— TechnoFeminism —

JUDY WAJCMAN

polity

— 2 —

Technoscience Reconfigured

> Men and things exchange properties and replace one another; this is what gives technological projects their full savour.
>
> Bruno Latour, *Aramis*

Feminist approaches of the 1990s and today adopt an optimistic perspective on the nature of digital technologies and their implications for women. In doing so, they present an image of new technology as radically distinct from older technologies and, as such, positive for women. In looking forward to what these new technologies may make possible, they elaborate a new feminist 'imaginary' different from the 'material reality' of the existing technological order. In this way, in common with other proponents of the impact of information and biotechnologies, they distinguish new technologies from more established ones, and downplay any continuities between them.

While attributing a technological determinism to the past, paradoxically such approaches infer a new form of technological determinism, albeit one that predicts a future that advantages women over men. The consequences of this are explored in subsequent chapters. We shall see that

if the social relations of older technologies are presented in too rigid a form, then the new technologies come to be seen as too open and malleable. If the former give rise to an immobilizing pessimism, the latter obviate the need for feminist technopolitics. Recent studies of science and technology have transformed our understanding of the social relations of technologies, both old and new. What I suggest in this chapter is that the social shaping, or constructivist, perspective offers the possibility of a fruitful interchange with feminism that can overcome the unsatisfactory dualisms with which much feminist analysis has been plagued.

Beyond Technological Determinism

Although technological determinism has been a central theme in social theory (and re-emerges in recent debates on the network society, as well as in strands of feminist theory), it began to be seriously challenged as an intellectual position by the development, since the 1970s, of social studies of science and technology. Many of us who got involved then had a simple polemical purpose: to shake the stranglehold that a naïve 'technological determinism' had on the dominant understanding of the intertwining of society and technology. We were concerned that this view of technology, as an external, autonomous force exerting an influence on society, narrows the possibilities for democratic engagement with technology, by presenting a limited set of options: uncritical embracing of technological change, defensive adaptation to it, or simple rejection of it. Against this, the social studies of science and technology had its origins in a belief that the content and direction of technological innovation are amenable to sociological analysis and explanation, and to intervention.

Social scientists have increasingly recognized that technological change is itself shaped by the social circumstances within which it takes place. The new sociology of

technology set out to demonstrate that technological artefacts are socially shaped, not just in their usage, but especially with respect to their design and technical content. Crucially, it rejected the notion that technology is simply the product of rational technical imperatives; that a particular technology will triumph because it is intrinsically the best. Technical reasons are vitally important. But we need to ask why a particular technical reason was found to be compelling, when it could have been challenged, and what counts as technical superiority in specific circumstances. Studies show that the generation and implementation of new technologies involve many choices between technical options. A range of social factors affect which of the technical options are selected. These choices shape technologies and, thereby, their social implications. In this way, technology is a sociotechnical product, patterned by the conditions of its creation and use.

There is now a vast literature and a variety of social shaping approaches to the social study of technology. Whereas references to the 'new sociology of technology' were common in the 1980s, the terms 'constructivist studies' or 'social studies of technology' (STS) are now used to include actor-network theory, the social-constructivist approach, social shaping and systems approaches to technology studies.[1] As an introduction to the richness of the field, it may be useful at this point to outline the principal concepts that inform it.

The idea of a technological 'system' or 'network' has been key. Although technological innovation crucially builds on previous technology, it does so not in the form of separate, isolated devices but as part of a whole, as part of a system. An automatic washing machine, say, can work only if integrated into systems of electricity supply, water supply and drainage. A missile, to take another example, is itself part of an ordered system of component parts – warhead, guidance, control, propulsion – and also part of a wider system of launch equipment and command and control networks. The need for a part to integrate into

the whole imposes major constraints on how that part is designed. A technological system is never merely technical: its real-world functioning has technical, economic, organizational, political and even cultural elements.

Take something you rarely think twice about – the electric refrigerator. We know from historians of technology that once upon a time you could choose between an electric refrigerator and a gas refrigerator, both equally effective.[2] General Electric had the financial resources to invest in the development of the electric model, while the manufacturers of gas refrigerators, although they had a product with real advantages from the consumer's point of view, lacked the resources to develop and market their machine. Economic power, not technical superiority, gave the electric refrigerator the edge over its competitor. However, the design of this kitchen 'white good' was also shaped by the post-Second World War spread of single-family houses, with correspondingly small-scale appliances. This built environment in turn sustains the cultural ideal of the separation of the public and private domestic spheres.[3] Gender roles and sexual divisions are part of the sociotechnical system or network.

This example illustrates the way technological decisions are the result of 'heterogeneous engineering': engineering 'social' as well as 'technical' phenomena by constructing an environment in which favoured projects can be seen as viable.[4] The usual economic explanation, which assumes that firms simply choose technologies that offer the maximum possible rate of profit, has also been the subject of much criticism. In response, some economists utilize the notions of technological trajectory, path dependence and lock-in to capture the mechanisms through which the evolution of a technology becomes more and more irreversible. The more that technologies are adopted and their problems resolved, the better their performance, and the greater their adoption. This clearly generates a powerful path-dependence over time, one that marginalizes competing or new technologies.

The social studies of technology emphasize that it is not necessarily technical efficiency, but rather the contingencies of sociotechnical circumstances and the play of institutional interests that favour one technology over another. Indeed, in situations of technical innovation, costs and profits are inherently uncertain; they cannot be taken as given facts. Economic calculations, such as estimating future costs and profits, are affected by the entire way a society is organized. Even markets are beginning to be understood as embedded in social networks.

The general point emerges most sharply when we consider the efficient use of labour, apparently a vital issue in technical change. David Noble's classic study of the development of automatically controlled machine tools in post-war USA shows how production technologies can reflect management's need for control over workers.[5] Noble notes that two options existed: 'record playback', whereby the machine merely replicated the manual operations of a skilled machinist, and 'numerical control', in which tool movements were controlled by a mathematical programme produced by a technician. He shows how the machine-tool suppliers, technologists and managers in the aerospace companies deliberately suppressed record playback in favour of numerical control, in order to reduce their reliance on the unionized craft-workers. As it happened, however, management found that it needed to retain skilled machinists to operate the new machines effectively. Thus the intentions underlying the technological design, to shift power from the shop-floor to the office, were not fully realized.

Furthermore, the linear model of innovation, which represents innovation as an activity restricted to engineers and computer scientists in research and development, producing finished products, has been questioned. Long after artefacts leave the industrial laboratory, the process of technological design is still taking place. Take the example of microwave ovens, a direct descendant of military radar technology, developed for food preparation in US navy

submarines. When manufacturers first turned their eyes to the domestic market, they conceived of the microwave as a device to reheat prepared food for use by men, especially single men. As a result, it was marketed as a 'brown good', and sold next to hi-fi equipment, televisions and video recorders – goods for leisure and entertainment. This attempt to frame demand was unsuccessful, and subsequently both the product and the consumer were reconstituted, as a 'white good' for the housewife who still wants to cook.[6] The way in which women users appropriated this domestic technology was not foreseen by the male managers and engineers who designed it. The finished form of the microwave, which redefined the gendered character of the user, meant that the microwave literally shifted its place in the department store. It now sits alongside washing machines, fridges and freezers as a humdrum domestic appliance.

These cases highlight the divergent requirements and assumptions of technology developers and users. The making of the microwave is as much a story about the transformation of a quintessentially human activity, cooking, as it is about a technical invention. Technologies are not fixed at the innovation stage but evolve in their implementation and use. The idea of 'interpretative flexibility' captures this malleable character of technologies.[7] It emphasizes that there is nothing inevitable about the way technologies evolve. Rather, technological change is a contingent and heterogeneous process. Different groups of people involved with a technology can have very different understandings of that technology, including different understandings of its technical characteristics. Thus users can radically alter the meanings and deployment of technologies.

This point about the interpretative flexibility of technology refers not only to the symbolic meanings of technologies, but, importantly, also includes variation in criteria for judging whether a technology 'works'. Social studies of technology emphasize that machines work because they have been accepted by relevant social groups.

As a result, closure or stabilization occurs as some artefacts become increasingly the dominant forms of the technology. The fact that a machine 'works' needs to be explained, rather than taken for granted.

This goes right to the heart of decisions about the vast technoscience research and development budgets in, for example, military weapons. Think for a moment about the crucial role that testing plays in attempts to justify the recent Bush Administration's missile defence shield. Yet, testing the accuracy of missiles has never been a straightforward empirical matter. Donald MacKenzie's study of nuclear ballistic missiles reveals the extent to which definitions of accuracy and reliability are constructed rather than being simply factual.[8] For a start, the conditions for peacetime testing are fundamentally different from those under which missiles would need to operate during a war. MacKenzie's point, however, is both more profound and more general than this. He shows that testing inevitably involves a number of differently constructed background assumptions. As a result, no single test is ever accepted by all the parties involved as the ultimate arbiter. Indeed, those most closely involved in the scientific work of testing have a high degree of uncertainty about their knowledge of missile accuracy figures. The more one looks inside the 'black box' of nuclear weapons technology, or any other technological artefact, 'the more one realizes that "the technical" is no clear-cut and simple world of facts insulated from politics'.[9] Whether or not the 'Son of Star Wars' works will necessarily be as much a political as a technical judgement.

Technology and society, then, are bound together inextricably, and the traffic between the two is reciprocal. Indeed, since the widespread adoption of 'actor-network theory', technology and society are no longer seen as separate spheres which influence each other.[10] Rather, the metaphor of a 'heterogeneous network' conveys the view that technology and society are mutually constitutive: both are made of the same stuff – networks linking human

beings and non-human entities. The technological, rather than being a sphere separate from society, is part of what makes large-scale society possible. Their most controversial idea, that we cannot deny a priori that non-human actors or 'actants' can have agency, has helped us to understand the role of technology in producing social life.

The conception of the non-human as actant serves as a corrective to a rigid conception of social structure. It involves a view of society as a *doing* rather than a *being*. The construction of technologies is also a moving, relational process achieved in daily social interactions: entities achieve their form as a consequence of their relations with other entities.[11] This idea of the agency or power exercised by objects is generalized in Bruno Latour's concept of 'delegation to non-humans'.[12] His popular examples of automatic doors and road bumps show how technical objects define actors, the space in which they move, and the ways in which they behave and interact. Fittingly called 'sleeping policemen', road bumps are delegated the job of reducing motorists' speed where the rule of law does not suffice. In this way, it can be said that the material world itself exercises a kind of agency.

Studies of technoscience, then, have drawn attention to the neglect of technology or materiality in much social theory. Apart from research concerned with the impact of technology on society, the main focus of social science has been on social structure and social relations. Machines, artefacts and things have generally been treated as background context, rather than even-handedly alongside persons, institutions and events.[13] Technoscience approaches contribute to an understanding of social change by exploring how technologies and new forms of social life are co-produced. Material resources, artefacts and technology make society possible. To talk of 'social relations' as if they were independent of technology is therefore incorrect. Indeed, what we call 'the social' is bound together as much by the technical as by the social. Society itself is built along with objects and artefacts.

The common neglect of the power exercised by objects is not surprising given that when technical systems are completely integrated into the social fabric, they become 'naturalized', disappearing into the landscape. Take, for example, the way seemingly innocuous technologies such as photography and film assume, privilege and construct whiteness. Richard Dyer describes how it is extremely difficult to film black and white faces in the same film and do equal justice to both.[14] Each requires a completely different handling of lighting, make-up and film development. This means that when black and white actors are portrayed together, one group tends to lose out, and systematically it is black actors who are technologically shortchanged. Dyer traces this bias in the use of film techniques to the film industry's origins in the USA and Europe. From the mid-nineteenth century, experiments with the chemistry of photographic stock, aperture size, length of development and artificial light all proceeded on the assumption that what had to be got right was the look of the white face. By the time of film (some sixty years after the first photographs), technologies and practices were already well established, and shaped subsequent uses. So the very chemistry of photography represents a subtle form of technological apartheid.

From Gender-Blind to Gender-Aware

Within these mainstream – even malestream – bodies of work in technoscience, the ways in which technological objects may shape and be shaped by the operation of gender interests or identities have not been a central focus. This is as true of recent developments like actor-network theory as it is of earlier work. Whilst innovations are seen as sociotechnical networks, it has been largely incumbent on feminists studying technoscience to demonstrate that social relations include gender relations. So what is it about the social studies of technology that has made it

hard for gender issues to be recognized? Several problems are involved, and I will outline them below.

To begin with, the marginalization of gender is indicative of a general problem with the mainstream methodology. This is related to the conception of power deployed by theorists in this genre. Using a conventional notion of technology, these writers have been concerned to identify and study the social groups or networks that actively seek to influence the form and direction of technological design. Their focus on observable conflict led to a common assumption that gender interests are not being mobilized. What many have overlooked is the fact that the exclusion of some groups, while not empirically discernible, may none the less impact upon the processes of technological development.

While the effects of structural exclusion on technological development are not easy to analyse, they should not be overlooked. Feminists have stressed that women's absence from spheres of influence is a key feature of gender power relations. Few women feature among the principal actors in technological design, as the sexual division of labour has excluded them from entering science, engineering and management. The problem with a primary focus on relevant social groups in the process of technological development is how to take account of those actors who are routinely marginalized or excluded from a network. Their absence is as telling as the presence of some other actors, and even a condition of that presence.

Within earlier socialist feminist approaches, it was relatively straightforward to discuss systematic male domination over women as a sex in terms parallel to those of class exploitation. Just as capitalists were deemed to have a relatively stable set of interests in maximizing profits, so men's interests as a sex were seen as institutionalized. The concept of patriarchy was often deployed as shorthand for institutionalized power relations between men and women, where gender is a property of institutions and historical processes, as well as of individuals. However, this was not meant to imply that men are a homogeneous group. For example, in

Feminism Confronts Technology I stressed that men's interests are not all identical, and that when it comes to influencing the design and development of a specific technology, some groups will have more power and more resources than others. So, long before the so-called postmodern challenge, 'difference' within the category of men, and between women, was already widely recognized.

By contrast, recent technology studies, such as actor-network theory, are more strongly influenced by a Foucauldian concept of power, where power is represented as capacity and effectiveness. Latour, for instance, suggests that power is not a possession – indeed, it must be treated as 'a consequence rather than a cause of action'.[15] Elsewhere Latour has argued that such constellations as classes, countries, kings or laboratories should not be treated as the cause of subsequent events, but rather as a set of effects.[16] In other words, they should be seen as consequences of sets of heterogeneous operations, strategies and concatenations. The job of the investigator, then, is not to discover final causes, but to unearth these schemes and expose their contingency.

In my view, an overemphasis on the enabling aspects of power can make it equally awkward to address the obduracy of the link between men and technology. Feminists' traditional concerns with women's access to technology, the differential impact of technology on women, and the patriarchal design of technologies have sat uneasily with this analysis of technology. The networks that actor-network theory is interested in are networks of observable interactions. While this theory perceives that artefacts embody the relations that went into their making, and that these relations prefigure relations implied in the use and non-use of artefacts, it is less alert to the inevitable gendering of this process. Such approaches do not always recognize that the stabilization and standardization of technological systems necessarily involve negating the experience of those who are not standard. Networks create not merely insiders, but also outsiders, the partially

enrolled, and those who refuse to be enrolled. Attendance to practices of exclusion or avoidance and their effects are integral, not peripheral, to adequate descriptions of the process of network building.

A central argument of feminist theory has been that men are set up as the norm against which women are measured and found wanting. This involves celebrating certain forms of masculinity over any form of femininity. Indeed, this thesis is at the core of my book, *Managing Like a Man*, about the male definition of management.[17] An investigation of senior managers in multinational corporations, it shows how the hegemonic organizational culture incorporates a male standard which positions senior women managers as out of place. A parallel argument can be made that the standardization of networks implicitly places men's experiences and men's investments at the centre, without acknowledging their specificity. The corollary is the simultaneous denial of other realities, such as women's. So, while it is true that the imputation of social interests to social structures and institutions is always contestable and difficult to specify, there are nevertheless important contexts in which feminist analysis has no choice but to invoke interest explanations.

The absence of women from view is also a function of the concentration on issues of design. Innovation studies have underplayed the importance of enrolling other groups in the alliance of forces that enables a technological innovation to succeed. Agents in mainstream social studies of technology are most commonly male heroes, big projects and important organizations, in what Susan Leigh Star has described as a 'managerial or entrepreneurial' model of actor networks.[18]

A case in point is Bruno Latour's study of *Aramis*, a rapid transit system combining the efficiency of a subway with the flexibility of the car.[19] A professor of sociology and his engineering student investigate why an innovative technology, which would have transformed personal transport in Paris, failed. The story is told in multiple voices,

including that of Aramis the artefact. As the intriguing plot unfolds, perspectives keep shifting to demonstrate that 'no technological project is technological first and foremost'. But neither does locating the project in its political, organizational or economic context render an adequate explanation. While networks of engineers, company executives, politicians and bureaucrats must be fully committed for the project to succeed, non-human resources also need to be enrolled. The relationship between humans and their technological creations can be understood only by seeing artefacts as fully involved in their own creation. This 'translation' model of innovation captures the diverse and multiple groups of individual people and things that jointly determine whether or not the project will be implemented.

Latour vividly illustrates how multiple networks continually transform the project as they become interested or disinterested. In the end, Aramis died when, like Frankenstein's monster, no one loved it any more. The story is not however as fully told as it purports to be. The voices we hear are those of male designers, politicians and technical experts, the male professor and his male student. Even the personification of Aramis as actant is implicitly a 'he'. Surprisingly, 'the love of technology', which serves as the subtitle of the book, is never examined as a peculiarly masculine feature of engineering culture. Men's love of machines embraces the car, which has a central place in hegemonic male culture. A fetishized object for many men, cars symbolize for them individual freedom, self-realization, sexual prowess and control.

Women's specific predisposition to cars is also overlooked. Many women value the car for its convenience in navigating their multiple roles. As mothers, unpaid domestic workers and paid workers, their journeys tend to be shorter, more complex and more multi-purpose than men's. They are more likely to travel with grocery bags, baby carriages and dependants. Women are also more vulnerable to sexual harassment and male violence when utilizing public transport, so the fact that Aramis consisted

of separate, small cabins was a major flaw. Herein may lie important reasons for resistance to the innovation. The account of Aramis's network is incomplete because it does not include the gendered use of a transport system.

Once the lens is widened to include routine technoscience, manufacturing operatives, marketing and sales personnel, and the consumers and end-users of technologies, women immediately come into view. More women are literally present, the further downstream you go from the design process. Women are the hidden cheap labour force that produces routine science and technology; as the secretaries, cleaners and cooks, they are part of the sales force and the main users of domestic and reproductive technologies. The undervaluing of women's 'unskilled' and delegated work serves to make them invisible in mainstream technology studies. Actor-network theory is more interested in delegation to 'actants' than in the inequalities that arise in delegations among 'actors'.

Most scholars are habituated to considering gender issues only when their subjects are women. Mainstream studies have generally assumed that gender has little bearing on the development of technology because the masculinity of the actors involved was not made explicit. Despite a burgeoning literature on men and masculinities, the critical role played by technology in hegemonic masculinity has been largely ignored. It might be seen as ironic that the focus on agency has rarely sensitized these authors to issues of gendered subjectivity. By bracketing issues of sexual difference and inequality, mainstream technology studies fail to explore how technologies operate as a site for the production of gendered knowledge and knowledge of gender.

Combining Feminist and Technology Studies

Over the last decade, there has been an increasingly fruitful interchange between feminist and mainstream social

studies of science and technology, although, as we have seen, this has not been symmetrical. The common ground is extensive, such as the constructivist emphasis on understanding technology as a sociotechnical product and the need to integrate the material, discursive and social elements of technoscientific practice. While feminists have drawn on many concepts from the social studies of technology, they have in turn modified them, partly in response to the problems outlined above. In the remainder of this chapter, I will briefly outline some of these attempts to reconfigure feminist and mainstream technology studies. Subsequent chapters will develop in more depth the issues foreshadowed here.

Technofeminist research has been at the forefront of moves to deconstruct the designer/user divide and, more generally, that between the production and consumption of artefacts. It is these divides that conventionally place men on one side and women on the other. One exemplary study that deliberately set out to combine an innovation study with a user study is that by Cynthia Cockburn and Susan Ormrod, who trace the trajectory of the microwave oven from its conception right through to its consumption.[20] Well aware that the standard technology studies' focus on invention underplays the role of women, the authors unravel the way that the sexual division of labour is mapped on to each stage in the journey of a domestic technology.

Like other domestic technologies, the microwave is designed by men in their capacity as engineers and managers, people remote from the domestic tasks involved, for use by women in their capacity as house-workers. Where women do enter the picture, apart from on the production line, is primarily as home economists, as their cooking expertise is crucial to the successful design of the artefact. These women see themselves as doing 'a kind of engineering or science', but it is not acknowledged as such by the predominantly male culture of engineers. Their technical skills are undervalued because of the strong association of

cooking with femininity. As a result, even at the one point when women enter the innovation process, they wield little influence over the development of new technologies – evidenced, for example, by the lack of attention given to the browning of food in microwave cooking.

What is so original about the microwave study is that it follows the gendering processes through the various stages of the artefact's life. Gendering does not begin and end with design and manufacturing. Domestic technologies are also encoded with gendered meanings during their marketing, retailing and appropriation by users. Whilst the technology is made into a physical object during production, the symbolic meanings attaching to it are continually being negotiated and reinvented. Marketing and retailing play a key role in framing demand: 'there is an unclear dividing line between accurately *representing* the customer, *constructing* the customer and *controlling* the customer'.[21] In particular, the study explores the extent to which interpretative flexibility exists once a given commodity reaches the hands of the consumer. For purchasers, the consumption of a domestic commodity is an activity of self-expression, and a marker of gender identity. Thus marketing and consumption are all part of the social shaping of technology.

Thus the microwave study demonstrates how men's and women's different relationship to machines affects every stage in the life of a technology. As we saw earlier, even the microwave's colour reflects a gendered conception of household functions and, consequently, a gendered conception of potential purchasers – those concerned with domestic work as opposed to those concerned with leisure and entertainment. Whereas white goods are portrayed as serviceable and simple to use, brown goods are portrayed as complex, clever technologies that require skills in handling. This has much in common with recent studies about cultures of consumption that explore how consumers or users modify the meanings and values of technologies in the practices of everyday life.

However, culture is not just about the modification of goods in consumption, but also about how cultural meanings enter the production of goods. Cockburn and Ormrod conceive of technologies as in a continuous process of negotiation, as we 'domesticate' or make new technologies our own. However, this process is firmly located in the gendered assumptions of designers about prospective users. This technofeminist approach brings together the interpretative flexibility or malleability in how artefacts are read symbolically, with an understanding of how they are physically shaped and remade. It is therefore a study of a sociotechnical product that encompasses both material and immaterial networks.

Much of the best writing that combines feminist perspectives with the social studies of science and technology is in the area of biomedical innovations. In contrast to earlier feminist analyses of reproductive technology, this literature adopts a more nuanced version of the sociotechnical network that encompasses the medical profession, including the entry of women into the profession, as well as women's consumer power. Several recent studies on cervical cancer screening, for example, are concerned with the processes whereby technologies are deployed and appropriated by users.[22] They share with the microwave study the choice of a routine, mundane technology, as opposed to heroic technoscience. Eschewing the 'executive approach' that would necessarily focus on male technoscientists, they widen the lens to incorporate women 'downstream'.

One such study is concerned to show how a rather recalcitrant tool, the 'Pap smear', became the major cancer screening technology in the world. Monica Casper and Adele Clarke argue that several sets of concrete practices, or 'tinkering', have been used to make the Pap smear appear to be the right tool for the job. One such practice, often overlooked, has been the gendering of the division of labour in cytological screening. It appears that the success of the Pap smear depended on the feminization of

the job of technician, with its accompanying low pay for difficult work. This makes clear the centrality of women's undervalued work in the standardization of a technology. The authors also explore the role of the women's health movement and public health activists, those outside the usual boundaries of the network, in successfully reshaping elements of the tool.

This approach combines actor-network theory with feminism and symbolic interaction. Clarke welcomes the emphasis on the role of non-human actors in scientific practice – that is, the pivotal role assigned to machines and natural objects in network building.[23] Such an approach helps to explain how particular scientific claims and technological innovations become successful – the requisite drawing together of discursive and material elements to enrol a large and diverse group of allies. However, Clarke sees her own 'social worlds analysis' as addressing the more common feminist critiques of mainstream technology studies, such as drawing attention to those who have been rendered invisible or disempowered by science in action. Her approach bridges internal and external concerns, locating scientific practice in the wider social and political context. Whereas most mainstream studies stop at the point where a technoscientific claim has developed enough power to start affecting people's lives, such feminist work draws attention to those effects and integrates them within their understanding of the sociotechnical.[24] The scientist or the executive is not given primacy. In this sense, it is very unlike the example of Aramis described above.

The technology of cervical screening is part of a long history of medical procedures designed for use exclusively on women's bodies. Indeed, medical technologies, such as sex hormones, have manufactured what we consider as our bodies. Nelly Oudshoorn's book *Beyond the Natural Body*, for example, shows how discourses about the natural body shaped the precise form of the contraceptive pill.[25]

Oudshoorn reminds us that the conceptualization of male and female bodies as essentially different, rather than similar, is a modern one, dating only from the eighteenth century. The identification of the female body as the Other resulted in positioning it as the quintessential medical object. Sex and reproduction were seen as the defining characteristics of women, and this was reflected in the establishment of gynaecology as a separate branch of medicine. With the rise of sex endocrinology in the 1920s and 1930s, the notion of the female body as the reproductive body was integrated into the hormonal model. Women's bodies thus became set apart as the prime site for biomedical practices of the body.

It was logical, then, for research on the first physiological contraceptive to be focused exclusively on women. Oudshoorn shows how discourses about the natural body shaped the Pill, and how the Pill, in turn, constructed women's bodies as universal with respect to their reproductive functions. The scientists who were developing the Pill attempted to design a universal 'one-size-fits-all' contraceptive technology, because they saw all women as being basically the same.

What is particularly interesting about this account is that it shows how these scientists succeeded in literally 'making' women the same. It turns out that the design of the Pill as a regime of medication, to be taken for twenty days a month, was shaped by moral considerations and notions of the natural body. Gregory Pincus, the American biologist who headed the research team, could have chosen any desired length for the menstrual cycle. He chose to make a pill that mimicked the 'normal' menstrual cycle. As a result, all Pill-users now have a regular cycle of four weeks, and the variety in menstrual cycles amongst women has been diminished. The Pill thus literally homogenized women's reproductive functions on a mass scale.

So far in this chapter, I have shown how 'older' technologies are malleable, and are constructed in ways similar

to those ascribed to new technologies. In addition, I have shown how gender relations are crucial to that shaping and have, in turn, been shaped within sociotechnical networks. I have chosen my examples of the microwave cooker and biotechnologies deliberately, because they show the continuities with domains claimed by recent cyberfeminists to be radically different. The first shows how cultures of consumption impinge upon technical design, while the second is about the technical modification of bodies. To illustrate this further, I want to look at the development of the typewriter. Once again, this is important for drawing out the relation between old and new technology: the typewriter keyboard remains the primary interface for connection to cyberspace.

The strength of my final example is precisely that it, too, locates women and machines in a historical context. Here is a machine (the typewriter), an occupation (the typist) and typing (a skill), all signified as feminine. A deterministic account sees the typewriter as having caused the feminization of office work, thereby rendering this gendering entirely self-evident. However, the story is more complex, as women, who were not meant to work, were to occupy posts hitherto regarded as exclusively male. How, then, did this dramatic gender inversion take place, and come to be seen as the natural order of things?

The answer lies in two concurrent and interrelated processes that were taking place as the typewriter was introduced: the gendering of the typewriter as an object and the construction of the practice of typing as feminine.[26] Indeed, in examining the early discourse about the typewriter, it is difficult to separate descriptions of the machine from those of its imagined and embodied users. This makes it an ideal case study of the process by which technology and a new social order between the sexes are reciprocally shaped.

The typewriter was gendered right from its initial commercialization in the USA in the 1870s. The first models happened to be produced in Remington's sewing-machine

workshops. This influenced their appearance and design, with the original models using a pedal to work the carriage return and mounted on a cast iron table like a sewing machine. The domestic nature of the technology was reinforced by its association with the piano-style keyboard. This affinity between the techniques of typing and playing the piano was drawn in many an analogy as making the machine suitable for young, educated, middle-class women, whose principal pastimes were playing the piano and embroidery. These associations, presented in a technological guise, lent credibility to the idea that the typewriter was a feminine tool.

At the same time, a number of discourses about a new femininity were emerging that promoted the idea that women could gain fresh ground by being employed in respectable jobs in business. This helped to construct the profession of typing as female. Emblematic of modernity, typists were presented as ushering in an era full of progress and promise. Observers and journalists regularly enthused about how well typing suited women, and how the typewriter was a woman's machine. These discourses permitted certain categories of women to enter the workforce, and sanctioned the intrusion of a female machine into the masculine world of the office. Although male stenographers were introduced to typing in the 1880s, as typing became more professionalized and more narrowly focused on technical skill and speed, the male figure of the stenographer gradually receded. It would be almost another hundred years before personal computers would make it natural once more for men to be seated at a keyboard typing, and for the practice of typing to lose its sex.

Conclusion

The way gender is theorized in these studies, which I would characterize as 'technofeminist', represents a major advance over previous work. In developing a theory of the

gendered character of technology, there is inevitably a danger of adopting an essentialist position which sees technology as inherently patriarchal. Early feminist studies of gender and technology tended to theorize gender as a fixed, unitary phenomenon, which exists prior to and independently of technology, and then becomes embedded within it. The success of a technology was explained in terms of the economic or political interests of powerful groups, typically regarding these interests as established, and in need of no further explanation. Conversely, there is the danger of losing sight of the structure of gender relations through an overemphasis on the historical variability of the categories of 'technology' or 'women'.

The technofeminist studies discussed in this chapter have avoided both these dangers. They have not taken interests as static and pre-given, but they have also maintained the centrality of gender relations in the social shaping of technology. They have drawn upon developments in the social studies of science and technology, and have extended them within a feminist framework. In the process, they have given a more subtle and relational view of sociotechnical networks, and transformed our view of technologies, old and new.

This has parallels with wider developments in gender theory that have influenced cyber- and cyborg feminists such as Plant and Haraway, as we shall see in the next two chapters. Judith Butler, for example, has argued that men's and women's interests are not objectively given, but are collectively created.[27] Influenced by post-structuralism, she conceives of 'gender as a performance', in order to stress that gender is not fixed in advance of social interaction, but is constructed in interaction. Individuals act or perform gender, and demonstrate their gender identity. Gender is a social achievement that requires a constant process of reiteration.

This notion of performativity, or 'gender as doing', chimes with the actor-network theory view of society as a doing rather than a being (although, as we have seen, the

latter does not see that the 'doing' is always gendered and that when women aren't there, men are still doing gender). The construction of gender identities, like that of technologies, is a moving relational process achieved in daily social interactions. The question is now posed in terms of how interests are shaped together with the technology in the making. This model of technological development enables us to understand technologies and interests as products of mutual alliances and dependencies among groups involved in the specific technology. It follows from this that gendered conceptions of users are fluid, and subject to a variety of interpretations. The relationship between particular gender power interests and their inscription in technological innovation must be treated with subtlety and its complexity recognized.

An emphasis on the contingency and heterogeneity of technological change helps to locate its possibilities in wider social networks. Such an analysis introduces space for women's agency in transforming technologies. This is not a space that has simply been opened up by new technologies. The feminist technoscience studies discussed in this chapter have shown that it is also a characteristic of existing sociotechnical networks, rather than simply a possibility presented by new technology in itself. However, it is necessary to recognize not only possibilities, but also constraints. Sociotechnical systems are not merely performed symbolically; they are also enacted materially. New technologies are malleable, but they also reveal continuities of power and exclusion, albeit in new forms.

There is always a danger of confusing new developments in theory with new developments in the things that theories are about. If performativity is a feature of all social relations, and if technologies and new forms of gendered cultures are co-produced, then this has been the case in the past, as much as it will be the case in the future. In arguing that new technologies should be seen as having continuities with older technologies, I am not arguing that nothing has changed. We have new and better theories to

apply. There are revolutionary changes in technology under way. But the futures they encompass will require similar forms of analysis to those of existing technologies and a similar engagement with feminist technopolitics.

– 5 –

Metaphor and Materiality

> There is no 'place' for women in these networks, only geometries of difference and contradiction crucial to women's cyborg identities. If we learn how to read these webs of power and social life, we might learn new couplings, new coalitions.
>
> Donna Haraway, *Simians, Cyborgs, and Women*

In this book I have explored the complex and often fraught relationship between feminism and technoscience. Technology is an intimate presence in our lives and increasingly defines who we are and how we live. Just as the typewriter and the automobile were icons of freedom for women in the discourse of modernity that presaged first-wave feminism, so cyberspace and cyborgs have become ubiquitous postmodern symbols for feminism today.

Women's lives have changed irrevocably during the twentieth century, rendering traditional sex roles increasingly untenable. Dramatic advances in technology, the challenge of feminism, and consciousness of the mutating character of the natural world have prompted visionary thinking. Feminist theorists have asked whether mass digitalization will finally sever the link between technology and male privilege – indeed whether new technologies have

undergone a sex change. Yet, even as this question is contemplated, there is a suspicion that existing societal patterns of inequality are being reproduced in a new technological guise.

Feminist theories of the woman–machine relationship have long oscillated between pessimistic fatalism and utopian optimism. The same technological innovations have been categorically rejected as oppressive to women and uncritically embraced as inherently liberating. At the heart of these deliberations lies a concern with the connection between gender and technology. What has been lacking is a coherent theoretical framework that allows us to engage with the process of technical change as integral to the renegotiation of gender power relations. I think this is worth striving for, even while recognizing that knowledge is situated, and theories come to life and have meaning only in specific local contexts of practical activity.

The technofeminist approach I outline in this final chapter fuses the insights of cyborg feminism with those of a constructivist theory of technology. This position eschews both the lingering tendency to view technology as necessarily patriarchal and the temptation to essentialize gender. The theory of technofeminism builds on the insights of cyborg feminism, but grounds it firmly in a thoroughgoing materialist approach to the social studies of technology, including its own role in those studies. In this way, technofeminism also offers a more thoroughgoing critique of mainstream science and technology studies.

I have outlined the problems that feminists have encountered in adopting and adapting the social studies of science and technology approaches in chapter 2, so I will not rehearse them here. But I want to reiterate that they – for example, actor-network analyses – have often been blind to gender, race, religion, class, sexuality and other axes of social difference. The turn from macro-structural to ethnographic approaches has served as a compelling critique of a static notion of social interests, but the 'doing' of gender,

both by male academics and by those they study, is rarely considered. As researchers, many fail to recognize that women's absence from the sociotechnical network does not mean that it is a gender-free zone. The network certainly has a gender politics. For this to become visible, the concept of the sociotechnical network needs to be extended.

In this final chapter, I argue for a recognition that gender and technoscience are mutually constitutive, and explain how this opens up fresh possibilities for feminist scholarship and action. I shall show that beneath a discourse of a gender-neutral sociotechnical network there is frequently to be found the hidden agency of new social movements, many of which are feminist in character, or have been inspired by feminism.

Changing Technologies, Changing Subjectivities

I began the book with a discussion of early feminist writing on gender and technology, much of which adopted a pessimistic tone. Originating from a liberal concern with women's historical exclusion from technical skills and careers, this perspective evolved into an analysis of the masculine character of technology itself. Technology was seen as a key source of male power, encompassing technologies of human biological reproduction and those of the workplace. Socialist and radical feminism emphasized the social relations of technology, and delivered a compelling critique of popular and sociological arguments that were (and still are) characterized by technological determinism. Technology was seen as socially shaped, but shaped by men to the exclusion of women. Problems of essentialism remained in much of this writing, leading to an over-emphasis on the intransigent aspects of patriarchal structures and norms embedded in technology. This scholarship was however much more sophisticated than is now

acknowledged and, as I have suggested in chapter 1, was prescient about developments in biotechnology and the computerization of work.

Much of this literature made a strong link between capitalism and patriarchy, seeing class and gender as bound together in the social relations of capitalism. For most social theorists, capitalist industrial society was characterized by sharp divisions between manual and non-manual work, between valued employment and devalued, privatized work in households, and gender-segregated employment patterns. However, as I argued, this dominant view of capitalism and its future development was in the process of breaking down, and the trends in computerization and biotechnology that socialist and radical feminists had identified were increasingly being associated with a fundamental change in capitalism itself. According to theories of post-industrial society, the old hierarchies were disintegrating and being replaced by less rigid, more flexible networks. At the same time, with rising standards of living, identities formed within consumption seemed to be becoming more important than those formed within the social relations of work and production. Theorists like Anthony Giddens and Ulrich Beck have argued that a new process of 'individualization' is undermining traditional sources of identity and solidarity, such as gender, local neighbourhood and class. For them, individuals in a post-industrial society are becoming 'reflexively aware', taking responsibility for their own biographies and 'choosing' life-styles and identities.

Reflecting more general trends in social theory, feminists have become increasingly uneasy with the negative cast of the debates about technology and society. They have warmed to information, communication and biotechnologies as being fundamentally transformative, unlike previous technologies. Theories of the global, networked, knowledge society see these technologies as revolutionary in their impact, providing the basis for a new information age. Cyberfeminists have been particularly influenced by

these ideas and, more generally, the 'cultural turn' in social theory. The virtuality of cyberspace and the Internet is seen as ending the embodied basis for sex difference and facilitating a multiplicity of innovative subjectivities. In the wired world, traditional hierarchies are replaced by horizontal, diffuse, flexible networks that have more affinity with women's values and ways of being than with men's. Here, I suggest, we have a technological and biological determinism in a new postmodern guise, this time as cyberculture in and of itself freeing women.

The optimistic register of such feminisms, stressing women's agency and capacity for empowerment, resonates with a new generation of women who live in a world of much greater sex equality. That a strong current of Seventies feminism sought to reject technology as malevolent is now seen as fanciful. Wired women in cyber-cafes, experimenting with new media, clutching mobile phones, are immersed in science fiction and their imaginary worlds. It presents a seductive image for a culture with an insatiable appetite for novelty. The possibilities of reinventing the self and the body, like cyborgs in cyberspace, and the prosthetic potential of biotechnologies, have reinvigorated our thinking. But the sometimes tenuous link between visceral, lived gender relations and the experience of virtual voyages has led many to desire a more materialist analysis of gender and technology.

To move forward, we first need to bridge the common polarization in social theory between metaphor and materiality. Technology must be understood as part of the social fabric that holds society together; it is never merely technical or social. Rather, technology is always a sociomaterial product – a seamless web or network combining artefacts, people, organizations, cultural meanings and knowledge. It follows that technological change is a contingent and heterogeneous process in which technology and society are mutually constituted. Indeed, the linear model of innovation, diffusion and use has given way to the idea that technology is never a finished product. Long

after artefacts leave the research laboratory, they continue to evolve in everyday practices of use. The interpretative flexibility of technology means that the possibility always exists for a technology and its effects to be otherwise.

If society is co-produced with technology, it is imperative to explore the effects of gender power relations on design and innovation, as well as the impact of technological change on the sexes. An emerging technofeminism conceives of a mutually shaping relationship between gender and technology, in which technology is both a source and a consequence of gender relations. In other words, gender relations can be thought of as materialized in technology, and masculinity and femininity in turn acquire their meaning and character through their enrolment and embeddedness in working machines. Such an approach shares the constructivist conception of technology as a sociotechnical network, and recognizes the need to integrate the material, discursive and social elements of technoscientific practice.

Feminist scholarship has been critical in exposing the gender-blindness of mainstream technoscience studies. Donna Haraway's contribution has been key, continuing the tradition of socialist-feminist inquiry into the possibilities that technoscience offers women. I have argued that her material-semiotic approach moves beyond the limitations of cyberfeminism, with its tendency to biological essentialism. The issue is no longer whether to accept or oppose technoscience, but rather how to engage strategically with technoscience while at the same time being its chief critic. Haraway's spotlight on the life sciences raises crucial issues of our time – in particular, whether the boundaries between nature and culture and between humans and machines, which have been an underlying premiss of the Enlightenment world-view, can be sustained and, if not, what the consequences are for our conception of humanness and the gendered body.

While broadly sympathetic with Haraway's unique attempt to bridge socialist and postmodern feminism, I

have argued that her 'cyborg solution' risks fetishizing new technologies. Her piercing analysis of the interconnections between capitalism, patriarchy and technoscience sits uneasily with her belief in a radical discourse of discontinuity and the emancipatory potential of advanced technologies. At times, the cyborg solution comes dangerously close to endorsing cyberfeminism's embrace of all technological innovations *per se*. While Haraway's lively textual deconstruction is appealing, as is her optimism, her focus on gender-as-it-could-be loses sight of the pervasive and relatively obdurate gender structure of sociotechnical relations. In the end, Haraway and those influenced by her give semiotics precedence over materialist aspects of technoscience.

Towards Technofeminism

Throughout this book, I have called into question the implicit division between cutting-edge technologies and existing technologies. I have suggested that all technologies be properly characterized as contingent and open, expressing the networks of social relations in which they are embedded. With this in mind, we will be less inclined to identify technology itself as the source of positive or negative change, and will concentrate instead upon the changing social relationships within which technologies are embedded and how technologies may facilitate or constrain those relationships.

I have frequently drawn on examples from earlier technologies to emphasize the heterogeneity of technological innovation. I now want to look in more detail at examples of digital technologies and their sociotechnical networks in order to draw the different threads of my argument together. I shall argue that while these technologies are different in important respects from those that preceded them, the social networks in which technologies are embedded have also changed. Importantly, they have

changed their character and identities in part as a consequence of feminist politics. Technological advances do open up new possibilities because some women are better placed to occupy the new spaces, and are less likely to regard machinery as a male domain.

This is in no small measure due to the sustained efforts of liberal feminists over the past thirty years. International feminist networks, such as Gender and Science and Technology (GASAT), have campaigned to encourage women and girls into scientific and technical education and employment. Workshops to encourage women to take up computing became widespread, and the analogy between the binary logic of writing software and knitting patterns was drawn to feminize this skill. Around the world, government policies reflect these concerns. Special programmes have been devised to encourage girls to pursue mathematics and technical subjects in schools. The standard engineering curriculum has also been targeted as a key barrier to changing the sex composition of students.

These efforts are continuing, and are an established feature of formal women's equality strategies. Progress has been halting. A recent report comparing six countries, including the USA, found that women are generally under-represented among graduates in the information technology, electronics and communications-related subjects, despite the fact that they form the majority of university graduates overall.[1] In the USA, for example, women were particularly under-represented among graduates in computer and information science (33 per cent) and engineering (20 per cent). At the doctoral level, in computer and information science, women accounted for but 19 per cent of degrees, and in engineering, only 17 per cent. The exception is the biological sciences, where women continue to be well represented.

This imbalance in women's and girl's educational choices has major repercussions because employment in the information technology, electronics and communications sector is graduate-intensive. It is reflected in women's

low participation in these occupations across the US economy, which declined from 37 per cent in 1993 to 28 per cent at the start of the twenty-first century. Where women are relatively well represented is in the lower-status occupations, such as telephone operators, data processing equipment installers and repairers, and communications equipment operators. By contrast, male graduates are heavily concentrated among computer systems analysts and scientists, computer science teachers, computer programmers, operations and systems researchers and analysts, and broadcast equipment operators.[2]

Such relatively stubborn sex-stereotyping is particularly intriguing given the feminization of higher education and work which has seen, for example, women entering law, medicine and business schools in unprecedented numbers. Moreover, it is highly irrational in a post-industrial society, whose economy is reputedly based on investment in human rather than physical capital. To paraphrase Manuel Castells, the key to success in the Network Society is self-programmable labour – knowledge workers who are highly educated, talented, flexible, innovative and autonomous. Whereas the key technologies of the industrial era were largely muscle-enhancing, information technologies are considered to be brain-enhancing.

So, the traditional basis for men's domination of scientific, engineering and technical institutions has been well and truly undermined. Yet women still face considerable barriers when they attempt to pursue a professional or managerial career in technoscience. It is necessary therefore to revisit the liberal feminist agenda of equal opportunities, and not to regard it simply as superseded. Women are missing out on good jobs in the knowledge economy, thereby impeding their financial independence. While the labour market remains so strongly sex-segregated and marked by a gender pay gap, social justice in employment will continue to elude us.

Moreover, a democratic commitment to equality between the sexes must go beyond the objective of equal

pay. What has been missing from much of the debate about getting women into technoscience is that their under-representation profoundly affects how the world is made. Every aspect of our lives is touched by sociotechnical systems, and unless women are in the engine-rooms of technological production, we cannot get our hands on the levers of power. This is the insight that technofeminism brings to these debates. I believe that there is room for an effective politics around gaining access to technoscientific work and institutions. There are opportunities for disruption. The involvement of more women in scientific and technological work, in technology policy, education and so on may bring significant advances in redesigning technology. It would also both require and constitute a challenge to the male culture of technology.

Understanding the alliance between technoscience and male power involves seeing technology as a culture that expresses and consolidates relations amongst men. Feminist writing has long not only identified the ways in which gender–technology relations are manifest in gender structures and institutions, but also highlighted gender symbols and identities. Men's affinity with technology is integral to the constitution of subject identity for both sexes.

I have written elsewhere about archetypal masculine cultures such as engineering, where mastery over technology is a source of both pleasure and power for the predominantly male profession.[3] This resonates with today's dominant image of IT work: the young, white, male 'nerds' or 'hackers' who enjoy working sixteen-hour days. Indeed, it is rare to see a female face among the dot.com millionaires. The 'cyber-brat pack' for the new millennium – those wealthy and entrepreneurial young guns of the Internet – consists almost entirely of men. The masculine workplace culture of passionate virtuosity, typified by hacker-style work, epitomizes a world of mastery, individualism and non-sensuality. Being in an intimate relationship with a computer is both a substitute for, and a refuge from, the much more uncertain and complex relationships that

characterize social life. Writers such as Castells, who eulogize the counterculture hacker origins of the Internet, fail to notice that the culture of computing is predominantly the culture of the white American male.

This is not to imply that there is a single form of masculinity. Sexual ideologies are remarkably diverse and fluid, and for some men technical expertise may be as much about their lack of power as a realization of it. It is indubitably the case however that in contemporary Western society, the hegemonic form of masculinity is still strongly associated with technical prowess and power. Feminine identity, on the other hand, has involved being ill-suited to technological pursuits. Entering technical domains has therefore required women to sacrifice major aspects of their gender identity.

A successful career in IT requires navigation of multiple male cultures associated not only with technological work but also with managerial positions, as I have discussed in *Managing Like a Man*.[4] For many women the price is too high. No equivalent sacrifice has been expected of men. Their identification with technology has been taken for granted, women's absence cast as women's problem. But women's problem is men, even though not all men are directly implicated. The challenge is for men who have premissed their masculinity on technical mastery to relinquish their hold on technology and give up the privileges and power that go with this construction of masculinity.

These technoscientific spheres will become more attractive to women when entry does not entail co-option into a world of patriarchal values and behaviour. As the proportion of women engineers grows, for example, the strong relationship between the culture of engineering and hegemonic masculinity will eventually be dismantled. Contemporary feminist criticism has sought to recover the feminine subject by challenging notions of women's passivity and identifying the different ways in which women actively resist and subvert conventional constructions of femininity. Wary of premissing a subjectivity on the

commonality of women, postmodern feminism stresses the multiplicity of identities and the desire for self-determination. Such an approach helps to account for different women's mixed and contradictory feelings when encountering technology. It also foregrounds the idea that women want to participate in technoscience on their own terms, and not as surrogate men.

Ultimately this depends on transforming gender power relations, which in turn requires changing the nature of work itself. Information and communication technologies offer the possibility of transforming the organization of work, making it more flexible and potentially enabling an easier blend of work and caring responsibilities. Personal computers, fax machines, mobile phones and e-mail mean that the performance of paid work no longer requires personnel to be physically present in the workplace. Mothers, and increasingly fathers too, are tapping into the space-time flexibility this affords to combine employment with child care. A reintegration of work and personal life, involving more sharing of paid work and housework, puts pressure on the traditional institutions of work that are themselves founded on gender inequality. Any move towards more egalitarian domestic arrangements will, in turn, enable women to take their full place in technoscientific work.

As feminists have argued, reordering the work–life balance will require recognizing the 'politics' of time. The different patterns currently found among men and women, and between parents and non-parents, reflect earlier negotiations of employment and personal life in different sociotechnical conditions. However, it is somewhat ironic that the 'imaginary' of new technologies emphasizes how they might liberate time, while the cutting-edge industries associated with them frequently exhibit the long hours associated with particular male work cultures.

At the same time, some women are using biotechnologies to enable them to adopt the male template of uninterrupted work. After all, the construction of women as

different from men is a key mechanism whereby male power in the workplace is maintained. Taking the contraceptive Pill, followed by Hormone Replacement Therapy, women are able to avoid the biological characteristics of femininity – namely, menstruation, pregnancy, breast-feeding and menopause. These corporeal processes signal women's difference, and mark them as unsuitable for the global, mobile, elite levels of corporate careers.

Postmodern analyses have correctly identified the body as increasingly a site for capital accumulation, and not just reproduction. New body regimes are seen as a linchpin of personal identity processes. However, much of this writing locates the body as an article in consumer culture, emphasizing the work people do on themselves through purchasing commodities. Cyborg feminism sees these technologies as potentially dissolving the sex/gender nexus in the hybridization of the lived sexed body and machines. Less attention has been given to work organizations as crucial sites in which the doing of gender is routinely accomplished. In this context, it may well be that Haraway's FemaleMan© could serve to sustain rather than undermine patriarchal work cultures. We must not forget that the future is open, and its direction will depend upon the forms of agency that shape it.

We saw earlier how the formation of engineering as a white, male, middle-class profession in the late nineteenth century cemented the gendered definition of technical expertise still familiar today. Muscles, skill, strength, dexterity, rationality and labour time became the preserve of men and important power resources. While the masculine subject was enrolled into this sociotechnical network, standard versions of femininity were simultaneously excluded. Indeed, the tight connection between gender identities inscribed on the body and the emerging networks accounts for their durability. Recent social studies of technology share with post-structuralist feminism an emphasis on the contingent and performative character of the self. As we have seen, the appeal of digital virtuality for postmodern

cyberfeminist writing is that it enables women to occupy new discursive positions beyond the dualism of gender. However, while escaping the corporeal body may be an appealing emancipatory strategy, it leaves untouched the gendered distribution of materials and resources that typically afford women less scope for initiatives in the workplace. It also misses the extent to which it is female corporeality that is being socially constructed as the problem, thereby reinforcing the power of masculine norms.

In order to renegotiate the cultural equation between masculinity and technology, technofeminism insists that we must attend to women's and men's concrete sociotechnical practices. A central theme of early feminist writing on technology was the power that men gained through their privileged access to muscle, capability, tools and machinery, 'part of the process by which females are constituted as women'.[5] We stressed that men's physical capacity and tangible skills were not so much due to natural difference, but were largely socially acquired, resulting in sex differences in ways of using the body to perform tasks. Moreover, women's marginalization from technical work has made it more difficult for them to acquire the practical experience and tacit knowledge necessary for expertise and confidence in physical engagement with objects. Rereading this literature now, it is strikingly resonant with current developments in feminist philosophy and sociological theory that stress the embodied character of social identity.[6] Actor-network theory, for example, sees the embodied self as a relational and material phenomenon, an assemblage acquiring its substance through its connections and embeddedness in networks.

Pierre Bourdieu's concepts of habitus and embodied cultural capital are in vogue as a way of grounding cultural theory in a sociology of practice. The habitus of social relations and practices includes machines; but what is less well understood is how machines themselves have a habitus and embody particular forms of cultural capital. Research on information systems and artificial intelligence is

increasingly emphasizing the importance of the body in human cognition and behaviour. For example, researchers at the University of Texas in Dallas have created a robot – K-Bot – with a human face, to facilitate interaction between humans and socially intelligent machines.[7] Unlike Andy, the first prototype, K-Bot has a female face, perhaps indicating that women are associated with emotional intelligence. None the less, the emotions that K-Bot can express – from sneering and frowning to smiling – are part of a repertoire of human communication that is highly gendered in terms of its use in social settings, including its use in hierarchy and dominance. The fact that K-Bot is represented as female is potentially about diminishing the threat that intelligent machines might pose to their human creators. It may also reflect the fantasy of systems designers, in a service economy predicated on female labour, who dream of being relieved of the mundane work involved in servicing themselves.[8]

If the gendered self is 'an assemblage of materials', then women's emancipation requires changing the woman–machine relationship to enhance women's capacity for initiatives over machines. In other words, all these streams of argument strengthen the need for women's greater appropriation of tools and technical expertise. Our interest here is the way in which some men can effectively deploy their technical and bodily capital to control technology, and the way in which male bodily capital can become embodied in technology. This point is routinely overlooked in the field of men's studies, which rarely sees sociotechnical relations as central to defining various masculinities. By linking gender to technology, technofeminist perspectives add a new dimension to sociological analyses of gender difference and sexual inequality.

Sociotechnical Practices: Expertise and Agency

The way technologies are encoded with gendered meanings that shape their design and use has been a recurring

theme in this book. It is worth briefly reminding ourselves about the process of innovation, outlined in chapter 2. During the design process, the developer maps out a plan for how the technical system will be used. This plan can be thought of as inscribed in the infrastructure. The inscription includes programmes of action for the users, defining roles to be played by users and the artefact or information system. Being inscribed in this way, technology becomes an actant imposing its programmes of action on its users. To be effective, programmes of action need to be inscribed not only in discrete devices, but also in aligned networks of technologies, humans and social institutions.

Of course, actual practice can deviate from the assigned programme of action. The construction of technical artefacts is not the exclusive domain of inventors and manufacturers. When studying the use of technical artefacts, one necessarily shifts back and forth between the designer's projected user and the real user, in order to describe this dynamically negotiated process of design. The interpretative flexibility of objects does provide entry points for women to renegotiate sociotechnical networks. Feminist systems developers are also involved in alternative forms of participatory design practice that take women's knowledges into account.[9] But for present purposes I want to highlight how the predominance of men in the design process may affect the shape and direction of technological innovation. It also positions women as *responding* to technologies that are already there.

Let us take the example of the wired house. One of the great paradoxes about domestic technologies is that, despite being universally promoted as saving time, these technologies have been singularly unsuccessful in lessening women's domestic load.[10] We might have hoped that the electronic home would achieve the wholesale elimination of household labour. The smart houses occupied by the very affluent display what high-technology dwellings might offer the family of the future. Magazines like *Wired* and futuristic films present home networking as the backbone infrastructure of the twenty-first-century life-style.

But it seems that the designers and producers of the technological home, such as the MIT 'House of the Future', have little interest in housework.[11] Home informatics is mainly concerned with the centralized control of heating, lighting, security, information, entertainment and energy consumption in a local network or 'house-brain'.[12] Prototypes of the intelligent house tend to ignore the whole range of functions that come under the umbrella of housework. The target consumer is implicitly the technically interested and entertainment-oriented male, someone in the designer's own image. The smart house is a deeply masculine vision of a house, rather than a home, somewhat like Corbusier's 'machine for living'. The routine neglect of women's knowledge, experience and skills as a resource for technical innovation in the home is symptomatic of the gendered character of the process.

While there would certainly be a commercial market for smart technologies that reduce housework, such as the robotic vacuum cleaner, the variety and complexities of household labour impose limits on its mechanization. Even in the differently ordered world of paid work, robots perform only routine tasks in manufacturing, and personal service work has proved impossible to automate. However, my point here is that even the most visionary futurists have us living in households that, in social rather than technological terms, resemble the households of today. The space-age design effort is directed to a technological fix rather than to envisioning social changes that would see a less gendered allocation of housework and a better balance between working time and family time. The wired home may have much to offer but democracy in the kitchen is not part of the package.

I have argued that the possibilities afforded by technological advances do not inhere in individual artefacts but are contingent upon the networks in which they are located. Once we look beyond the house itself as the site of domestic labour, we immediately see that working women are using their new-found economic independence

to buy their way out of housework. Cleaners and child-carers are only part of the story. Most striking is the extent to which women have embraced innovations in market-based alternatives to home-produced meals. Restaurant meals, take-away food, and almost-ready-to-eat goods from the supermarkets are extensively used to reduce the time women spend on domestic tasks.[13] Earlier I described how the microwave oven was seized upon by women, although it was designed for single men. These food technologies have changed the boundaries between the private sphere of the home and the public sphere of production. Despite the significance of this, they have received much less attention from third-wave and post-feminisms than, for example, biotechnologies.[14] However, it may be that these unsung sociotechnical networks have played a key role in transforming gender relations in the home and opening up the public sphere to women.

The telephone is another classic case of how women can actively subvert the original inscription of a technology. Designed by telegraph men for business purposes, the telephone was taken up by women for social functions. Similarly, the business-oriented mobile phone is widely used by women for reasons of personal security and maintenance of contact with the family. While this may be an intrusion of domestic pressure on women into spaces and times where previously they were isolated from it, remote mothering enables women to exist in domestic and work modes simultaneously.

Indeed, early concerns about women being left out of the communications revolution now seem misplaced. A proliferation of mobile phones, the Internet and cyber-cafes are providing new opportunities and outlets for women. This is particularly the case for middle-class women in highly industrialized countries, who are better placed than other groups of women to take advantage of these technologies. More than two-thirds of the Internet's content is, after all, in English. However, the Internet and the mobile phone may ultimately have even greater

significance for women in low-income households and communities in the global South. Pay-as-you-go mobiles have enabled hundreds of millions in Africa, Asia and the former Soviet Union to bypass the financial and bureaucratic obstacles of land-line phones and get connected. Around the world, although women still account for a lower proportion of Internet users than men, their share is rapidly rising.

Fear that the globalization of communications leads to homogenization, and reduces sociability and engagement with one's community, is a recurring theme in the literature. But all the signs are that new electronic media can help to build local communities and project them globally. The expansion of cyberspace makes it possible for even small, poorly resourced NGOs to connect with each other and engage in global social efforts. These political activities are an enormous advance for women who were formerly isolated from larger public spheres and cross-national social initiatives. 'We see here the potential transformation of women, "confined" to domestic roles, who can emerge as key actors in global networks without having to leave their work and roles in their communities.'[15] Just as the car increased women's mobility and capacity to participate in public space, so the new media have expanded women's horizons and capacity to connect with networks and campaigns to improve their conditions. To this extent, women are reinterpreting the technologies as tools for political organizing and the means for creation of new feminist communities.

Recognition of these opportunities is not to endorse utopian ideas of cyberspace being gender-free and the key to women's liberation. I remain sceptical of exaggerated claims by cyber-gurus and cyberfeminists about the Internet being the technological basis for a new form of society. Rather, it is to stress that the Internet, like other technologies, is flexible and contains contradictory possibilities. Much has been made of the 'digital divide' producing new forms of social exclusion. Policies to reduce dispari-

ties in Internet access, and the acquisition of skills to use these new media, are important. However, a technofeminist perspective points beyond the discourse of the digital divide to the connections between gender inequality and other forms of inequality, which come into view if we examine the broader political and economic basis of the networks that shape and deploy technical systems.

Most commentators take the technical architecture of new media, such as the Internet and the Web, as pre-given. The issue for them is one of diffusion. However, most new media configurations are biased towards exclusive electronic spaces for commercial activity. As Saskia Sassen notes, the three properties of digital networks – decentralized access, simultaneity and interconnectivity – have produced strikingly different outcomes in the private, fire-walled sites of global finance from the distributed power of the public-access cyberspaces. In fact, there are trends towards increasing privatization of the Internet, with multiple classes of service and access to information depending upon the ability of users to pay.[16] Network power is not then inherently distributive, as cyberfeminists among others would have us believe. In the hands of multinational corporations and capital markets, it can concentrate power.

Much of the triumphalism about digitization rests on the assumption that we are living in a post-industrial, consumer-based society. There is a widespread belief that production is no longer the organizing principle of contemporary society. The focus has shifted to information, consumption, culture and life-style. However, production has not disappeared, but is being carried out in strikingly novel forms on an increasingly global basis. Much low-skilled, assembly-line work has moved offshore to the Third World, and is performed predominantly by women rather than men. The quintessential product and symbol of the new age, the computer, is often manufactured in precisely this fashion. For a young woman in the West, her silver cell phone is experienced as a liberating

extension of her body. The social relations of production that underpin its existence are invisible to her.

As material objects, mobile phones have to be mass-produced in factories. Furthermore, along with other electronic devices, such as laptops, they require the scarce mineral Coltan. One of the few places where this can be found is Central Africa, where it is mined under semi-feudal and colonial labour relations, to provide raw product for Western multinational companies. The sharp rise in the price of Coltan on global markets has local effects, accentuating exploitation and conflict among competing militias, with the very specific consequences for women that military conflict brings – namely, rape and prostitution.[17]

A mobile phone then is a very different artefact, depending upon a person's place within the socio-technical network. In tying together these relations of production and consumption, technofeminism not only scrutinizes the emancipatory metaphors, but also seeks to balance this analysis with an equal emphasis on the material realities of a technology's production and use.

It is much remarked upon that anti-corporate globalization protests rely on global new media for their mobilization, as well as enjoying simultaneous broadcast on conventional mass media such as television, radio and newspapers. Electronic space is thus a crucial force for new forms of civic participation. Consumers are using this space to express solidarity with the poorly paid producers of their fashionably branded goods. These initiatives can bypass national states, and create new networks involving historically disadvantaged peoples and groups. Foremost among these are women, who are a dynamic presence in cyberspace.

Indeed, the communications revolution coincides with massive social transformations associated with increasing emancipation of women world-wide, economically, culturally, and politically. Likewise, when we look back at the revolution in contraceptive technologies, we can see that women were not the passive recipients of a 'magic bullet'

delivering sexual liberation. Western women were ready for the Pill because of other changes to the family and the economy, which were giving rise to second-wave feminism; but they had practised contraception long before the advent of the Pill.[18] Today much is made of innovative biomedical techniques bringing about new family forms and disrupting traditional blood-based kinship. But developments such as the increased incidence of lesbian mothers are a product of women's economic independence and feminist/gay/queer politics, rather than *in vitro* fertilization. The belated emergence of the male Pill similarly reflects changes in gender politics rather than recent scientific advances.

In the previous chapter we saw how Haraway deconstructs the 'modest witness' to the birth of experimental science as being implicitly a white European male. The gender critique of scientific knowledge, and the attempt to regain control over women's bodies, were key to second-wave feminism. There was a growing disenchantment with male medical theories and practices. The development and consolidation of male expertise at women's expense was splendidly captured in *Witches, Midwives and Nurses: A History of Women Healers*.[19] As well as being scholarly, studies such as this inspired new political practices. Collective self-help groups for purposes including contraception, pregnancy testing and gynaecological self-examination empowered women in relation to professional medical control. These initiatives were born of the conviction that women could develop new kinds of knowledge and skills, drawing on their own experience and needs, while being sensitive to racial, class and ethnic differences.

Women have come into medicine in great numbers at all levels, and now form a critical mass in the biological sciences and as doctors, as well as being the principal consumers of health services. Birthing practices that once had mothers flat on their backs with their legs in stirrups have been transformed as a direct result of feminist campaigns to give women more control. Women have mobilized to

share medical information and compare treatment regimes, challenging deference to medical expertise. They have been quick to seize on the Internet, both as a source of information and as a tool for global exchange, support and political lobbying. For example, the National Breast Cancer Coalition used such means to convince the US Congress to more than double its funding for breast cancer research. These new patient associations are displaying a new militancy, and are demanding a voice in how their conditions are conceptualized, treated and researched. Such networks promote women's agency and increase their capacity to engage in the production of scientific knowledge.

While the grass-roots AIDS treatment movement is now routinely credited with transforming the relationship between patients, disease and medication, it learnt much from the women's health movement of the 1970s. The AIDS movement, however, had a distinct advantage in being dominated by white middle-class men with a degree of political clout, fund-raising capacity and a high proportion of medical and other professionals, unusual for an oppressed group. Examining the gay community's efforts to speed up and direct AIDS treatment from 1987 to 1992, Steven Epstein argues that they succeeded in influencing how scientific research is done by adopting strategies that scientists themselves use. AIDS activists accomplished an identity shift: 'they reconstituted themselves as a new species of expert – as laypeople who could speak credibly about science in dialogues with the scientific research community'.[20] Establishing themselves as the legitimate representatives of the entire HIV-positive population, they became obligatory passage points, standing between researchers and the clinical trials they sought to conduct. Importantly, activists tied their moral and political concerns to epistemological and methodological arguments, using accepted notions of good science to gain credibility and support from scientists and the general public.

Clearly the politics of such coalitions is not without contradictions: primarily the conflict between commercial and

public interests. In this case, AIDS activists wanted wider access to health care, including experimental new drug treatments; companies wanted to design and market new, profitable drug treatments. While the negotiation between the two sides did not make the drug companies community-oriented, changes in the approval process did incorporate many of the users' demands. Moreover, the movement's success has had an enduring impact on biomedicine in the USA, enhancing consumers' right to biomedical knowledge and allowing new actors to enter sociotechnical networks of health care. New campaigns linked both to these health movements and to anti-capitalist protests have had some success in pressuring pharmaceutical multinationals to waive their patent rights, thereby making life-prolonging HIV/AIDS treatment drugs more affordable for people in developing countries. There women bear the brunt of the epidemic: more than five million young women (between the ages of fourteen and twenty-four) are living with HIV/AIDS in sub-Saharan Africa, and two and a half million young men.

However, the best immunization against AIDS for children is to ensure that girls have the resources to grow up to be financially independent and that boys learn to respect women. Without access to education, land and credit, young women do not have the knowledge or economic power they need to negotiate sexual activity successfully. Condoms and AIDS education are of little use to girls who lack the bargaining power to negotiate safe sex. In Uganda and Senegal – Africa's most heralded successes in stemming the spread of HIV/AIDS – the empowerment of women and girls has been instrumental in changing risky sexual practices.[21] Both countries have opened up access to productive resources to women, starting with girls' education. The lesson from this experience is the importance of empowering women, rather than relying on a technological fix. The idea of the sociotechnical web emphasizes the need to contextualize the meaning, effects and perceived value of technologies, as they vary by culture and country.

While there are enormous differences between women, especially in the developed and developing countries, educating girls may in the end be the universal key to transforming female embodied subjectivities.

Conclusion

One of the ironies of mainstream science and technology studies is that, while its central premiss holds that technoscience is socially shaped and inherently political, there has been a reluctance to consider the implications of its own methodologies. Practitioners act as if their own methodologies are not affected by the social context and have no politics. They do not reflect on how the preponderance of white, privileged, heterosexual men might have framed the field. Paradoxically, under attacks from science wars writers, some science studies authors have taken refuge in conventional social science attitudes of disinterest and disembodiment. Some go as far as to claim the principle of generalized agnosticism, according to which the investigator should not take sides in the technical or social aspects of the controversy being studied.[22]

Feminist scholars have long rejected this 'principle', substituting a reflexivity about the relationship between researchers and the subjects of their research that acknowledges the bond between theory, research and experience. Mainstream authors are much more reluctant to deconstruct their own claims to authority. Legitimating the scientific status of the field has involved erecting a boundary between 'good' science studies and feminist approaches, the common charge being that feminist technoscience has a 'frankly political agenda'.[23]

This is so, but not in the way that the mainstream charges. For technofeminism, politics is an 'always-already' feature of a network, and a feminist politics is a necessary extension of network analysis. Science and technology embody values, and have the potential to embody different values. The strength of feminism is that it is

strongly attached to a rigorous social analysis – that is, one that meets certain evidence standards, yet always links research to a political practice of making a difference to the network and its effects. It is this relationship between social analysis and projects of social transformation that marks a fundamental difference between standard techno-science studies and technofeminism.

But can we speak of techno*feminism* in the singular in the midst of an efflorescence of theoretical work contesting and revisioning the categories of gender and sexuality? The emergence of black and post-colonial feminism, for example, has posed a critical challenge to the privileging of the preoccupations and knowledges of white, Western women. As a result, feminist conversations are much more attuned to the different ways women live and experience technoscience, depending on their location.

For all the diversity of feminist voices, however, there is a shared concern with the hierarchical divisions between men and women that order the world we inhabit. I have set out examples of the many different ways in which women's groups and others inspired by feminist political practice have infiltrated and begun to reshape the networks of science and technology. The feminist project may not be finished, but it has made a difference, and, in conjunction with emerging technologies, is creating new spaces for further development of the project. Issues of embedded inequality and privilege recur, and must be addressed. A technofeminist conception of sociotechnical networks enables such connections to be made, from the micro-politics of local activism to the macro-politics of global movements.

The feminist project is incomplete, and some, as we have seen, have responded to the distance we have yet to travel with the kind of pessimism that fosters an essentialist view of technology and its gendered power relations. Cyber-feminists have taken a utopian position, looking to new technologies as in themselves transformative. The problem with both positions is that they assign too much agency to

new technology, and not enough to feminist politics. Technofeminism is grounded in the understanding that only we can free ourselves. This makes a feminist politics both possible and necessary. Feminist politics has made a difference, and we can build upon the difference it has made. We do not live in a world that is post-feminist, but we do live in a world that feminism has shaped and will continue to shape.

The denial of feminist politics remains a feature of mainstream discourses, both academic and everyday, and it would be cruelly ironic if our own frustrations with what remains to be done should contribute to our own marginalization. Especially since feminist politics remains one of the major sources of contestation of inequality and privilege in a world where it can frequently seem as if gains previously won might easily be lost.

For example, the juxtaposition of scientific expertise with lay citizens' knowledge has become a mainstream political issue in today's accident-prone world. In contrast to the bright future predicted by information society theorists, Ulrich Beck's 'risk society' struck a chord with growing popular concerns about the human and environmental consequences of technoscience.[24] Here science has become full of uncertainties, and is responsible for generating new and unprecedented risks to society and the natural environment, whose destiny is increasingly interwoven with our own. The promises of knowledge have been overwhelmed by the omnipresence of risk.

Once again, these new discourses of risk tend to assign change to technology itself, as if it were outside the social networks upon which it impinges. Indeed, Beck's emphasis upon de-traditionalization suggests that older, more solidaristic social networks are being replaced by looser networks made up of reflexively aware, but anxiety-prone, individuals. What is missing, however, is precisely an account of the new solidarities that are being created by the collective movements that feminism has helped to engender. In this context, it is interesting that a dominant theme of

the new malestream in social theory is 'individualization' as a central feature of the 'risk society', just as these collectivities have entered the social networks of science.

Indeed, the heightened public awareness of risks means that gaining public acceptance of science and technology is on government agendas everywhere. There is renewed interest in bringing non-expert citizens into participatory contact with specialists, experts and policy-makers, to create a sense of participation in risk-policy choices. Ideas of deliberative democracy are in vogue, drawing for example on models of consensus conferences and citizen juries. There is a proliferation of innovative deliberative exercises in many countries. These ideas are in tune with Haraway's call for a move away from an expert identity in science to a more democratic identity that recognizes the multiple and diverse voices of women and 'others', who are seldom heard in the conversation.[25] It is easy to understand that this may be experienced as a loss of the older certainties among previously solidary elites, but the process depends upon new solidarities and forms of agency entering to inform social and political agendas.

So it is timely that there is much debate at the moment about the way in which some feminist discourses seem to essentialize women's identity, by trying to identify commonalities in experience that could form the basis of a shared moral commitment. This is juxtaposed with a perspective that sees identities as fractured, variable and changing with context. For many, the latter position captures the truth of our postmodern condition. Yet, it also contributes to a current pessimism.[26] For is not a common identity a pre-condition for collective action? I think I have shown that this is a false opposition. We do not need to have the 'appropriate' identity prior to entering social networks; identities are formed and shaped in the manifold relations that *are* social networks. Far from this being an obstacle to feminist politics, it has been the very context in which feminist politics has flourished, linking the personal to the political, and the local to the global.

Perhaps our ideas about identity and agency remain too close to the model of solidarity and collective action proposed for the transformation of class-based industrial society, a model in which gender was conspicuous by its absence. It is doubtful that gender identities will have that form; but neither did class identities approximate their model. If the model is inappropriate, it could not describe a problem that feminism must overcome in order to be successful. Just as feminism has made a critical theoretical contribution to the understanding of science and technology as social and political, so feminist movements are among the most successful at practising 'smart' politics and shaping sociotechnical networks.

The promise of technofeminism, then, is twofold. It offers a different way of understanding the nature of agency and change in a post-industrial world, as well as the means of making a difference.