in different ways according to gender stereotypes in different contexts and during different times in history (e.g. Cowan 1983; Wajcman 2000; Hicks 2017; Bray 2007, see also Bray this volume).

Fourthly, taking his point of departure in a phenomenology of the body in the early 1990s, Tim Ingold would bring tools and skills back to the fore in his efforts to (re)define the anthropology of technology. Together with Kathleen Gibson, Ingold convened a Wenner Gren Symposium on 'Tools, Language and Intelligence: Evolutionary Implications', resulting in the publication of their edited volume, *Tools, Language and Cognition in Human Evolution* (1993), which was, however, dominated by contributions from the fields of archaeology, biological anthropology, cognitive psychology, and neurophysiology. While cognitive scientists were interested in how technology was related to evolving language and intelligence in different cultures, drawing on the ecological psychology of James Gibson and the phenomenology of Merleau-Ponty, Ingold insisted that what was needed was a theorisation of skill and craft. These themes were subsequently taken up in a seminar series on *Technology as Skilled Practice* held at the University of Manchester from 1994 to 1996 that

brought together anthropologists (including, among others, Penelope Harvey, Tim Ingold, Bryan Pfaffenberger, and Marilyn Strathern), psychologists, and historians of technology, resulting in a special issue of *Social Analysis* (Harvey 1997). For this group of scholars, anthropology must continue to pay empirical attention to the skills and tools that people need and use in their everyday lives wherever they might be (Ingold 1997, 2001).

Finally, alongside feminist studies of science and technology, postcolonial theory would also significantly shape the now burgeoning field of anthropology of technology during the 1990s, as scholars demonstrated how the development of modern science and technology was inextricably bound up with colonial histories (Prakash 1999). As already noted, anthropologist Arturo Escobar was quick to point out that most of the ethnographic studies of so-called emerging technologies by Haraway-inspired anthropologists were being carried out in countries of the Global North and, consequently, 'the effect of cosmopolitan technologies on Third World groups remains insufficiently understood' (Escobar 1995a, p. 410). Invoking Arjun Appadurai's notion of technoscapes and ethnoscapes (Appadurai 1990), and as seen in one of the opening epigraphs of our introduction, Escobar argued that 'once seen as producing worldwide homogenization and generalized acculturation, cosmopolitan science and technology are now viewed in terms of their real or potential contribution to the formation of hybrid cultures and to processes of self-affirmation through selective and partially autonomous adoption of modern technologies' (Escobar 1995a, p. 410). His call would not go unheeded as ethnographers began studying the uptake and development of, for example, mobile phones in Jamaica, assisted reproductive technologies in India, or agricultural machinery in Thailand (Horst 2006; Bharadwaj 2016; Morita 2013). These are all examples of the 'sciences from below'—which Sandra Harding and colleagues suggested should receive greater attention—which is to say, 'any and every culture's institutions and systematic empirical and theoretical practices of coming to understand how the world around us works' (Harding 2008, p. 16). The decolonisation of knowledge and technology has, in recent years, been bolstered by insights from indigenous knowledge (e.g. TallBear 2013; de la Cadena 2015) and critical race theory (e.g. Benjamin 2016, 2019) and these forms of critique have subsequently been brought into areas of study, such as design (Escobar 2018), which have otherwise more often than not been limited to western contexts. At the same time though, anthropologists have also shown how a globalising bioscience continues to reify, for example, biologised notions of race, despite promises to end its use as a proxy for genetic difference (Kowal this volume; see also Anderson 2006; Fullwiley 2008).

It is little wonder, then, that by the turn of the millennium Michael Brian Schiffer (2001) was noting that 'sociocultural anthropologists of the late twentieth century are avidly investigating technology, developing theories and case studies, and their works are beginning to influence practitioners in other disciplines' (Schiffer 2001, p. 1). Schiffer had brought together Bryan Pfaffenberger,

Tim Ingold, Lucy Suchman, and other colleagues for a seminar on the 'Anthropology of Technology' at the Amerind Foundation in Arizona (11–16 October 1998) leading to an edited volume outlining *Anthropological Perspectives on Technology* (Schiffer 2001). In his introduction, Schiffer points to the numerous definitions of technology that were then circulating among anthropologists ranging from those focusing on the manufacturing and use of artefacts to those which understood technologies in terms of instrumental means to achieve goals.

And so, with foundations in the nineteenth-century origins of the anthropological discipline, and developed through the twentieth century, we might well say that by the turn of the millennium an anthropology of technology had 'finally' established itself as a subfield in anthropology, but one that supplements rather than substitutes for other fields of anthropology, such as medical anthropology, environmental anthropology, political anthropology, and more, as these fields have themselves come to be dominated by 'new' technologies. Now, as the chapters in this *Handbook of the Anthropology of Technology* so clearly attest, it is no coincidence that such a subfield has taken root in a globalised twenty-first-century world where forms of individual experience, lifeworlds, systems of meaning, and forms of social organisation are in profound ways being shaped by and through technoscapes (Appadurai 1996; Kearney 1995), technocracies (Ferguson 1990; Escobar 1995b), technoscientific knowledge production (Marcus 1995a; Fujimura 1996; Haraway 1997; Rapp 1999), 'emerging technologies' (Martin 1994; Rabinow 1996; Downey and Dumit 1997a; Pink et al. this volume), technocapitalist frictions (Tsing 2005), and global assemblages (Collier and Ong 2005), all of which connect multiple sites and scales at one and the same time (Marcus 1995b; Schiffer 2001). It is these multiple sites that anthropologists of technology continue to engage to this day.

The Early 2000s: Interdisciplinary Collaboration and Methodological Innovation

In the first two decades of the twenty-first century, anthropologists around the world have continued to reinvigorate research into the ways in which technologies are shaped by and come to shape daily lives in a host of different settings. One landmark publication was the volume, *Global Assemblages* (Ong and Collier 2005), that included such influential contributions and conceptualisations as those on 'therapeutic citizenship' (Nguyen 2005), 'biological citizenship' (Rose and Novas 2005), biopolitics (Collier 2005) and, of course, assemblage (Collier and Ong 2005; see also Wahlberg this volume), among many others. New empirical fields of study have arisen together with new technical developments (e.g. anthropological studies of algorithms (Seaver 2017, 2018)), data (Douglas-Jones et al. 2021), datafication (Hoeyer 2019), new interlocutors, such as data scientists and programmers (Kelty 2008; Knox and Nafus 2018; Seaver 2017, 2018) and hackers (Coleman 2013, 2014; Nova and

Bloch 2020), and revived concepts, such as infrastructure (Larkin 2013; Harvey et al. 2017; Anand et al. 2018; see Part V this volume).

In this last section of our historical account of the formation of today's anthropologies of technology, we emphasise two tendencies that we suggest have in particular characterised the first two decades of the twenty-first century. First, anthropologists are increasingly being called upon to participate in interdisciplinary collaborations that are centred in and around the so-called emerging technologies that drive the contemporary global economy, enjoying enormous corporate and state investment at the forefront of technological innovation. Emerging technologies range from health and medical technologies to biotechnology, artificial intelligence, and robotics, 'green' technologies, energy infrastructures, information and communication technologies, as well as big data and financial technologies.

Much has been written and said of the 'collaborative turn' in social studies of science and technology, not least within anthropology (see Marcus 2000; Lassiter 2005; Prainsack et al. 2010; Stavrianakis 2015; Fitzgerald and Callard 2015; Hastrup 2018). As noted above, beginning in the 1980s, anthropologists had entered the 'citadel' to study the practices of biomedical scientists, computer engineers, physicists, and more. Partly as a consequence, they were eventually asked to participate in collaborative research applications, not least those focusing on the ethical, legal, and social implications (ELSI) of 'emerging technologies'. This was because epistemic partners from the technical, medical, and natural sciences feared the public's concerns and possible rejection or lack of confidence in new technologies, as was the case with genetically modified organisms (Wynne 2001), while also hoping to gain socially robust knowledge and products (Nowotny et al. 2001). Ever since the large investments in the Human Genome Project that provided fertile grounds for anthropological studies (cf. Lindee et al. 2003; Pálsson 2007; Kowal this volume), funding agencies have increasingly included demands for interdisciplinarity that combines social science and humanities perspectives in their calls. From the very outset, however, these collaborations have entailed frictions due to more or less explicit disciplinary hierarchies and less than reciprocal commitments to 'inter-literacy' between the disciplines (see e.g. Frickel et al. 2016). Nevertheless, anthropologists of technology have steadily entered into collaborations on the strength of those insights that can be gained through fieldwork focused on the daily lives of people and institutions involved in the development, manufacturing, deployment, and/or use of particular technologies. Interdisciplinary engagements with emerging technologies, such as the development of humanoid robots (Hasse this volume), spur perennial questions for anthropology about what it means to be human and how human relationships and sociality with other humans, animals, plants, and other animate or inanimate non-human objects are enacted in different places and at different times.

One such field of interdisciplinary engagement and collaboration worth noting in regard to anthropology of technology is design (e.g. Clarke 2011; Blomberg and Karasti 2013; Smith et al. 2016; Murphy and Wilf 2021), where

anthropologists within and beyond academia have collaborated with designers, software engineers, and other technicians. In design anthropology, a new wave of future-oriented researchers is urging anthropologists to take on active interventionist roles in collaborations with industry actors and to take responsibility not only for their interventions during fieldwork but also for new inventions that may come out of these collaborations outside academia (Salazar et al. 2017; Pink et al. this volume).

A second tendency that has characterised the first two decades of twenty-first-century anthropologies of technology has been anthropologists' quests for methodological innovation when studying technology, sometimes studying technologies by means of the technologies under study, such as in the case of digital and computational technologies (Coleman 2010; Horst and Miller 2012; Fortun et al. 2014; Pink et al. 2015; Knox and Nafus 2018; Geismar and Knox 2021; see also Munk and Winthereik this volume). Whether engaged in ethnographic studies of Internet use in different social contexts (Miller and Slater 2000) or in virtual ethnography from inside the Internet as a site of interaction (Hine 2000; Boellstorff 2008), the field of digital ethnography has contributed to the development of a range of methodological innovations as new possibilities for online ethnography are explored—not least during the COVID-19 pandemic when in-person interactions were impossible (Lupton 2020; Breslin et al. 2020).

While classic fieldwork with participant observation is still a core modality (not least in the chapters of this handbook), 'anthropology by means of design' (Gatt and Ingold 2013) and design methods, such as prototyping (Corsín Jiménez and Estalella 2016), are on the increase. Indeed, the very idea of anthropological fieldwork as a design process and the field as constructed, designed, or curated has been gaining ground since the critique of 'Malinowskian' fieldwork in *Writing Culture* and *Anthropology as Cultural Critique* in the 1980s (Clifford and Marcus 1986; Marcus and Fischer 1986). Today, and especially in fieldwork related to technology, research participants are often engaged as 'epistemic partners' in conceptualising the research through carefully staged events, or para-sites, such as workshops and seminars (Faubion and Marcus 2009), or experimental collaborations (Estalella and Criado 2018).

We are faced with methodological challenges when we want to capture the complex flows of digitalised information and communication (Waltorp 2021; Waltorp and Bruun forthcoming), technology-mediated sociality on social media or gaming platforms (Burrell 2012; Nardi 2009; Boellstorff 2008; Boellstorff et al. 2012), or the opaque work practices of people working in front of screens (Messeri 2021). Multimodal research methods (Collins et al. 2017), from drawing (Douglas-Jones 2021), mapping, filming, and photographing to utilising Facebook, Instagram, Twitter, or other platforms for 'life fieldnoting' (Wang 2012), 'appnography' (Cousineau et al. 2019), or 'sending private messages from the field' (Abidin and Seta 2020), are helpful in these endeavours. Perhaps more than ever before ethnographic research methods have become flexible and pliable.

A Handbook of the Anthropology of Technology for the Twenty-First Century

Two decades into the twenty-first century, we now have both a vantage point on the diverse ways in which technology has been conceptualised within anthropology, and a sense of urgency about the relevance of what has become a firmly established field in different parts of the world, namely the anthropology of technology. In the sections and chapters that follow, a host of different approaches and empirical fields of study are presented. All chapters contain both a review of the key literature in relation to their topics and advance an ethnographic case through which the particular theme and take on technology is unfolded empirically, in keeping with anthropological mores. While diverse, there are nonetheless certain characteristics that we suggest tie most anthropological studies of technology together, characteristics which are directly linked to the anthropological conceptualisations of technology we have discussed in this Introduction. Firstly, through its commitment to fieldwork, an anthropology of technology tends to focus on embodiment, skills, and/or materialities in the daily lives of those people involved in the development, manufacturing, deployment, and/or use of particular technologies, whether in the form of a power grid, a kitchen blender, or assisted reproduction. Forms of design anthropology, ethnographic studies of tools and skills, STS-inspired laboratory ethnographies, or ethnographic studies of how, for example, water meters or water pipe infrastructures are tampered with and appropriated by people living in slums or shanty towns, each aim to bring to light the everyday practices that emerge when specific technologies are (co-)produced and become routinised parts of embodied daily practices.

A second distinctive feature of the different anthropologies of technology covered in this Handbook is that they 'stay with the trouble' (Haraway 2016) when empirically identifying those conundrums and ethical issues that very often emerge alongside new technological opportunities, as well as the (un) intended social consequences of, for example, algorithms or industrial food production technologies. By attending to practices and material actions, ethnographers often map out and bring to the fore the situated ways in which particular technologies generate ethical dilemmas and problems as much as they provide 'solutions' to particular challenges. Indeed, as noted above, anthropologists are increasingly invited into interdisciplinary collaborations for this very reason.

Finally, in locating particular technologies within broader political economies, socio-technical systems, and infrastructures, anthropological approaches to the study of technology often highlight how particular technologies are always embedded within socio-historical processes that shape access and often reinforce inequalities and forms of discrimination. The production of technoscience, as well as the diffusion or routinisation of specific technologies throughout the world, cannot be detached from the entrenched stratifications that continue to underpin global technocapitalism.

These distinctive features of the subfield of anthropology are clearly discernible within the chapters that make up this Handbook. Without pretending to be fully exhaustive, we cover a total of nine perspectives, approaches, and fields in the anthropological study of technology that, as we have shown, have crystallised over the past three decades. What makes a perspective, an approach, or a field is not always clear-cut, however. Indeed, part of the diversity found within the anthropology of technology relates exactly to the ways in which ethnographers can mobilise insights from across the differences in analytical foci, methodologies, and empirical settings that we cover through the chapters in the handbook's first section: first, *technique*, technical activity, and the *chaîne opératoire* (Coupaye this volume); second, *skill*, skilled practice, and tool use (Bunn this volume); third, *materiality* and material culture studies (Bille this volume); fourth, *feminism* and in particular feminist technoscience (Lie this volume); fifth, *post-structuralism*, with its focus on assemblages, socio-technical systems, and infrastructures (Wahlberg this volume); sixth, *posthumanism* (Hasse this volume); seventh, *biopolitics* and biotechnology in postcolonial studies (Kowall this volume); eighth, *design* anthropology (Pink et al. this volume); and finally, ninth, *digital* and experimental anthropologies (Winthereik and Munk this volume).

These overarching perspectives, approaches, and fields that have coalesced within the anthropology of technology over the past decades, we suggest, remain so important given that technology—and ideas about what technological solutions can accomplish (cf. Morozov 2013)—seems to be the 'big narrative' of the twenty-first century. Regardless of whether you see climate change, global health problems, economic inequality, poverty, racial discrimination, or the ageing of populations as the major problem of our time, throughout the world, governments, companies, non-governmental organisations, and grassroots social movements look towards possible technological solutions as a way to comprehend, present, and address these societal challenges. 'Change the world one app at a time', as one slogan goes. At the same time, however, technologies are also recurrently portrayed as inherently troubling, whether in the form of the carbon emissions and toxic pollution for which they are responsible; the 'tampering with nature' view of the genetic modification of plants, animals, and humans; the disturbing possibilities for surveillance, control, and discrimination they are seen to hold; or the divisive and polarising effects for which social media are held culpable. As such, technologies can be said to incarnate our best hopes and worst fears (cf. Bijker and Law 1992). As several commentators have noted (e.g. Dijck et al. 2018), the political landscape is changing too, as big tech companies and their digital platforms are not only competing with states to be the most powerful governing bodies, but it is also through them and their services that people take their bearings and look for the fulfilment of their needs, from medical services to food, education, finance, and transport.

Technologies do not only play a supporting role in people's lives. Rather, as anthropologists have insisted, technologies have always been co-extensive with

humans: lending humans agency, empowerment, and new identities, as attested to by the everyday use of hearing aids and prostheses, the ubiquity of smartphones, watches, and other computing devices, biotechnological vaccine development, and intensifying efforts to produce 'green energy'. We live in a world where human-technology configurations can tinker with human lives in unseen ways, reaching new heights as gene-editing CRISPR technology, big data, and digital devices come together in new forms of surveillance, and human's technological activities anthropogenically impact not only our near surroundings but also the Earth's ecosystem and geology. We are all cyborgs, or biological-machinic-digital amalgams, and there is no easy way to draw a line between nature, culture, technology, and humans (see Suchman 2007; Hogle this volume). Indeed, discussions about, and critiques of, anthropocentrism, humanism and posthumanism, and the agency of materials and objects continue to drive debates about the anthropology of technology forward (see Latour 1993; de la Cadena 2015; Escobar 2018; Hornborg 2019, 2021; Hasse this volume).

It is the multiscalar perspectives found within the anthropology of technology that make it so well equipped to help address these many urgent challenges. The embodied skills required to play a musical instrument or culture cells in a laboratory are always located within larger socio-technical systems. Conversely, the political economies and material actions that shape water infrastructures or algorithm development are always tied to intimate moments in stratified and discriminatory ways as human (and non-human) lives are affected. It is the role of anthropology and anthropologists to cultivate and provide empirically informed, critical analyses of technology in a multiplicity of ways. Some anthropologists make it their contribution to speak up for those whose voices are otherwise silenced, discriminated against, or overlooked in discussions about the development, uses, and (unintended) consequences of specific technologies (e.g. prenatal screening, digital payment infrastructures, or electricity meters). Others see an important role in tempering the 'hype' that can surround 'emerging technologies', such as self-driving cars or personalised medicine, by focusing on the many trade-offs and often damaging effects that they unavoidably generate. And still others insist on historically and ethnographically situating that which has come to be taken for granted—such as the routinised prescription of pharmaceuticals or proliferating use of biometric identification—as a way of demonstrating that things could be otherwise. These different forms of critique do not amount to a rejection of technology, which would be futile in any case given the inseparability of *anthropos* and *techne*. Rather what they enable are more nuanced and sophisticated understandings of how and why technologies come to take the shapes and generate the kinds of effects they do in and among those people whose everyday lives are unavoidably touched by them. We hope that this handbook, at this particular moment, will be a vehicle for asking new questions and opening new research agendas.

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Notes

1. Indeed, Mauss makes a case that 'technology' should be formalised into the science of techniques: 'Technology is to technics what every other science is or would be to its objects, what linguistics is to language, for instance, or ethology to behaviour' (Sigaut 1994, p. 422).The question of whether we understand technology as the study of techniques (as biology is the study of organisms) or as an operative system built into the machinery of production (as we sometimes talk of the 'biology' of the body) has been hugely influential for the divergent ways in which the anthropologies of technology have developed, for example, in Francophone and Anglophone countries, and it also lies behind many misunderstandings (Ingold, personal communication; cf. Canguilhem 2009).
2. Disputes between evolutionism and diffusionism partly continued within anthropology, for example through Julian Steward's (1955) cultural ecology as the study of human adaptation to the environment and Leslie White's (1959) neo-evolutionary studies of technology, even though they were gradually marginalised from mainstream socio-cultural anthropology.
3. An interesting debate about questions of technology's materiality (or not) was set in motion following a book symposium on Lemonnier's *Mundane Objects: Materiality and Non-Verbal Communication* (Latour 2014; Lemonnier 2014; Ingold 2014).

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