towards a feminist transformation of the sciences

Love, power and knowledge

HILARY ROSE

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To Steven for (mostly)
sharing dreams and being
practical

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Towards a Feminist Transformation of the Sciences

Hilary Rose

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Prologue

The genesis of this book lies a long way back in personal biography and its continuing intersection with history. As with any preoccupation which has developed over a period of years there is no one single moment, no clear unfolding, just a lumpy thread in the fabric of everyday life, a lumpiness which insisted that I look at it more closely. Genesis becomes less a tidy chronological account than a series of troubling memories; generation as well as gender, class and 'race' frame my thinking. The starting point is memories of war, the horrifying enigma of the Nazi death camps, for these were simultaneously real and unbelievable. How could anyone systematically exterminate an entire people? Other cultures, not least that to which I belonged, had massacred and killed; the new dimension was the meticulous book-keeping of murder. Thus the specific obscenity of the death camps was this 'rationality'. At the time I think I understood this as perverse, for my sense of rationality stood on the side of freedom and justice. But history was to render this sense problematic.

It was perhaps not until the fifties, as a very young woman, that I became intensely aware that the nuclear bomb might well mean no future for my own or for any other child. How was it that science, which seemed to promise so much, was also so deadly that it threatened the human experiment itself? With many others of that generation I walked at Easter to Aldermaston, the centre of bomb research in Britain. Science's collusive relationship to militarism, and scientists' liking for the corridors of power, were untidily entangled with the social optimism of that postwar generation which believed that full employment and an improving welfare infrastructure were

its birthright. I remember reading a book in the late fifties which spoke of the authoritarianism of science; it was like being told about a key which might unlock the puzzle.

The 1960s brought the Vietnam War and the explosive appearance of an international student movement which wanted both an end to an imperialist war and a beginning to a new and more democratic society. An enraged opposition to a genocidal technoscience was integral to the refusal of a genocidal and racist culture; the visible and international network of those who were both in and against this technoscience formed the radical science movement. Being part of an immense social movement gives courage, not least courage to look closely at science and at its self-representation – even to begin to smell and see the possibility that not only was science these things but also both it and its critics were profoundly androcentric.

As I grow older I feel that trying to capture criticism in words, by writing and publishing, is like trying to put salt on the tail of a devil. The book that Steven (Rose) and I wrote in the sixties called *Science and Society* – which at the time seemed just the right title – later made both of us feel rueful. For such a title reinforced the very idea we were trying to overcome, namely that science and society were distinct. Collected essays grouped under the banners of *The Radicalisation of Science* and *The Political Economy of Science* seemed fine in the mid-seventies until my growing sense of the conceptual and political obliteration of gender brought discomfort. Adding women to the marxist political economy of science and stirring was no longer enough.

Trying to comfort research students who tell me that their theoretical framework has changed and that they are finding it difficult to finish their theses, I sometimes suggest looking critically but kindly at oneself over time, as, rather concretely, the 'younger and misguided Hilary Rose'. They and I know that it is not quite as easy as this; I still feel myself accountable for what I have written before (taking responsibility for that allegedly generic 'he' I know I have used) and that I have to make a reckoning with that younger self. So writing, as I did, a paper called 'Hand, Brain and Heart' in the early eighties (*Signs: Journal of Women in Culture and Society*, 9 (1) 1983, pp. 73–90) was for me a way of seeking the reconciliation of a number of different selves and above all of this new self, which had been able to come more clearly into existence within second-wave feminism. In my essay the metonym of the Heart stood in for the caring labour of women, left out by marxist political economy, and for the responsible thinking that arose from this labour which was left out of a marxist theory of knowledge. Such a new feminist knowledge might, I argued, re-vision rationality itself, fostering representations of nature which were more pacific to women and nature alike.

Teaching social work and women's studies students at the University of Bradford, with their immense respect for women's every-

day lives, has made me very conscious of the relationship between knowledge and love. Yet what were the connections between that everyday responsible rationality, that thinking from caring, and the power/knowledge couple which has dominated thinking about science from Francis Bacon to Michel Foucault? There were theoretical difficulties too. Although I felt myself to be a marxist feminist, within Britain the feminism which took gender and the body most seriously was that of radical feminism. How could I admit the body without biological reductionism, and still make connections to class and race? My precarious solution was to think of myself as a materialist feminist and to engage with the feminisms of Scandinavia and the US, as these placed gender as central and took the body as real. For that matter so did the strong tradition of British feminist research on human reproduction to which I also felt indebted.

However, for those of us living in Britain, an old industrial society with a problematic economy and a growing culture of social indifference, the changed context of the 1980s and 1990s has seen those fierce divisions of radical and socialist feminisms diminish; the body and gender are now central issues for feminism. The significant difference is that now feminist materialism is itself having to compete for intellectual space against a strong poststructuralist current. It has been in and against this changing context that the present book has been all too slowly written. I wanted to explore and listen to the many different voices within the feminist science debate. I have felt more than uneasy at some of the new developments but have had no intention of returning to that tradition of fierce polemic in which I was constructed and which it has been a source of satisfaction to resist. (Though I am not so good a feminist that I do not chuckle over robust and witty denunciations, usually from within that self-same marxist viriculture of androcentric poststructuralists.)

The nine chapters of *Love, Power and Knowledge* are organized around three broad concerns: first, the content, context and history of the feminist critique of science as it has developed since the 1970s (chapters 1–4); second, the situation of women within the institutions of science (chapters 5–7); and third, the culture of science – both actually existing science, and science as feminists might reconstruct it (chapters 8–9, and the epilogue).

The book thus begins with a focus on theoretical issues. Chapter 1 surveys feminist science criticism and theory as they have developed (primarily but not only) in the West, tracing their origins as in part the disobedient daughters of the radical science movement, and in part the daughters of the women's liberation movement and of academic feminism. These were to become powerful voices within and of feminism in the eighties and nineties. The second chapter explores feminist constructions of a responsible rationality as shaped by the everyday lives of women and by feminist values; the belief which is central to my book is that such a revisioning of rationality is crucial to

the reconstruction of science. Such a feminist project is both politically realist and utopian; realist because the contemporary culture of technoscience is so deadly that it must be reconstructed; and utopian because the gap between this reality and any gentler one is still immense. Chapter 3 explores the institution of academic feminism as the means through which feminism as a social movement is seeking to change the knowledge system. This chapter is preoccupied with the tension between academic feminism, its cultural and political projects, and its location in diverse national contexts within a global production system of knowledge. I wrote it as a first stab at a feminist sociology of feminist knowledge, as it seemed to me that this might help academic feminists in our many and manifold struggles against that old and appropriately gendered adage of 'he who pays the piper calls the tune.' My fourth chapter turns to the debates within feminist science theory. I read these debates between realists (or standpoint theorists) and postmodernists as very different from those within the mainstream culture, because of the overt commitment of all their participants to feminism as a political project, but also as subtly different from the debates in other areas of feminist knowledge and cultural production. The common preoccupation with nature and with representations of nature frames the debate in ways that are different from discussions of literature, film or the psyche.

My second theme occupies the next three chapters, which are concerned with the structure of the scientific knowledge system and where women scientists are within it. Chapter 5 is thus a structural counterpart to chapter 4; where the latter looks at ideas, the former looks at how far different patriarchal academies have admitted, or been forced to admit, women. Just how far has feminism achieved its goals of equality of representation within the academic labour force? How near is the objective of 'nothing less than half the labs'? Chapter 6 examines the story of the admission of women scientists into the Royal Society, that bastion of British scientific eminence which for three centuries managed to exclude women. The interest of this particular account is the dramatic contrast between the self-representation by this elite body of how Fellows are customarily elected, and the quite extraordinary treatment accorded the first woman candidate to be proposed in the light of the anti-discriminatory legislation passed some two decades previously. The archives of the Royal Society provide a marvellous insight into the ways men have managed to exclude women and how actively they 'man'aged their admission into elite institutions. It is to the credit of the Royal Society that unlike the British government it does not seem to weed its archives, so that the mechanics of the patriarchal scientific power elite are exposed to view. The third chapter in this group focuses on women scientists at the apex of the prestige sytem of science, the nine women Nobel Laureates there have been over the nine decades since

the institution of the prize. As well as honouring the extraordinary achievements of these women I wanted to show how their biographies could also be understood as like those of other women scientists of their time. (Working on this chapter in Sweden, where governmental papers are, especially to a British social scientist accustomed to a culture and law of official secrecy, remarkable for their openness, was peculiarly frustrating, as the Nobel archives are closed for fifty years.) Chapters 5–7 thus seek to reinforce the need to battle for space for women within the organizational structure of the production of knowledge even while feminism struggles to reconceptualize the knowledge system itself.

Chapters 8 and 9 are in very different ways about threats and hopes. Chapter 8 focuses on the powerful emphasis given to the new genetics within the life sciences. Increasingly consuming a significant section of the life science budget, its highly reductionist explanations of human bodies and behaviour alike seek to dominate the biomedical culture and bring particular challenges to women. The chapter brings together a recognition that science is socially shaped with a critical analysis of the cultural content and implications of that knowledge. Chapter 9, for me one of the most enjoyable to write, explores some of the texts of feminist science fiction in an extensively revised version of a paper, 'Dreaming the Future', originally published in *Hypatia*, 3 (1), 1988, pp. 119–37. Here, in a laboratory of our own, feminists can explore and experiment with other ways of knowing, other sciences and other futures than those offered by the seeming inevitability of an androcentric technoscience. Finally, in the epilogue, I address the unfinished business of moving beyond the one-sided rationality of masculinist science, to ask how, within our everyday lives, we can begin to create sciences which bring together love, power and knowledge.

Thinking and writing this book in a changing socioscape has for me been a protracted process, a mixture of isolation and feeling part of a continuing and immensely creative conversation. At the birth of modern science in seventeenth-century England the men and tiny numbers of women who corresponded with one another nationally and internationally, sharing and arguing over ideas about nature, felt themselves to be part of an invisible college. Over the past two decades a new invisible college, this time of feminist critics and theorists of science, has come into existence. Initially no more than a handful, the numbers have grown quite rapidly. Making my acknowledgements is thus, for very welcome reasons, hard. But the particular invisible college to which I am indebted, both individually and collectively, and which I think has never corporeally and completely met, includes: Lynda Birke, Tarja Cronberg, Anne Fausto-Stirling, Donna Haraway, Sandra Harding, Nancy Hartsock, Ruth Hubbard, Evelyn Fox Keller, Maureen McNeil, Nellie Oudshom, Vandana Shiva, Kate Soper and Ethel Tobach. Death has taken some

of the most wonderful participants; I think with sadness of Ruth Bleier's and Wendy Farrant's premature deaths; yet different others enter. A central pleasure in this feminist symposium is heterodoxy, pleasure in contention rivalling delight in discovered agreement.

The University of Bradford has provided an extraordinarily rich feminist milieu, especially since we established the women's studies degree in 1981, an act of creative resistance in a year of brutal and stupid cuts in British higher education. Colleagues and friends there have been a precious resource; two with very different approaches to feminism, who live a caring responsibility of knowledge and have been particularly important to me, are Sheila Allen and Jalna Hanmer. Errollyn Bruce, Pauline Brier and my students within the West Yorkshire Centre for Research on Women have been a valued source of stimulation and friendship. Conversations with feminists over the years working in and on human reproduction have been important, notably Ann Oakley, Frances Price, Wendy Savage, Meg Stacey, Michelle Stanworth and Gail Vines.

In addition to drawing general support and encouragement from being part of a rich feminist culture I have many directly book-related debts owed to an amazingly multidisciplinary network of friends and colleagues who read draft chapters and sets of chapters: Lynette Hunter, my literary friend; historian Diana Long; and biologists Ann McLaren, Clare Woodward and Val Woodward. I owe very special intellectual political and personal debts to that heroic band who read and commented on the entire book: Sandra Harding, Donna Haraway, Ruth Hubbard and my Polity editor Michelle Stanworth. Last I must thank Steven Rose, who read and discussed many drafts at different stages and whose sustained emotional and intellectual support was crucial to my finishing.

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Introduction: Is a Feminist Science Possible?

Science it would seem is not sexless; she is a man, a father and infected too.

Virginia Woolf, *Three Guineas*

For the master's tools will never dismantle the master's house. They may allow us to beat him at his own game but they will never enable us to bring about genuine change.

Audre Lorde, *Sister Outsider*

To ask, 'Is feminist science possible?' is to return to our own history of struggle and the contradictory relationship of feminism to science and its changing definition.[1] For second-wave feminism, science and technology have not – with the almost single and certainly exceptional voice of Shulamith Firestone – been seen as progressive for women's interests. There has been little chance of invoking the metaphor, unhappy or otherwise, of courtship and marriage that was widely used to foster the hoped-for relationship between marxism and feminism. Where the radical science movement of the 1960s had to free itself from the progressivist claims of science – to show that science was not even neutral but often oppressive and antithetical to human liberation – many women, already outside such progressivist claims as a result of their very exclusion from science, had a hunch that modern science and technology served all too often as means of domination and not liberation.

Overtly relegated to nature by the recrudescence during the seventies of the patriarchal determinism of sociobiology, feminists learnt to uncover and contest the practices of an androcentric science. In claiming a place in culture, feminism has had to think much more deeply about both social relationships and the relationship of women to nature. Indeed feminist biologists, in contesting the boundaries of nature and culture laid down by sociobiology, understood in a direct and practical way that as women we, our bodies and ourselves, are part both of nature and of culture. Political and cultural struggles waged by feminists within and without science have contested a patriarchal science's right to determine those boundaries. For the most part feminist struggles have resisted biological determinism, which reduced women to nothing but their wombs, hormones, genes, or whatever was the bodily part in biological fashion,[2] but there is also a record of feminists using nature – even essentialism – as a resource in the defence of women.[3]

The recurrent mood, as and when the feminist movement preoccupied itself with science, has been one of anger. This anger extended from a sense of injustice at being shut out of an activity that some women, despite the engendered rules of the game, always wanted to take part in to an overwhelming sense of fury that masculinist science and technology are part of a culture of death. The ideology of science, proclaiming objectivity, freedom from values, and dispassionate pursuit of truth, has excluded women and been integral to our cultural domination, has harmed women's bodies (in our best interests, of course), and has threatened the environment itself. That science claimed its ideological purity, leaving by implication its partner technology to carry the responsibility for the dirty side of the relationship, was part of science's skill at conveying a culture of no culture.

Second-wave feminism began relatively slowly to analyse and contest science, to see the connections between this entity called 'science' and those issues that the movement defined as its own.[4] There were good reasons why the movement was slow; its central preoccupation was with women's shared experience, to reclaim what had been denied or trivialized out of existence and return it to social and political existence. The feminist movement has developed and changed in many ways since those early, path-breaking years of the late 1960s and early 1970s. Then, to consider housework, abortion, sexuality, love, birth control, motherhood and male violence as central social issues was to work against the grain of an arrogant and naturalizing masculinism. Feminism necessarily embraced body politics; the struggle for the repossession of our bodies, including knowledge about them, was to become central to the movement. The very process of examining these everyday aspects of women's lives, learning to speak about them, forged new concepts, new names.

Naming – conceptualizing – has been rightly seen within feminism

as empowerment.[5] Naming brings into consciousness phenomena and experiences hitherto denied space in both nature and culture. In the fierce opposition to new concepts, it becomes clear that often these are not merely unacknowledged aspects of reality waiting to be discovered, but are actively erased by the values of the dominant culture. Even today feminism's concept of gender meets strong resistance from androcentric social theorists, or it is used as a euphemism for women, thus denying relationality and so diminishing the political and cultural claims. Naming, above all when the words become part of the language of new historic subjects seeking to take their place in society, simultaneously contests existing hegemony and affirms a changed consciousness of reality.

Feminists both constructed new knowledge, new accounts of the world from the perspective of women's everyday lives, and also tore down existing hegemonic ideas. Central concepts which had organized thought and culture, not least sacred reason itelf, were interrogated and found to be far from some timeless universal thought form, but instead a gendered, historically and geographically specific construct. The intense abstractionism of masculine thought came into visibility.[6] To catch the distinctive character of women's and feminist thought, feminists evoked alternative metaphors of spinning and quilt-making, reconstructions of a responsible rationality, of an ethic of care.[7] As Adrienne Rich wrote: I am convinced that 'there are ways of thinking that we don't yet know about. I take these words to mean that many women are even now thinking in ways which traditional intellection denies, decries or is unable to grasp.'

Although feminism has touched women's lives the world over and draws increasing numbers of women into its vortex, it is none the less true that the movement has been strongest within the old capitalist societies – and it is here that the discussion of science has been most intense. This is not to say that feminists in what were the societies of 'actually existing socialism' and third world or sometimes black feminists within advanced industrial societies have experienced science and technology in a particularly favourable way; rather that, for necessary reasons, their attention has been primarily focused elsewhere. It has been the unremitting struggle to produce enough food without further green revolutions harming people and land alike, the struggle against disease, not least the AIDS which sweeps Africa, and other crises of the environment which have placed science and technology on the agenda of third world women's struggles to survive.[8]

From the earliest days of the radical science movement of the 1960s, the critique of science and technology has focused attention on the ways in which existing science and technology are locked into the contemporary forms of capitalism and imperialism as systems of domination. This denunciation has served two functions. Negatively, it has facilitated the growth of an antipathy to science that rejects all

scientific investigation carried out under any conditions and at any historical time.[9] Within feminism this took the form of denouncing all of science and technology as monolithically and irretrievably male. More positively, the denunciation has fostered the difficult task of constructing, in a prefigurative way, both the forms and the content of a different, alternative science – one that anticipates the science and technology possible in a new society and, at the same time, contributes through innovatory practice to the realization of that society.[10] But from its inception, with its false starts as well as real achievements, its perilous balancing between atheoretical activism and abstract theoreticism, the project was not without its contradictions and difficulties. Feminism is just beginning to recapture the full force of Virginia Woolf's compelling aphorism; science, it would seem – to rephrase – is neither raceless, sexless nor classless; she is a white man, bourgeois, and infected too.

The trouble with science and technology from a feminist perspective is that they are integral not only to the systems of domination of late capitalism and its new forms of imperialism, but also to one of patriarchal domination; yet to try to discuss science under these structures of domination or to argue that they constitute one social formation has proved peculiarly difficult. The present chapter serves to open that discussion by looking, first, at the radical critique of science of the 1960s and 1970s, and then at the growing body of feminist scholarship which developed partly in co-operation with, and partly against, the androcentric voice of the radical science movement.[11]

The radical critique of science

The critique of science was to explode into practice and to struggle into theory during the radical movements of the late 1960s and early 1970s. The rich and complex issues contained in the class and social struggles of those movements were frequently narrowed and constrained as the theoreticians filtered the wealth of lived experience through the abstract categories of theory. From an early rhetoric which attacked with a certain even-handedness the class society, imperialism, racism and sexism (those who were black, colonized or women might well have had doubts about their equal prioritization in practice as well as in rhetoric), two main lines of analysis were devloped. The first considered the political economy of science, and the second took up the relationship between science and ideology. While the two are linked at many points, work in political economy was more coherently developed; work on the debate over science and ideology was and remains more problematic.[12]

The need to reply immediately to the renewed biological determinism of the 1970s and 1980s was urgent as scientific racism sustained a

growing political racism. In Britain the movement did not manage well the double task of opposition and maintaining internal coalitions. As I discuss later, despite the potential alliance between the critics of IQ theory, in which social constructionists and those who argued that it was 'bad science' ideologically organized around race and class interests shared a common project of overturning a would-be canonical IQ theory,[13] the movement split. In a larger country with a larger movement this might have been less significant. As it was the split did tremendous harm, making it very difficult for radical working scientists and radical social constructionists to co-operate. At the time my own feeling was that such radical relativism, such hyper-reflexivity, aided the monolithic rejection of science which was simultaneously being proposed by the counterculture.[14]

The new left came into existence opposing the old left analysis which claimed that there was an inevitable contradiction between the productive forces unleashed by science and the capitalist order. Within the old left account science was seen as uninfluenced by class, race, gender, nationality or politics; it was the abstract accumulation of knowledge – of facts, theories and techniques – which could be 'used' or 'abused' by society.

In the chill early years of the cold war the only space open to left scientists was to criticize science's use for militaristic purposes, a space epitomized in Britain by the organization of Science for Peace. While this movement failed to criticize the content of science, one of its abiding offshoots has been the continued struggle against the scale and proportion of the British science budget spent on military purposes – a struggle no less urgent in the 1990s. Despite the collapse of the former Soviet Union there has been little in the way of resetting of research objectives, so that half the UK science budget is still directed towards military ends.[15]

But the experiences of the sixties and seventies overthrew notions of reharnessing actually existing science. What the sixties' radicals discovered in their campaigns against a militarized and polluting science was that those in charge of 'neutral' science were overwhelmingly white and male occupants of positions of power within advanced industrialized society – whether the project of that society was capitalism or state socialism. The anti-human (and as feminists were increasingly to demonstrate, the specifically anti-women) technologies that science generated were being used for the profit of some and the distress of many. Thus the politics of experience brought the radical movement's attitudes toward science into a confrontation with the old left analysis of science, in particular in an effort to recover those hopes of a second science, a science for the people, which had been a striking feature of the early days of the Soviet revolution but had subsequently been brutally destroyed. Hope for that lay buried in the cupboard of the Lysenko affair, and

disinterring and coming to terms with this denied past was critical for the radical science movement.

The Lysenko affair epitomizes the period from the 1930s to the 1950s in the Soviet Union, during which there was an attempt to develop a specifically proletarian interpretation of all culture, including the natural sciences.[16] This interpretation of the history of science, with its thesis of the 'Two Sciences' (bourgeois and proletarian), had been raised by the theorists from the young Soviet Union and introduced to the West at the 1931 International Conference for the History of Science in London. The thesis was strongly attractive to a group of young British marxist scientists, who wanted to revolutionize their science along with their society. Such hopes died in the Lysenko controversy. Against the genetic consensus, but apparently in accord with dialectical principles, the plant breeder Trofim Lysenko advanced the thesis that acquired characteristics are inherited. Initially it was merely a scientific dispute, but Lysenko also set his social origins as a peasant (and thus his experiential knowledge as a proletarian) against the aristocratic origins (and therefore abstract knowledge as a bourgeois) of his leading opponent, Nikolai Vavilov. The debate was resolved by Lysenko's presentation of falsified statistics on the amounts of grain produced and by the direct intervention of Stalin on the side of this fraudulent, but proletarian-claiming, science. In 1940 Vavilov was arrested and Lysenko became director of the key Agricultural Research Institute.[17] Marxist scholarship at the time, as for example expressed in the debates within the British Communist Party, particularly in the natural science group (the Engels Society), tore itself apart on the issue, which was ultimately presented starkly as a matter of loyalty to the Soviet system at the height of the cold war. Many biologists and geneticists distanced themselves from the Party, leaving non-biologists, above all the distinguished crystallographer J. D. Bernal, a leading figure within the Communist Party, to support Lysenko's claims in loyalty to the Soviet Union. The Engels Society soon ceased to exist.

Thus, when the radical movement of the 1960s and 1970s turned to marxist analyses of the natural sciences, it found either the terrifying language of 'mistakes' and a desire to repress all mention of the past or an insistence, by for example the biologist and historian of Chinese science Joseph Needham, a figure from the old left but who was felt to be more sympathetic to the aspirations of the radical science movement, that there is only one universal modern science.[18] Nor was the movement helped by the special status of science within the history of marxism – from Marx's and Engels's claims for a scientific socialism, Engel's tendency to claim scientists as natural allies of socialism, and Lenin's enthusiasm for the Taylorist scientific management of industrial production to Althusser's structuralist project to remove the human agent from marxism so as to make it truly scientific. Indeed the enthusiasm for structuralism of marxist social

sciences – not least cultural studies[19] – was not shared by the radical science movement, which was struggling both to restore agency and responsibility into the impersonal deterministic voice of science and more generally to locate science in social context.[20]

The myth of the neutrality of science

While the movement was forging its own politically engaged critique, within the academy there was also a parallel and dramatic shift in the history, philosophy and sociology of science. A sophisticated form of 'externalism',[21] holding the thesis that scientific knowledge is structured through its social genesis, had by the early 1980s become common to all three, so that one major strand of research has become aimed at demonstrating how interests construct knowledge while another has focused on the deconstruction of the language of science.[22]

The academy's recognition of the changed universe that modern science inhabited was signalled by Thomas Kuhn's 1962 publication *The Structure of Scientific Revolutions*, which presided over the steady thaw of an epistemology that had seemed forever frozen in the timeless certainties of positivism and the Vienna circle. More or less concurrently the historian Derek De Solla Price pointed to the distinction between a past era of 'Little Science' and the modern trend towards 'Big Science'.[23] Later Jerry Ravetz[24] developed this distinction through an examination of the circumstances in which scientists actually produced scientific knowledge. Abandoning the internalist and very abstract Popperian theory of 'bold conjectures and refutations'[25] which had come to dominate mainstream philosophy and history of science, Ravetz showed that whereas in its early period science was considered a craft,[26] by the beginning of the twentieth century scientists increasingly adopted industrialized methods of production.

More oriented towards contesting existing science in practice, others within the radical science movement were none the less pursuing the same theoretical concerns. Revolted by the genocidal technoscience that the United States was employing in its war in Southeast Asia and by the expanding new technologies of urban repression at home, they asked how science can claim to be ideologically pure, value-free, and above all neutral when it is torn from the context from which it is constructed and within which it will be used. Slowly, from a simple 'use-and-abuse' model in which science, though open to abuse by political others, was seen as itself fundamental, basic and pure (created by scientists who by implication shared in the purity and disinterest of their creation), the new critics

of science – to the equal concern of both the scientific establishment and the old left – laid siege to the myth of the neutrality of science itself.[27]

Advocates of the new political economy of science[28] argued that in bringing science into the capitalist mode of production, knowledge itself, as the product of scientific labour, had been made a commodity. The history of patenting within science and technology was one of steady encroachment, beginning within physics and chemistry[29] but now enveloping the burgeoning area of biotechnology – and indeed life itself. In the 1990s the marxist analysis has been matched and replaced by the market language of 'intellectual property' designed to police ownership patterns in the interests of capital. Even for the basic sciences, seemingly remote from technological exploitation, the rewards and prestige go to those who publish the knowledge first. The very process of diffusion reduces the value of the knowledge (typically produced in the elite institutions of the metropolitan countries) as it is transferred to the weak and isolated institutions in the periphery. The value of the knowledge as it passes from the centre of production to the periphery declines as surely as that of a car as it moves from second to third hand. Susantha Goonatilake gives support to this thesis of 'dependent knowledge', drawing on the third-world experience of Sri Lanka and India.[30]

The change in the mode and place of scientific production, and its subjugation to the laws of commodity production, are features of the sciences most closely integrated with the reproduction of social and economic power. The physical sciences, above all physics itself, are at once the most arcane and the most deeply implicated in the capitalist system of domination. The means of producing new knowledge based on experimentation are symbolized by the giant machines (above all the particle accelerators, whose costs are so immense that they are restricted to the US, the former Soviet Union, Japan and, as a shared facility at CERN – Centre Européen pour la Recherche Nucléaire – the reinvigorated capitalism of Europe), and by the international collaboration/rivalry of the Human Genome Project. Experiments now take immense teams of researchers, so that a single paper may have some thirty authors, who acknowledge the support from unnamed cadres of technical staff without whom the experiments could not take place. At the same time, the physical sciences, particularly in the old capitalist countries, more or less successfully exclude all but extremely small numbers of women.[31] Industrialized sciences – Big Sciences – have been highly resistant to feminist reconceptualization; the successes of feminist re-visioning have lain in sciences such as sociology, history and ethology – all characterized by little capital equipment per worker and by craft methods of production.[32]

The social origins of science as alienated knowledge

While many within the radical science movement were influenced by the writings of the Frankfurt school, which alone within the Western marxist tradition saw science as a social problem,[33] it was Alfred Sohn Rethel, as part of that tradition, who was to seek to explain the social origins of the highly abstract and alienated character of scientific knowledge.[34] He suggested that while abstraction arose with the circulation of money, the alienated and abstract character of scientific knowledge has its roots in the profound division of intellectual and manual labour integral to the capitalist social formation. Scientific knowledge and its production system are of a piece with the abstract and alienated labour of the capitalist mode of production itself. The Chinese Cultural Revolution, with its project of transcending the division of mental and manual labour and their associated knowledges, was seen by Sohn Rethel – and indeed by many or most of the New Left – as offering a progressive model of immense historical significance. They saw not only the possibility of transcending hierarchical and antagonistic social relations, but also the means for creating a new science and technology not directed toward the domination of nature or of humanity as part of nature. It was politically significant that the hope for this new science came from the East, decisively breaking that Eurocentric and class story of the birth of science.

Today, it is questioned how far the radical impulse of Maoism was constrained and deformed by the continued practices of Stalinism, yet at the time the attempt to create new knowledge drawing on both the everyday experience of peasants and workers and the academic knowledge of the intellectuals was embraced.[35] (It goes without saying that the Cultural Revolution was an ungendered project, so that both peasants and intellectuals in an entirely naturalized way were understood as the necessarily masculine harbingers of change.)

The Cultural Revolution was not an isolated phenomenon, and was reflected by and influenced struggles in a number of third-world as well as first-world countries. In an early article the US black mathematician Sam Anderson[36] reported the struggles within Guinea Bissau and Mozambique to build a new science and technology *with* the masses. He also drew attention to the related task of recovering the erased history of African and Asian scientific achievement, pointing to the 40,000-year history of iron smelting in Zimbabwe and the history of the systematic destruction of cotton production in India and Africa so that production could be relocated in Manchester, where child labour could profit the British imperial trade. (By the 1980s, cotton along with other textiles was relocated once more, this time to the newly industrializing countries, as a new global – and

sexual – division of labour was established by the alliance of footloose patriarchal capital and new technologies.)

Anderson's is an almost solitary voice, for he writes compassionately about the pain and danger of being inside and outside, of being, as a black scientist, one of 'America's peculiar beings'. He proposes that each black scientist could ensure that 'at least two sisters or brothers' get into college and pursue the sciences for black people'. Because today history seems to be erasing the pioneer voices trying to make such links between movements, it is important to set the record straight. Well before the powerful wave of black feminism of the eighties there were exceptional voices insisting on the connections between feminism and black militancy. The poet and political activist June Jordan, who taught and advanced black writing, was among the numbers of early black feminists criticizing the 'ostensible leadership' of the black movement for only advocating the liberation of black men.[37]

In a world where the costs of the new technosciences confront us in the pollution of the seas, the cities, the countryside, and in the fear of nuclear holocaust, such longings for alternative knowledges encompassing both the sciences and the arts and whose purpose is to serve the people cannot be dismissed as merely romantic. The realization of such longings has become a contributor to survival itself. Such hopes lay behind the mobilization of white male aerospace workers in Britain in the 1970s[38] – people not easily equated with romantic intellectuals – who were driven to conclusions very similar to those of Sohn Rethel. Beginning with their opposition to the threat of redundancy and with a moral distaste for being so deeply involved in the manufacture of war technology, the workers went on to design, and in some cases to create, alternative, socially useful technologies such as a vehicle which could run on both road and rail.[39] Although such projects could only be seen as prefigurative, and did not outlast the arrival of Thatcherism at the end of the decade, in their contestation of the division of mental and manual labour in the production of technology through the unity of hand and brain, they were part of the long struggle to transform technology itself.[40]

Although it is retrospectively easy to criticize the radical science movement for its shortcomings, not least its androcentricity, its preoccupation with the global political economy of science did help weaken the Eurocentricity of the history of science.[41] Above all the radical science movement had restored, through its political demands for a science to 'serve the people' without the need for corrupt statistics or Stalinist terror, the epistemological possibility of a 'two sciences' thesis. The movement had laid powerful siege to claims that science and technology transcend history, and made plain the class character of science within a capitalist and imperialist (or for that matter state socialist) social formation. The ideology of science was 'demystified', the myths that had served to gloss over the class

structure of scientific production were exposed. From outside science it has become quite difficult to remember the hegemonic grip of science, the taken-for-granted internalism of the academic history, philosophy and sociology of science in the 1960s and 1970s, and to appreciate the transgressive practices and analyses which destabilized the old categories and created space for new alternative accounts – including those of feminism.

There is, however, a paradox. While today's social studies of science take for granted the social context of science, their practitioners none the less typically tell their own origins story so as to emphasize the internal development of their history, and to neglect any version of externalism, whether the historical materialist question of 'What conflict outside us was within us the reflex of thought?' or any social constructionist account. There has been a tendency to focus on Kuhn as founding father, single-handedly opening the doors to the possibility of a fully social account of science.[42] To question this account is not to diminish Kuhn's contribution, nor to neglect the importance of intellectual development, but rather to insist that attention is paid both to theories and to their historical location – not least our feminism's own theorizing and our own contexts of production.[43]

Thus while feminists discuss the relationship of feminism as a social movement to other such movements – in the past the New Left, and today the peace and environmental movements – the connections between the feminist critique of science and the radical science movement with its primarily class but also anti-racist concerns have been often left in some obscurity.[44] Indeed, as the radical critique of science developed, the disjuncture between the politics of practical struggle and the politics of theorizing seemed to increase. Looking back over the writing of the sixties and early seventies, it is difficult not to feel that, as the critical work became more theoretical, more fully elaborated within a marxist viriculture, so the theorists' willingness to engage with the complexity of social relations – not least of those between women and men activists, which had been thrown into visibility through political struggle – was reduced.

The birth of the feminist critique of science

The willingness to engage with feminist questions within science, or rather technoscience (to give full weight to that iron-bound marriage of science and technology in the West), had to wait until the new wave of feminism was ready; initially there were other more pressing issues of women's daily lives to respond to. In the rest of this chapter I introduce the strands within the feminist critique of science with

which the remainder of this book is concerned, but I am conscious that the price of selecting these is that I leave out other connected areas such as the work of feminist science educators,[45] feminist studies of technology in both employment and the domestic contexts,[46] feminist critics of militarism and feminist environmentalists.[47]

I have named my five strands as follows: first, 'Why so few?', recalling Alice Rossi's provocative question concerning the paucity of women in the university and research system in 1965;[48] second, 'Recovering Hypatia's sisters', to evoke that patient historical and biographical work to recover the history of women in science, from Hypatia herself to present-day women scientists; third, 'Contesting patriarchal science', to bring out the committed resistance by feminist biologists against the 1970s' wave of biological determinism, and also the work of feminist historians of science in exposing science's construction of women's nature. The fourth strand introduces 'The feminist critique of epistemology', which speaks both to the strong hopes of the early 1980s for an alternative feminist epistemology as a successor science but also to the challenge posed by the post-modernist turn to any meta-narrative, and how this debate has been managed among the feminist critics of science.[49] Finally, my fifth strand I call 'Dreaming the future'. A number of friends remain surprised that I here discuss feminist science fiction, as this seems to me to have a special relationship both to feminist culture and to technoscience. This relationship is both playful and serious; 'we' read it – certainly more of us than follow the feminist science criticism. My feeling is that, as a critical, wide-reaching engagement in feminist debates around technoscience, feminist SF is quite simply far too important to be left out.[50]

The ordering of these strands is fairly arbitrary, not least because they start from different places in different countries, for example in Britain and the US. Thus concerns about science in the British feminist movement reflect the dominant radical feminist and socialist feminist currents, and therefore began by contesting patriarchal science. In the US, by contrast, the dominant radical feminist and liberal feminist currents meant that their critique also began by contesting patriarchal science but spoke strongly about the under-representation of women in science. Within the framework of liberal feminism, science and technology were simply occupations where women were particularly thin on the ground.

Why so few?

'Why so few?' can be read as one of the central questions around which the feminisms of the second wave have organized their critical analyses of science. As the sixties come into historical perspective, it becomes even clearer what a well-posed question this was, as the

problem in higher education and research was rarely that of the total and legal exclusion which first-wave feminism was to challenge so effectively, but of material and ideological practices which served to exclude all but a handful of women. The distinctive contribution of feminists who have survived in what Anne Sayre's[51] pioneering biography accurately called 'an especially male profession' has been pointed accounts of the men-operated exclusion mechanisms of science, from physics to psychology.[52] Naomi Weisstein's 1977 paper is a classic in this genre.[53] She wrote:

> I am an experimental psychologist, doing research in vision. The profession has for a long time considered this activity, on the part of one of my sex, to be an outrageous violation of the social order and against all the laws of nature. Yet at the time I entered graduate school in the early sixties I was unaware of this. I was remarkably naive.

Later, Weisstein was to add a footnote observing that she had since realized how exceptional it was for a woman to have survived as far as graduate school. Evelyn Fox Keller, writing of her experiences as a student physicist and later as a research worker, echoes this theme – the continuous, subtle and not-so-subtle exclusion mechanisms deployed against women scientists. She writes that as a student, she had to be careful to enter a lecture room with or after other students; if she entered first and sat down, men students found it threatening to sit near this low-status person – a woman student – and she was often surrounded by a 'sea of seats'. On one occasion when she solved a mathematical problem the male university teacher was so incredulous that Keller, like Naomi Weisstein in a similar situation, was quite gently asked who (i.e., which man) did it for her, or where she got (i.e., stole) the solution. Keller's experiences were not, however, unique; what was new was that they, and the sexual harassment that often accompanies them, are now discussed.[54]

As Diane Narek, teaching physical sciences, wrote, 'The only reason that there aren't any more women scientists and technicians is because the men don't allow it.'[55] Since the sharp insights of these pioneering voices, the careful historical work of Margaret Rossiter has detailed both what US men scientists would not allow and also how the feminist scientists of the time understood the nature of the problem, and what they were able to achieve in the task of change.[56]

Current liberal feminist attempts to attract attention both to the under-representation of women and to the lack of promotion for them have made but few inroads in Britain.[57] Indeed, despite some gains, such as the increase of women in medicine, losses are also evident and the proportion of women is now lower in some areas of science than it was in the interwar period. Further, it is not simply difficult to get into science, it is difficult to stay in. The labour process of an experimental scientist is even more in conflict with the demands

of child care than that of, say, a historian or a sociologist. What Airlie Hochschild in a brilliant pioneering article characterized as 'the clockwork of male careers' ticks in an even more pronounced way in the laboratories.[58] While both the woman laboratory scientist and the woman historian may have in common the problem of the double day, the former has much less flexibility in choosing when or where to work.

Women who manage to get jobs in science have to handle a peculiar contradiction between being women and not women (i.e. scientists) at the same moment. Many have resolved this by withdrawing or letting themselves be excluded from science; others become essentially honorary men, denying that being a woman creates any problems at all. Long before the postmodernist language of multiple fractured identities enriched feminist analysis, it was understood that a woman scientist is 'cut in two'. Ruth Wallsgrove wrote, 'A woman, especially if she has any ambition or education, receives two kinds of messages: the kind that tells her what it is to be a successful person; and the kind that tells her what it is to be a "real" woman.'[59] In a later article Keller observes that 'any scientist who is not a man walks a path bounded on one side by inauthenticity and on the other by subversion.'[60] Arguing for the continuing need to build two-way streets between feminism and science, biologist Anne Fausto Sterling agrees with this depiction of catch twenty-two for women scientists, and adds with some feeling that 'being a feminist scientist makes matters worse'.[61] Men scientists, as we see from Sharon Traweek's study of physicists, like to get marriage sorted out quickly so that once their needs for love, sex and a pleasant domestic life are resolved they can put all their energies into science.[62] Small wonder that women, let alone feminists, working in physics are still rare. It is difficult enough to conceal part of oneself to pursue knowledge of the natural world; it is even more difficult to develop a feminist practice in the competitive world of science.[63]

Rita Arditti, noting how common it was for women scientists to marry men scientists – often in the same field, saw that, 'All had secondary positions to their husbands regardless of ability; their loyalty as wives had led them to accept precarious work situations in which their research was dependent on their marriages.'[64] Nor is the problem only about love and personal relationships; it is also about motherhood. 'Can I be a geneticist (or whatever) and have children?' is a not a question from the past, but a painful and very practical question for young intellectual women interested in the sciences today. For women who wish to contribute to the frontiers of knowledge in the US, the answer seems pretty much to be 'Probably no', whereas in the UK it is still, 'Well, maybe.'[65]

What were the conditions through which the few survived and in some cases made important contributions to knowledge? Censoring out problems is particularly evident in the autobiographical accounts