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From Science and Technology to Feminist Technoscience

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In this chapter I introduce and discuss feminist approaches in science and technology studies not only with regard to their epistemological and ontological framework, but in the light of contemporary sociopolitical developments, prevailing technological practices, artifacts, and material cultures. My aim is to develop a stance which goes beyond euphoric affirmation or pessimistic refusal of technoscience as the 'Other'. Rather, I articulate a perspective from which the refiguring of central concepts like nature, body, and identity, and the omnipresence of technoscientific discourses and practices in our daily lives becomes visible and thereby available for feminist analysis. I interpret recent cultural studies of science and technology as reactions to the new epistemological and ontological challenges induced by technoscientific developments and the reorganization of knowledge culture in our messy global world.

INTRODUCTION

> taking responsibility for the social relations of science and technology means refusing an anti-science metaphysics, a demonology of technology, and so means embracing the skillful task of reconstructing the boundaries of daily life … It is not just that science and technology are possible means of great human satisfaction, as well as a matrix of complex dominations…It means both building and destroying machines, identities, categories, relationships…(Haraway, 1985: 181)

In most of contemporary Western theory, science and technology are regarded as a central part of culture with discourses and practices tightly interwoven with our daily lives. In the mid 1980s, when feminist science studies scholar Donna Haraway wrote the lines cited above, this understanding of science and technology was not self-evident. Science was often thought of in terms of classical sciences, such as physics, mathematics, biology, or chemistry, disciplines

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many of us 'well-educated girls' were not very fond of at school. In the Cold War period, most science studies scholars directed their attention towards so-called 'Big Science' (Price, 1963). Researchers equated science and technology with hierarchically organized scientific and technological projects planned and undertaken by governments and the military. Huge technological systems like nuclear power plants, weapon systems, and undertakings like the Manhattan Project or ARPANET[1] were the prototypes of the technology of that time. No wonder that feminist or critical theory stressed science and technology as 'masculine culture' (Wajcman, 1991), partly driven by masculinist dreams of omnipotence or ruled by fantasies of death (Keller, 1985). Equating science and technology with government projects and the military often led to a 'demonology' of technology in feminist and other critical theory.

A good example is the critique of reproduction technologies in the 1970s and 1980s. These technologies were regarded as not driven by fantasies of death, but by the longing to unveil the secrets of life. Since the birth in the1970s of Louise Brown, the first *in vitro* fertilization child, reproduction technologies evoked fears of masculinist appropriation of women's reproductive abilities, leading to a repressive population policy. There were many women activists fighting against these new technologies, like the well-known group FINRRAGE, founded by Gena Corea, Maria Mies, and others. To them, reproductive technologies turn the female body into a laboratory for the industrialized production of living beings (Corea et al., 1985; Wajcman, 1991). These technologies were regarded as another means to prolong the subordination of women. Shulamith Firestone (1970) was one of the few feminists who celebrated the new reproductive technologies as a possible means to liberate women.

TECHNOLOGY, SCIENCE, AND MASCULINITY

Technology is often described as a genuine 'masculine culture' grounded in patriarchal structures, gender relations, and identity politics. While some feminists interpreted the desire for technologies as grounded in a 'natural' tendency of men towards aggression and an obsession with control, others insisted on distinguishing 'between different forms of masculinity in relation to different areas of technology. To say that control over technology is a core element of masculinity is not to imply that there is one masculinity or one technology' (Wajcman, 1991: 143). Not only does this view stereotype masculinity, but other feminists reminded us that the emphasis on male-dominated technologies like the cyber and life sciences 'reproduces the sterotype of women as technologically ignorant and incapable' (Wajcman, 1991: 136). Against this view, Ruth Schartz Cowan and Judith Wajcman, among others, stress the importance of the 'technological revolution in the home' (Cowan, 1976: 33).

The feminist lack of interest in science and technology studies until the late 1980s was mostly grounded in the understanding of science and technology

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as military-biased 'Big Science' and 'masculine culture', while household technologies, new media, as well as new technosciences were, for the most part, disregarded. The increased use of television, video, cable, personal computers, and other developments in communication and information technology as well as the proliferation of biotechnology in agriculture, medicine, and procreation challenged the identification of science and technology with centralized, top-down research projects and huge technological systems. Since the late 1980s, it has become more and more obvious that science and technology are deeply interwoven into our everyday lives.

Donna Haraway (1985), Elvira Scheich (1989), and others have shown how central humanist concepts like nature, body, and identity get refigured through technoscientific discourses and practices. The relations of nature and technology and concomitantly those of gender are profoundly reshaped in the process of appropriating nature in Western societies, facilitating the idea of the co-construction of science, technology, society, and gender. To give an example, when reprogenetics or sex change becomes a common commercial practice for many people or care robots are developed to take over the former 'feminine' task of caring for children or sick people, old borders between sex and gender, between private and public, between a so-called masculinist technology and a feminine *Lebenswelt,* implode. The constructionist move in feminist and other science studies challenges the borders of the social and the technoscientific.

Feminist theorists also articulated a new bonding of technoscience with transnational capitalism, arguing that new technologies contribute to 'increasing capital concentration and the monopolization of the means of life, reproduction and labor' and to 'global deepening of inequality' (Haraway, 1997: 60). The effects are twofold. On the one hand, relations of domination are becoming more complex and opaque. On the other hand, the reshaping of central categories through technoscientific practices opens up new options for refiguring gender, nature, and sociotechnical systems. As structures of domination are getting more and more complex and the reshaping of old hierarchical categories seems possible, the demonology of technology appears more and more inadequate as a critical attitude towards our technoscientific culture.

CONTINUING THE STORY

Today's feminist critique often uses the former demonology of technology as a point of departure to tell a story of progress from liberal to postmodern feminism.[2] According to this narrative, liberal and Marxist feminist critiques failed to critically analyze science and technology because they considered the latter as neutral or did not pay attention to the symbolic dimension of technoscience. However, the Marxist feminist critique is acknowledged at least for analyzing gender in terms of social structure, while it is conceded that radical and ecofeminist approaches successfully elaborated the symbolic

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dimensions of science, technology, and masculinity. However, these perspectives are blamed for locating 'women's essence…in their biology' (Gill and Grint, 1995: 5). Unlike the liberal and Marxist feminist approaches, early social construction feminism understood that 'women's alienation from technology is a product of the historical and cultural construction of technology as masculine'. Social construction, however, did not succeed in fully explicating 'the relations between the key terms, "men" or "males", "masculinity" and "patriarchy"' (Gill and Grint, 1995: 12).

I have deliberately exaggerated this somewhat Hegelian story of progress to clarify my argument that as knowledge is situated, it always takes a perspective. The problem is how to write a *non-linear and complex* historiography of theories and practical engagements, as well as the artifacts of science and technology. It might help to avoid linear stories of feminist theory by reflecting not only on the epistemological and ontological framework of earlier approaches, but also by rethinking these frameworks in the light of contemporary sociopolitical developments as well as prevailing technological practices, artifacts, and material cultures.[3]

Recent studies question essentialist understandings of science and technology partially because of their cumulative fusion. When science, technology, society, and industry amalgamate into dense networks, and the sociocultural and the technological are tightly interwoven, the idea that a masculinist technology determines a feminine *Lebenswelt* appears ridiculous. Technology as an intimate part of our lives is no more the 'Other', as it was often understood in the age of 'Big Science', but rather part of our human condition. The demonization of technology becomes counterproductive as it hinders understanding of our life conditions in the age of technoscience and the refiguring of ontological realms of science, technology, society, and gender.

I will, therefore, tell my story of feminist science and technology studies in this chapter using a situated sociocultural and historically grounded approach. I concentrate on the close ties between changing theoretical approaches of science and technology studies and the material, symbolic, and sociopolitical dimensions of science and technology. My aim is to develop a stance which goes beyond euphoric affirmation or pessimistic refusal of technoscience, and, rather, articulates a perspective from which the omnipresence of technoscientific discourses and practices in every realm of our daily lives becomes visible and thereby available for analysis.

GENDERED AND OTHER CRITIQUES OF SCIENCE

In the first decades of women's studies in the 1960s and 1970s, it was mostly women scientists confronted with discrimination via institutional and gender identity politics who engaged in critical science and technology studies.[4] They reconstructed the achievements of other women scientists, rendering them visible for a broader audience and analyzing the mechanisms of

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their exclusions.[5] By discovering the large number of women scientists who had to live on the margins of intellectual and academic life, they contributed to a growing mistrust of the self-ascribed values of neutrality and objectivity in science.

In addition to the analysis of the professional politics of gender, inquiries into scientific constructions of sex differences resulted in a misogynist portrait of science (Bleier, 1984; Fausto-Sterling, 1985; Hubbard, Henifin, and Fried, 1979). Feminist analysis showed that the construction of sex differences in biology revolves around 'errors of the following sort: (a) the world of human bodies is divided into two kinds, male and female (i.e., by sex); (b) additional (extraphysical) properties are culturally attributed to those bodies (e.g., active/passive, independent/dependent, primary/secondary: read *gender*)' (Keller, 1995a: 87). For example, the process of conception was until recently described as a 'passive egg' waiting for the heroic, active sperm (Martin, 1991). According to Ruth Hubbard, we find manifold versions of the 'sociobiologist's claim that some of the sex differences in social behavior that exist in our society (for example, aggressiveness, competitiveness, and dominance among men; coyness, nurturance, and submissiveness among women) are human universals that have existed in all times and cultures' (1988: 8).

The so-called 'objective' knowledge of male experts was also radically challenged by critical practices in the women's movement. For example, the famous workshop on 'women and their bodies', held in Boston in 1969, promoted alternative forms of health care. The workshop group continued to meet and compile information about women's bodies and health care. Their discussion papers were assembled and published in 1970 as the first version of *Our Bodies, Ourselves*; in the last thirty years, OBOS has been translated and adapted to many different cultures all around the world (Davis, 2002). Challenging men's expertise 'was an extension of this recognition of the power of scientific ideas to define women's sense of bodily awareness, sense of self and sense of reality that propelled the feminist analysis of science to investigate the historical emergence of particular constructions of women and the natural within scientific discourse' (McNeil and Franklin, 1991: 134).

In addition to the women's movement, other social movements, such as the Radical Science Movement in Britain, the anti-war movement, and the ecology movement, contributed to questioning the privileged status of scientific knowledge. The battles against reproductive technologies, biotechnological products, bio-piracy, the Human Genome Diversity Project, and the patenting of living beings have helped to question technoscientific practices. At the same time, they demonstrated their growing impact on everyday life. In view of ecological disasters caused by industrialization, ecofeminism and radical feminism criticized the Anglo-American understanding of nature as the 'Other', as feminine, inferior, and uncanny, that has to be controlled by an autonomous subject (a White man). They fostered the insight that nature should not be reduced to a resource and passive material for men's ends, but regarded as an active agent endowed with its own logic. As many critics

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pointed out, the hybridization of science, technology, the military, industry, and politics in the last decades also helped to undermine the understanding of science as the only legitimate producer of knowledge. These movements questioned so-called truths 'discovered' by science about the nature of nature, of woman, and of sex.

The growing interest in science and technology studies is partly attributable to the deconstruction of the grand narratives of progress, scientific truth, and objectivity. It also made technoscience a promising field for women's and gender studies. But the challenge to positivism and the rise of the social construction perspective are not due only to the radical critique of the practices and discourses of technoscience by feminists and 'other Others'. They are also related to changes in the theoretical premises in science and technology which formed the basis for the emergence of new technosciences. Wave/particle duality in quantum physics is probably the most famous example for challenging objectivity through scientific theories and practices. Haraway (1985; 1991), Katherine Hayles (1999), and others have analyzed the departure from the classical Cartesian heritage, with its dualism of observer and observed, subject and object, body and mind, towards constructivist epistemologies and 'posthuman' concepts of cybernetics, artificial intelligence, immunology, and brain research.

In view of the decline of classical scientific values, feminism strengthened the insight that trying to speak for nature – to interpret its own logic – always involves a politics of representation implying epistemological, ontological, and thereby political claims. Challenging the scientific and technological discourses of truth, feminism argued that nature, sex, and biology are not given nor are they beyond representation, rather they are agents in a high-stakes game, a dynamic relationship as well as a product, constructed and taking part in, or even constructing discourses and practices. The so-called 'natural laws' and empirical data of technoscience were reinterpreted as the outcome of cultural practices with many different human as well as non-human actors. At present, feminist and other critical science studies ask how and for whom knowledge, technologies, agents, and hybrids have been employed so far and continue to be employed:[6]

> with the hope that the technologies for establishing what may count as the case about the world may be rebuilt *to bring the technical and the political back into realignment so that questions about possible livable worlds lie visibly at the heart of our best science.* (Haraway, 1997: 39; my emphasis)

Feminist approaches reflect on the need for political reflexivity in theory, which is often neglected in mainstream science and technology studies. At the heart of feminist studies lies the search for better, or at least more visible, ways to design and use categories, knowledge, and technologies, to shape objects, artifacts, and worlds in order to make exclusions visible and to overcome the hardships of gender-asymmetries, reductionism, and injustice.[7]

In sum, the critique of positivism and naturalist rhetorics became possible through many different factors: the liberal feminist critique of an unfair and misogynist science, the ecofeminist critique of Western hyperproduction,

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social movements challenging the privileged status of science, and the postmodern critique of ventriloquial politics of representation. Posthumanist reconfigurations of so-called natural entities like nature, sex, and body also made visible the changed epistemological and ontological groundings of science, which were induced by critical as well as technoscientific discourses and practices. The merging of science and technology, as well as that of technoscience, industry, and politics, all raise questions about the idea of technological determinism.

In the following sections, I will map out movements of denaturalization, dematerialization, and renaturalization in constructionist technoscience and contemporary feminist science and technology studies. The merging of boundaries between nature/culture (*Denaturalizing nature*), sex/gender (*Constructing sex and gender*), and science/technology/society (*Technoscience*) are at the heart of the current epistemological and ontological reconfigurations of our age. Cultural studies of science and technology (*Technoscience as cultural practice and practical culture*) can be seen as an answer to the new epistemological and ontological challenges induced by technoscientific developments. I conclude with conditions of knowledge production (*The reorganization of knowledge cultures in a messy global world*) and make suggestions for future directions.

DENATURALIZING NATURE: CONSTRUCTIONISM IN CONTEMPORARY TECHNOSCIENCE(S)

Major concepts, such as nature, matter, and body, are profoundly refigured in contemporary technosciences. With the rise of system theory, cyberscience, and new life sciences, there is a move towards the molecularization of matter, breaking up organisms or cells into micro-parts down to the subatomic level (Kay, 1996). This miniaturization enabled 'the translation of the world into a problem of coding, a search for a common language … and all heterogeneity can be submitted to disassembly, reassembly, investment, and exchange'. Information becomes 'just that kind of quantifiable element…which allows universal translation' (Haraway, 1985: 164).

Technosciences nowadays do not see themselves as primarily engaged in subjugating nature and its processes through creating artificial natures via technological artifacts and systems, but through designing and engineering nature in the sense of reshaping and improving it. 'The claim of technoscience not to create but to continue the work of nature by rebuilding, converting and perfecting it, gives the border between nature and culture its chimerical character' (Weber, 1999: 470). Nature becomes a toolkit and the world a realm of endless possibilities of recombination – with evolution tinkering around to find new ways of development and investment (see, among others, Jacob, 1977). Similar to this logic, organisms are not regarded as something static and given, but as evolving, parallel, and distributed networks, that is a 'fast,

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responsive, flexible and self-organizing system capable of constantly reinventing itself, sometimes in new and surprising ways' (Hayles, 1999: 158). Attention is given to the creation of spontaneous entities and the logic of emergent behavior. In other words, a constructionist understanding of nature, organisms, and even sex can be found not only in critical feminist theory but also in contemporary technosciences.

Engineering nature makes technoscientific practices even more efficient (Haraway, 1997). This approach relies on a constructionist stance – which implies radical changes in the understanding of science and nature in general. While modern scientific theories linked women and nature, under the assumption that they were both immutable, the refigured posthuman body departs from these essentialist and naturalizing premises. The body is no longer considered as 'natural' and 'given' in the sense of static, unchangeable, and governed by teleological and harmonious principles. With this move, the radical feminist and other critiques of the naturalist or essentialist grounding of the natural sciences became partly obsolete.

This new denaturalization notwithstanding, there has been a strong movement of renaturalization emerging in the rhetorics of popular science, technosciences, and popular culture at the same time. Spontaneity, change, and dynamics are often reinterpreted as natural, evident, and given by 'Mother Nature'. The French molecular biologist François Jacob describes organisms as 'historical structures: literally creations of history. They present not a perfect product of engineering, but a patchwork of odd sets pieced together when and wherever opportunities arose. For *the opportunism of natural selection … reflects the very nature of a historical process full of contingency*' (Jacob, 1977: 1166, my emphasis). After all, it seems to be 'Mother Nature' which rendered organisms as patchwork creations via natural selection. The change of ontological and epistemological groundings in the technosciences is made invisible by declaring the turbulent, evolving body not as an effect of the change of paradigm in (techno)science but as natural.

CONSTRUCTING SEX AND GENDER IN THE AGE OF REPROGENETICS AND SEX-CHANGE SURGERY

Given the centrality of gender for feminist scholarship in general, science and technology studies are concerned with how 'gendered artifacts may constitute the glue that sometimes keeps gender relations stable, sometimes on the move' (Berg and Lie, 1995: 346). These studies ask how gender, understood as a product of diverse material, symbolic, and sociopolitical processes 'was at stake in key reconfigurations of knowledge and practice that constituted modern science' (Haraway, 1997: 27). Feminist scholars are 'particularly interested in the question how scientists have constructed "woman" as a natural category' (Oudshoorn, 1996: 123).

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What is the meaning of categories like 'woman', 'sex', or 'gender'? Thinking about the category of gender highlights the performative character of feminist theory and science studies, which are themselves a cultural practice and as such are entangled in language games, sociopolitical experiences, and values. One can understand sex/gender as a 'boundary object' (Bowker and Star, 1999), as a classification system which holds together a globalized but predominantly Anglo-American feminist discourse. The differentiation of sex and gender which pervades many feminist discourses in different languages shapes theoretical frames, perspectives, and questions. It is a historical and situated classification which produces a segmentation of the world which fosters strict differentiations between the social and the biological.[8]

The suspicion that every possible differentiation between biology and society, nature, and culture in feminist theories, too, only prolongs dubious definitions of the natural and reifies old normative descriptions of 'woman' might be only the flip side of difficulties in mediating the social and the biological.[9] Sometimes these fears result in a hyperproductive stance, whereby a dogmatic denaturalization of gender and the body turns into their dematerialization. In this conceptual frame of idealism, matter or bodies are conceptualized as the exclusive product of history, society, or discourse. Trying to overcome the dual sex/gender system and the separation of the biological and social often leads to an ignorance or even negation of material, bodily aspects.

While contemporary postmodern approaches favored denaturalization and even dematerialization of the gendered body, they often ignored the strong development towards construction and denaturalization in technoscience itself. Many sociotechnical developments already undermine the dual sex/gender system and the natural in a more profound way than many postmodern theorists had ever dreamed of: new reproduction technologies, cosmetic surgery, and sex-change procedures are radically denaturalizing (and sometimes renaturalizing) the category of sex (Stone, 1993; Stryker, 2000). For example, with the possibility of sex change in the second half of the twentieth century sex becomes – at least in principle – an open, free-floating category.[10] Technoscientific practices and artifacts such as reconstructive surgery and hormones render radical physical sex change possible. Thus the dual sex/gender system is destabilized by making it (at least theoretically) a matter of technological investigation and individual choice in Western societies.

The denaturalization of bodies is the ontological ground which makes it possible to think of bodies as a toolkit, breaking them down into small parts and reorganizing them in technoscientific practices. Bodies are fragmented into different functions, organs, cells, molecules, genes. A case in point is collaborative reproduction, in which body parts from different, sometimes anonymous donors are made to fit together in the laboratory. The laboratory product – an artificially fertilized egg – is subsequently implanted in a woman, who is not necessarily the child's genetic mother. Collaborative reproduction becomes possible by the separation of sex, sexuality, reproduction, and kinship

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through which new complex relations of social and biological kinship emerge. These denaturalizing technoscientific practices also produce new social and economic relations in the process of reproduction. But these new practices of reproduction are made invisible at the same time by renaturalizing rhetorics of 'blood ties' and the right to a 'child of one's own'.[11]

TECHNOSCIENCE: A NEW UNDERSTANDING OF SCIENCE AND TECHNOLOGY

With the growing interest in technoscience, we find more feminist science studies which try to mediate de/constructionist with materialist and realist positions. They share central epistemological and ontological premises, like commitment to self-reflexivity, contextuality of knowledge, and interest in empowerment. They reflect on 'standardization and local experience, (on) that which is between the categories, yet in relationship to them' (Star, 1991: 39). They are projects of political intervention and critique highlighted processes of domination and resistance. The goal is to enable empowerment, particularly of those who do not fit the standard or who are on the margins of the production of knowledge and culture.

While earlier approaches in the 1970s and 1980s[12] mainly investigated the social and political conditions of science (often using a 'classical' concept of society), the separation of science and society is now being challenged, along with other separations such as 'science and politics … or science and culture. At the very least, one such category cannot be used to explain the other, and neither can be reduced to the status of context for the other' (Haraway, 1997: 62). These challenges are due to fundamental dissolutions of borders between the ontological realms of science, technology, industry, and society and the refiguring of central epistemological concepts. At present, we are experiencing a changed understanding of technology not only in theory, but in the emerging technosciences themselves, which materializes in concrete sociotechnical changes.

In pre-modern societies, technology was understood mostly in the sense of human knowledge, while in modernity, technology's most important connotation was that of the artifact. Today, the contemporary dimension of technology as system and process becomes more and more important. Technological systems are regarded as networks with tightening connections and an organization of material and non-material components which rely on scientific knowledge, engineers, and juridical, economic, and other agents (Hughes, 1986). This new perspective makes visible the 'seamless web' of science, technology, society, industry. Strict distinctions between the sociocultural and the technical are no longer plausible. In addition, the differences between nature and culture are undermined by technosciences which conduct their research mainly in the laboratory as they construct the nature they are investigating.

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The term 'technoscience' marks the merging of science, technology, industry, and the military, as well as the intensified amalgamation of science and technology, of society fusing with the technological, and of a new efficiency in industrial technologies which refigures the organic in a new and most efficient way. These developments are accompanied by radical changes in the ontological premises of (techno)sciences as well as some of their rhetorical strategies and politics of representation (Weber, 1999; 2003). With these multifaceted changes, new epistemologies and methodologies arise which stress the constructionist character of categories such as science, technology, and society.

TECHNOSCIENCE AS CULTURAL PRACTICE AND PRACTICAL CULTURE

With the hybridization of science, technology, industry, and society, it becomes much easier to acknowledge that science and technology, deeply intermeshed in culture, are central sites for the production of ideology. It also becomes easier to grant oneself the right to intervene: 'we have a right, and in fact a duty, to debate, contest, modify and perhaps even to transform' (Balsamo, 1998: 294). Even if we are not trained and socialized in technosciences and even if we are not part of that community of knowledge producers, we are, nevertheless, required to reflect on technoscientific developments which are shaping our world in profound ways.

Today, hybrids, artifacts, and cyborgs populate feminist theories and narratives. There has been a shift within and outside many disciplines (sociology, cultural studies, art, philosophy, literature, anthropology) towards analyzing discourses and practices of technoscience and its growing impact on everyday life. While early approaches in feminist science and technology studies mainly focused on classical sciences, it is now the so-called technosciences – artificial intelligence, biotechnology, neurosciences – which are at the center of feminist scholars' attention. Now that science and technology have been identified as deeply interwoven with many other ontological realms, they are understood as 'cultural practice and practical culture' (Haraway, 1997: 66). Culture is understood as a social practice, as an always situated, heterogeneous, and complex process in which many different agents like concepts, machines, humans, and animals produce meanings and thereby maintain or refigure cultural boundaries.

With this perspective, it becomes much easier to develop approaches which go beyond either the euphoric affirmation of science and technology or their abstract negation. Feminist science studies scholars now want to challenge boundaries and to refigure concepts and frames of thought by inventing powerful stories and different socio-material practices. To strive for more livable worlds beyond the hegemonic tales of progress, of technoscience as biological, and technological determination means also to reinterpret what

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counts as nature, as sex, or as gender. The central premises of recent feminist science and technology studies are that science and culture are deeply interwoven, that facts are theory-laden, and that theories are not neutral but can better be seen as stories. There are close linkages between metaphors and factuality, between semiotic and material processes. The relationships between science, technology, knowledge, and society are increasingly viewed as open and dynamic. Intervention into semiotic–material configurations of humans, non-humans, and machines is now seen as not only a possible but a necessary political practice.[13]

THE REORGANIZATION OF KNOWLEDGE CULTURES IN A MESSY GLOBALIZED WORLD

Contemporary science and technology studies use theories and methods from very divergent disciplines and prefer no unified methodology. Inter- or transdisciplinarity is grounded in a radical challenge of the popular idea of two separate cultures of 'hard' and 'soft' science, which was introduced by Charles Percy Snow (1959) and was revived in the science wars in the 1990s:

> The current 'two cultures' discourse assumes a division of labor: humanities researchers are critics who write commentaries on art and ideas, while scientists, engineers, and physicians find out facts about the real world and fix real problems. More succinctly, the humanities are for reflection and the sciences are for investigation…[C]ultural studies of science, technology, and medicine violate this division of labor and violate our conventions of expertise. (Reid and Traweek, 2000: 7)

With the breakdown of borders between science and society, between nature and culture, and with the understanding of science as a cultural practice, it becomes more and more obvious that all sciences are determined by cultural values, language games, and politics of representation. Moreover, these values and ideas cannot be categorized in terms of different cultures of knowledge. They travel between different disciplines, realms, and discourses. Take, for example, the notable metamorphosis of system theory in the twentieth century. Starting with biology, it went on to become a central part of cybernetics and molecular biology, and later an important approach in the social sciences, especially sociology. Other frequent transdisciplinary travelers are the concepts of network, emergence, and cyborg, which lose and gain new connotations, change shape, and transport frames of meanings.

The (re)naissance of inter-/transdisciplinarity today seems due not only to developments in critical theory, but also to the floating of concepts and frames of meanings between the disciplines. While transdisciplinary exchange between cultures of knowledge has not been unknown to modern science, I would claim that this exchange rapidly increased with the emergence of technosciences in the post-World War II period. It might be an irony of history that exactly at the time when Snow complained about the advancing gap

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between scientists, intellectuals, and the public because of the specialization of science and technology, an advancing exchange emerged between scientists and intellectuals in new (techno)scientific fields. Many technoscientists had the feeling that the classical approaches could not provide answers to new demands and questions. Therefore they started to work transdisciplinarily out of a need for new methods and conceptional frames. For example, the transdisciplinary field of cybernetics or, as Evelyn Fox Keller calls it, cyberscience 'was developed to deal with the messy complexity of the postmodern world' (1995b: 85). This might be true as well for other research fields like molecular biology, immunology, and others.

Science studies scholars Egon Becker and Thomas Wehling stress that the transfer of concepts became a 'central element of the dynamic of science and of theories' since the 1950s (1993: 42; my translation). But the effects of these transfers had not been analyzed within the disciplines themselves. Since the 1990s several feminist science studies scholars have reconstructed the transfer of metaphors and concepts throughout divergent disciplines. For example, Lily Kay (1999) analyzed the use of linguistic metaphors and concepts in the life sciences; Elvira Scheich (1993) has shown the major impact of system theory on the social sciences. Crossing the borders between different disciplines, between the so-called hard and soft sciences, seems to be much more common than scientists and intellectuals in either 'culture' realized.

It is my contention that the intensified permeability of the borders of disciplines is linked to recent transformations in science, technology, and society. By this, I mean the reorganization of the cultures of knowledges in our globalized world. I will not draw here on the new organization of knowledge through education policy, restructuring of academic fields, and redistribution of resources (infrastructure, funding, and so on) in the context of multifaceted processes of globalization. What I want to stress here is that knowledge is restructured not along disciplines but primarily along certain theoretical fault lines. Mainstream research areas are currently operating at a level of metalanguage, that is formal systems and models. They succeed in making divergent objects compatible through a contemporary logic of translation and coding which abstracts from material aspects of these objects (Knapp, 1998: 49).

System theory is a good example of this move as is the already-mentioned dominant concept of information in cyberscience, which has been conceptualized as a quantifiable element beyond materiality and meaning thereby allowing universal translation. The decontextualization of knowledge allows the development of powerful theorems that can be applied to nearly every field and context, regardless of their contextual meaning and material grounding. The logic of universal translation is especially attractive in a global world where compatibility becomes a central value. These formal approaches also support the invisibility of political hierarchies and economic injustices – not the least between North and South, West and East.

Today successful fields of research (in terms of funding) are those that follow these new cognitive and epistemological premises. Others that are

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unable or unwilling to do so often lack funding and, therefore, many so-called old-fashioned academic institutes have closed down. This development might give some clues as to why such divergent disciplines as microbiology, bioethics, and robotics are advancing fields, while disciplines like zoology, philosophy of history, or botany are on the decline.

The reorganization of cultures of knowledge is not only shaped by processes of transnational capitalism and reorganized along theoretical fault lines, but also the outcome of new questions and objects of study emerging in a globalized word. As feminist science studies recognize the reorganization of knowledge cultures, I think it becomes a necessity to focus not only on the production of artifacts and practices but also on hegemonies of cognitive and epistemological frames of thought. Up to now we have no or only a few studies on the contemporary epistemology in terms of hegemonic styles and frames of thought (Foucault, 1970).

FUTURE DIRECTIONS

> After all, in the present world 'after modernity,' there is much to learn and much to do. To be sure, in a climate of polemics, thoughtful interdisciplinary reflection is hard to come by. (Reid and Traweek, 2000: 15)

Keeping in mind recent epistemological and ontological shifts in the age of technoscience, the emergence of posthuman bodies, nature(s), gender(s) as well as the reorganization of knowledge cultures, I want to make some suggestions concerning future directions for feminist studies.

Feminist science studies scholars analyzing transdisciplinary cultures of knowledge should not only be aware of the multifaceted transfer of concepts, methods, frames, and theories, but also adapt these insights to their own analysis. Reflecting on one's own conceptual frame requires at the very least a kind of second-order reflection that keeps in mind that theory itself is imprinted by the traveling concepts, epistemological approaches, and visual and rhetoric practices of the technosciences being analyzed. Thus, the critique of the discourses and practices of technosciences should question its own ontological and epistemological groundings and its entanglement with our technoculture. It is my hope that this kind of second-order reflection will enable alternative research which moves beyond euphoric celebrations of the most recent concepts and ideas from the technosciences as well as pessimistic and abstract negation of the so-called 'other' culture of technoscience – a stance that predominated gender studies for such a long time. Perhaps such a second-order reflection could also foster a critical usage of semiotic–material fields linked to the technosciences, which were so long imagined as the 'Other', as alien and rejected in the abstract. If feminist science and other critical studies succeed in showing the intensified blurring

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of the science and culture, it could help to overcome old dichotomies of euphoric affirmation of technology or its pessimistic refusal.

In my view, it is quite important that feminist studies continue to elaborate that *the technical is the political* for all the divergent fields of science and technology, showing and analyzing the ongoing co-construction of gender, science, and technology. In order to take part in the shaping of contemporary sociotechnical practices and discourses, we need to engage with today's scientific, cultural, and social turbulences, to engage in contests about what counts as nature, intelligible bodies, or efficient machines. To question techno-pragmatic and hegemonic forms of rationality and the dominant logic of efficiency, usability, and common sense, we need to intervene and challenge hierarchical sociotechnical relations by developing new theories of our age of technoscience.

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NOTES

1 ARPANET was the forerunner of the Internet and developed to promote computer networks for military use.

2 See, for example, Rosalind Gill and Keith Grint (1995) and Sandra Harding (1986).

3 In my usage, 'ontology' signifies the assumptions every theory has to make with regard to the existence (of constellations) of things, entities, etc. The core assumptions are contained in the meta-theoretical principles. These general principles encompass not only syntactical structures and criteria of critique but ontological options. The last are responsible for what counts as a fact, as being.

4 For the study of gender in science through history, see Londa Schiebinger (2000). Beside women scientists, there were also feminist sociologists (Berg, Cockburn, Wacjman), philosophers (Code, Harding, Longino, Merchant), anthropologists (Lie, Star, Suchman, Traweek), and a few historians (Duden, Schiebinger) who were engaged in the field of critical science and technology studies in the early days of the second women's movement.

5 For an overview, see Schiebinger (1989) and Renate Tobies (2001).

6 See Haraway (1985; 1997), Harding (1986) Susan Leigh Star (1991), and Lucy Suchman (1987).

7 See, for example, Lorraine Code (1987), Haraway (1988), Nancy Hartsock (1983), Helen Longino (1990), and Hilary Rose (1983).

8 On paradoxes of gender, see also Judith Lorber (1994).

9 See Wendy Cealey Harrison, in this volume.

10 This choice remains in the dual-sex system and is only given in few countries under strict juridical, medical, and financial restrictions.

11 See, for example, Heidi Hofmann (2003).

12 For example, the Sociology of Scientific Knowledge (SSK) and, respectively, the 'Strong Programme' of the Edinburgh School, ecofeminism, or radical/cultural feminism.

13 See, for example, Haraway (1997) and Reid and Traweek (2000).

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