

Articles

Biotechnology and the Society-Nature Relation

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Introduction

The emergence of biotechnology as an instrument of production in an increasingly global, information-based form of capitalism is quickly rendering the 'modern' boundary between society and nature obsolete. The impetus for this emergence was the advent of recombinant DNA in the early 1970s, a technique used to splice together the genetic material from dissimilar species in order that new, transgenic organisms might be 'persuaded' to produce proteins not otherwise 'found' in nature. This unprecedented control over the reproductive capacities of life at the molecular level distinguishes 'new' from 'old' biotechnology¹ and has allowed for the employment of living things as 'self-replicating factories' (King 1997) for the production of foods, pharmaceuticals, and even building materials.² Aimed at manipulating the reproductive capacities of living things at the molecular level, biotechnology 're-programs' the natural world so that its 'design' might better serve social needs. Thus, perhaps more than any other, *biotechnologies* challenge traditional conceptions of nature, society, and what it means to be human.

Despite their increasing interest in biotechnology as an instrument of production political economists have paid relatively scant attention to the unique implications of the technology for the society-nature relation. They have tended to focus instead on the social relations and interests shaping the development of biotechnology and, in particular, issues surrounding its unequal distribution. This is perhaps reflective of the long-standing concern amongst political economists with dispelling the notion that technology is an autonomous, inherently progressive force of social change. And indeed, the work of Yoxen (1983), Kenney (1986), and

Krimsky (1991), among others, has gone a long way toward revealing the social relations and processes obscured by the 'rhetoric of the technological sublime' (L. Marx, 1964; Nye, 1994) currently surrounding developments in biotechnology. Nevertheless, the absence of a concern in this literature with the implications of biotechnology for the society-nature relation is both theoretically and politically troubling. Not only does it constitute a theoretical gap in the approach, but it also risks political irrelevance inasmuch as many of the social movements mobilizing in opposition to biotechnology are concerned with just these implications (Shiva, 1995).

To be sure, discussions of nature are not absent from political economy more generally. In response to concerns over environmental degradation that have arisen since the 1960s there have been a number of attempts to incorporate 'ecological' issues into the corpus of political economy.³ The eco-Marxism of O'Connor (1998) and others redresses the neglect of 'nature' in a discipline that has focused its critical attention, for the most part, on capitalism as a set of social relations whose internal contradictions manifest in a series of crises and eventual social transformation. Central to the work of eco-Marxists is the notion of a 'second contradiction of capitalism'; namely, that which exists between a relentless drive to accumulate and the 'natural' limits to this accumulation posed by the environment. Relatively absent from this work, however, is a sensitivity to the role of technological change in transforming the society-nature relation. In fact, most 'ecological thought' tends merely to reinscribe a modern society/nature dualism insofar as its emphasis remains on the tendency for capital accumulation to 'disobey' natural laws and deny nature its 'relative autonomy' (Castree, 2000). To the degree that biotechnology is considered at all here, it is primarily conceived as a 'degradation' of nature in the interests of capital accumulation. In the end, the politics implicit in an eco-Marxist analysis is one focused on saving 'nature' from capitalism.

How might political economy theorize the implications of biotechnology for the society-nature relation so as to foster effective biopolitical imaginaries without appealing to such 'modern' society/nature dualisms?

This paper suggests the value to a political economy of biotechnology of two 'amodern' traditions in contemporary social theory. I argue that both the 'production of nature thesis' and 'artifactual constructiv-

ism' provide useful conceptual tools for grasping the unique implications of biotechnology for the society-nature relation, and therefore have the potential to enrich a political economy of biotechnology. I deal first with the production of nature thesis, central to which is the argument that 'nature' in a capitalist society, rather than violated by the drive to capital accumulation, is in fact itself increasingly produced as a commodity in the interests of accumulation. In this sense, biotechnology can be effectively conceived as the latest tool in the progressive production of nature as a commodity, one that projects the struggles and contradictions of capitalism into the very genetic structure of the world. However, while the PNT is effective in locating biotechnology within the historical development of capitalism as a mode of production, it is less effective in clarifying what is unique about biotechnology in this regard. In the second part of the paper I suggest that this limitation is reflective of a tendency to abstract from the concrete practices internal to the labour process through which the society-nature relation is constituted. In the final part of the paper I demonstrate the value of the 'artifactual constructivism' of Bruno Latour and Donna Haraway for redressing this limitation of the PNT. I conclude that both these traditions in social theory will prove indispensable to a political economy of biotechnology and a global biopolitics.

Biotechnology and the Production of Nature Thesis

Central to the production of nature thesis is a critique of the 'modern', dualistic assumption that the social and natural worlds are ontologically distinct. For Neil Smith (1984), whose *Uneven Development* is the seminal statement of the thesis, the notion that there exists a natural world independent of the forms of its social appropriation is both logically and empirically spurious (see also Braun and Castree 1998). On the one hand, such a position is logically contradictory insofar as "the very act of positing nature requires entering into a certain relation with nature" (Smith, 1984:18). On the other hand, the notion of a pristine, asocial nature is everywhere empirically contradicted by the concrete life-activity of human beings as they strive to meet their needs through transforming the world around them. The society-nature relation is always already social, then, both in the sense that human beings can only know 'nature' through particular social categories, and in the more literal sense that human beings only ever exist in a world that is in some way shaped

by their own transformative activity. Taking this critique of 'modern' society-nature dualisms as a point of departure, the PNT aims at uncovering the specific socio-historical conditions under which nature is produced as a social reality.

An emphasis on nature as a social product enables Smith and those who have followed in this tradition to identify and theorize a specifically capitalist form of the society-nature relation. While multiple forms of social appropriation may have characterized the production of nature in pre-capitalist modes of production, with the ascendance of capitalism the production of nature as a commodity comes to dominate all others. The unprecedented penetration of the natural world by the commodity form facilitated by the technical developments spurred by inter-capitalist competition, and the spread of this process across the globe, have literally allowed capital to remake 'nature' in its own image.⁴ These processes of intensive and extensive commodification have in turn served to perpetuate capitalist social relations through a progressive subordination of productive activity to a system of wage-labour and exchange. And insofar as 'nature' is produced as a commodity, the society-nature relation under capitalism becomes characterized by the same fetishism that attaches itself to other products of alienated labour.⁵ Thus, in locating the current society-nature relation within the socio-historical conditions of the capitalist mode of production, Smith uncovers an 'ideology of nature' reflective of the alienation endemic to a generalized system of commodity production. While alienation from nature is surely not specific to capitalism, the extent to which it is fostered by a system of wage-labour and exchange makes for a unique society-nature relation under capitalism.

The argument that the contemporary society-nature relation is one conditioned by the ascendancy of capitalist commodity production should be particularly appealing to political economists for whom the concept of 'nature' has long remained illusive. The society/nature dualism so pervasive in 'modern' thought has had a particularly strong hold on political economy. The natural world has generally been taken for granted as a collection of raw materials that, while (ab)used in different ways depending on the mode of production, is itself socially neutral. The result has been a general reluctance to enter into discussions of nature inasmuch as it has been deemed the sphere of the natural sciences. However, if nature, in both its material and discursive constitution, increas-

ingly takes the form of a commodity, then the tools of political economy become particularly relevant to any such discussion. Nature in this case, rather than external to the contradictions and struggles endemic to capitalism, is intimately bound up with them, a product of alienated labour that is increasingly revealed as such through the processes of intensive and extensive commodification. Thus, the production of nature thesis opens the theoretical space for what has heretofore seemed an oxymoron – a political economy of nature.⁶

Such theoretical space would seem especially vital if political economy is to grasp the significance of biotechnology as an instrument of production. The capacity to manipulate the reproductive capacities of living things at the molecular level, primarily through the technique of recombinant DNA, has allowed for an unprecedented penetration of 'nature' by the commodity form. Whereas previous technologies have been used to break down and re-shape a 'natural' raw material, biotechnology 'programs' living things themselves in the interests of 'designing' a world better suited to meet human needs. Every day, species boundaries are transgressed and organisms genetically engineered to produce nature as a commodity. Never has nature confronted human beings in so artifactual a form, thus revealing its status as a social product more than ever before. The production of nature thesis, with its emphasis on the process whereby nature comes to be constituted as a social reality would seem ideal for grasping the significance of these technological developments.

Of course these are not merely 'technical' achievements, but have taken place largely within the context of an increasing subordination of science and technology to capitalist relations of production (Levidow and Young 1981, 1984; Noble 1977, 1984), and so the biotechnological production of nature is in turn increasingly serving to perpetuate these relations. Its origins in the struggle of firms to overcome the limitations of an advanced Fordist form of the labour process, the intensive and extensive commodification facilitated by biotechnology is opening up new spaces for accumulation (Kenney 1999). The potential for both the replacement of old methods of production and the creation of new, previously unimaginable products through genetic engineering techniques has given impetus to the current proliferation and growth of biotechnology firms and their inter-linkages with both government and academic research facilities. The rapid emergence of this 'university-industrial

complex' (Kenney 1984) in biotechnology is testament to the degree to which the production of nature under capitalism is both shaped by and in turn serves to perpetuate the dominant form of property relations.

And this subordination of the biotechnological production of nature to the interests of capital accumulation is given expression in the ideology of nature dominant in western capitalist societies. While it may indeed be the case that the emergence of biotechnology reveals the social production of nature to an unprecedented degree, the alienation from this nature endemic in a system of generalized commodity production is reflected in the current desire for either a 'return to' or an 'escape from' nature. Critics of the contemporary society-nature relation often condemn 'humanity' for their transgressions against 'nature' and see biotechnology as merely the latest tool in the assault on the natural world. On the other hand, those in favour of the technology often view it as a final leap forward in the historical struggle of 'humanity' to liberate itself from the vicissitudes of a natural existence.⁷ In both cases 'nature' is conceived of as 'other' than 'humanity' rather than as itself a social product, a dualism indicative of the alienation from nature perpetuated by the process of capitalist commodity production.

The production of nature thesis, however, opens up the theoretical space necessary for grasping the implications of biotechnology for the society-nature relation without relying on any such dualism. In opposition to those who would suggest that biotechnology is 'liberating' human beings from nature, a logical and empirical absurdity, biotechnology can be effectively viewed as the newest tool in the capitalist production of nature as a commodity. As such, rather than transcending nature, biotechnology intensifies and extends the human relationship with the rest of nature insofar as the contradictions of the commodity form penetrate to the molecular building blocks of life and spread over the entire globe.

This process is not, however, a 'transgression' of a once pristine nature; indeed, such an interpretation is not only logically and empirically problematic, but unnecessary to grasp the significance of biotechnology as an instrument of production. While it may be the case that certain constructivist tendencies in the social sciences have resulted in a reduction of nature to epiphenomenal status, the notion that nature is always already social does not necessarily imply that nature is a mere shadow of the social, a discursive or cultural construct determined by

particular power configurations. The notion of 'production', rather than 'construction', emphasizes the degree to which nature is produced through concrete human praxis that is indeed always social, but nonetheless 'real' for all that. Accepting that nature is socially produced as a commodity, therefore, by no means precludes consideration of 'natural laws' or 'ecological concerns'; afterall, a commodity is not only an object of social exchange, but a determinate use-value created through a 'mastery' of these very 'laws', albeit often without due attention to 'ecological concerns'. What the PNT does preclude, however, is any attempt to distinguish 'natural laws' from the social processes through which they become manifest. In short, nature is always already social, and it is only by virtue of this very fact that it can have any 'reality' for us at all.

The PNT therefore demands a fundamental shift of perspective, but one that is necessary if critical biopolitics is to avoid relying on futile, and ultimately conservative, appeals to an immediate nature that somehow 'exists' independently of the various historical forms of its production. While Smith is sensitive to the fact that depriving nature of any distinct ontological status may appear politically debilitating to environmentalists, he effectively counters such criticism by pointing to the tacit conservatism of those critiques that promulgate a 'return to nature'. Such an approach inevitably involves a condemnation of productive activity *per se*, thereby diverting attention from the critique and possible transformation of those social relations and processes that determine the form this activity takes.

However, if nature is always already socially produced, then the goal of an effective environmental politics is not a 'return to nature', or even a 'liberation of nature', but the creation of a world conducive to better ways of producing nature. "The first question, is not whether or to what extent nature is controlled," Smith suggests, but "how we produce nature and who controls this production of nature"(1984: 63). Biotechnology in this view is best conceived not as an instrument for dominating an otherwise autonomous (even relatively) nature, but as an instrument for producing nature as a commodity in the interests of capital accumulation. The PNT can infuse critical biopolitics, then, through locating the development of biotechnology and its implications for the society-nature relation within the historical development of capitalism as a mode of production. Such politics would have a clear affinity with the oppositional movements currently coalescing around the globalization of capi-

tal insofar as creating a better society-nature relation would require, rather than some kind of moratorium on biotechnology to protect nature, a fundamental transformation of the social relations and processes within which the biotechnological production of nature takes place.

Thus, in refusing recourse to a society/nature dualism, the PNT provides an indispensable starting point for a political economy of biotechnology and the development of a critical biopolitics. Biotechnology can be effectively conceptualized as an instrument of production in a capitalist labour process that intensifies and extends the process of commodification through manipulating the genetic structure of living things, thereby perpetuating capitalist class relations and reinforcing the 'ideology of nature' through the further alienation of labour from 'nature'. Yet, while it is indeed important for a biopolitics to locate biotechnology within the relatively continuous process whereby the natural world has been penetrated by the commodity form, it is equally important to grasp the important qualitative changes that this process has undergone in recent years. In the following section I suggest that despite its strengths, the level of abstraction at which the PNT is posited serves to obscure important changes in the way nature is produced within the historical development of capitalism, the latest of which is largely an effect of the emergence of biotechnology as an instrument of production.

The Labour Process and the Practice of Producing Nature

In identifying a specifically capitalist form of the society-nature relation, the PNT draws attention to the important role that the labour process plays in producing 'nature'. While human beings have always met their needs through transforming their world with various tools, in a capitalist mode of production this process takes a particular form by virtue of its subordination to the interests of capital accumulation. A central characteristic of this capitalist form of the labour process is a near continuous revolution of the means of production as capital, under the compulsion of inter-firm competition, seeks to intensify and extend the process of commodification. With the increasing incorporation of science and technology into the capitalist labour process comes the increased penetration of the natural world by the commodity form, a further entrenchment of capitalist social relations and an unprecedented alienation from nature. A focus on the capitalist labour process as the primary site at which the society-nature is constituted is not, therefore, reflective of a narrow eco-

conomic reductionism in the PNT, but of the very real tendency under capitalism for commodity production to dominate all other ways of relating to nature.

However, while the PNT may point to the importance of the labour process in making concrete the society-nature relation under capitalism, its consideration of the labour process itself remains at a particularly high level of abstraction. For the most part, Smith remains content with a rather functional view of the labour process from the 'outside'; that is, the capitalist labour process is assumed to be functional for constituting a particular society-nature relation because it is subordinated to capitalist social relations. Relatively absent is any serious consideration of the concrete practices internal to the labour process through which the society-nature relation is actually constituted. This is not to say of course that the subordination of the labour process to capitalist commodity production is not a significant determinant of its form, nor is it to take away from the value of this insight for understanding the contemporary society-nature relation. It is merely to suggest that in abstracting from the concrete practices internal to the labour process, the PNT fails to adequately account for the precise means by which this relation comes to be a reality 'for us'.

This level of abstraction poses certain obstacles to grasping the significance of biotechnology for the society-nature relation insofar as it obscures the significant changes the labour process has undergone throughout the development of capitalism. While it is indeed the case that this labour process is subordinated to the interests of capital accumulation, and therefore shaped by a certain 'logic of capitalist development', this by no means precludes the possibility of it taking distinct forms. Marx (1976) was especially sensitive to the importance of qualitative changes in the labour process in his account of the transition from a system of manufacture to one of large-scale industry during his lifetime, but subsequent transitions to Fordist, advanced Fordist, and now post-Fordist forms of the labour process can likewise be discerned. It seems clear that these changes in the practices through which nature is transformed to meet human needs would have had, and continue to have, significant implications for the society-nature relation, an understanding of which would be integral to the formation of an effective oppositional politics. Yet, in abstracting from the practices internal to the labour process and the important changes these have undergone, the PNT must

remain content with the, albeit important, insight that capitalism produces nature as a commodity thereby perpetuating capitalist social relations.

This level of abstraction is particularly debilitating for a political economy of biotechnology inasmuch as biotechnology has emerged within the context of the current shift to a post-Fordist, informational form of the labour process. Since the early 1970s, western capitalist economies have been undergoing a process of restructuring at the heart of which has been the development of a new form of the labour process whose focus is the storage, transmission, manipulation, and application of information. Biotechnology is implicated in this 'information revolution' as it has both benefited from developments in microelectronics and is in turn converging with them in the form of biochips, molecular computers and other 'bioinformatic' devices (Rifkin, 1998: 175). These developments have led some to include biotechnology as itself an information technology (Castells 1996; Schiller 1996), and others to suggest that biotechnology is on the verge of subsuming these other technologies and serving as the technical foundation for yet another form of capitalism (Rifkin 1998). As the primary site at which the production of nature takes place, grasping these changes in the labour process would seem imperative to understanding the contemporary society-nature relation.

And indeed, the shift to an informational labour process has witnessed the emergence of a very different form of 'nature'. Developments in information technologies have facilitated a fundamental change in the practices internal to the labour process through which nature is produced as a commodity. Whereas in previous forms of the labour process 'physical labour' was applied at the point of production in order to re-shape a material found in 'nature', productive activity in this new form of the labour process increasingly takes the form of 'mental labour' focused on the reduction and recombination of these materials in their elemental forms through the use of computer-based technologies. Biotechnology is the most extreme example of this phenomenon in that it reduces living organisms to their genetic information and recombines this information to produce new organisms as commodities. Thus, while as an instrument of production in a capitalist form of the labour process biotechnology certainly produces nature as a commodity, it produces a very specific kind of commodity that reflects the interests of capital in its very genetic structure. The PNT, however, in remaining at a particularly high level of

abstraction, is inadequate to conceptualize these developments and their implications for the society-nature relation.

And not only does the nature pole of this relation taken on a very specific form with the emergence of biotechnology as an information technology, but the society pole is transformed along with it. The transition to an informational form of the labour process has taken place largely within the context of the struggle of capital to transcend the obstacles to accumulation posed by the nation-state. Information technologies are facilitating the transition to 'global capitalism' insofar as they provide capitalist firms with unprecedented flexibility (Hassan 1999; Teeple, 2000). Biotechnology figures in this process in a number of ways, a most significant of which is that it increasingly liberates commodity production from a reliance on raw materials and forms of labour that may be geographically specific. The increasing subordination of more traditional forms of agricultural production to a transnational agro-industrial complex, for example, has to a great degree been facilitated by developments in biotechnology (Kloppenber, 1998). Thus, biotechnology is not only implicated in the production of a new form of nature, but also in the production of a new form of society in which capitalist social relations have become global, subsuming an unprecedented portion of the world's productive activity. These important changes in the society pole of the society-nature relation fly under the radar of the PNT insofar as it tends to embrace a rather monolithic conception of capitalist social relations that are merely perpetuated by the production of nature as a commodity.

Similarly, significant changes in the contemporary 'ideology of nature' tend to be obscured by the level of abstraction at which the PNT is posited. Concomitant with the shift to an information-based form of the labour process has been the emergence of a very different view of nature. Whereas nature has traditionally been conceived of as an obdurate object, something to be 'tamed, squeezed, molded, and shaped', more recently there has been a shift to a view of nature as a flow of information that can be stored, manipulated, and transmitted (Keller, 1995; Rifkin 1998). Nature here is not so much an object to be subordinated to the human will, as a 'program' to be 'designed' so that it better serves human purposes. While this view of nature may indeed be 'ideological' in the sense that it still reflects the alienation wrought by generalized commodity production, it is clearly a unique form of this ideology that expresses the contradictions of this production in new ways.

Remaining at the level of an 'ideology of nature' reflective of the production of nature within capitalist social relations is inadequate to get at these important changes in the way nature is being experienced and perceived in the era of biotechnology; moreover, such abstraction obscures any progressive political imaginaries that may be implicit in these changing experiences and perceptions.

A sensitivity to these fundamental changes to the society-nature relation and the 'ideology of nature' concomitant with the shift to an informational form of the capitalist labour process is necessary if political economy is to grasp the significance of biotechnology and contribute to an effective critical biopolitics. While locating the technology within the historical 'logic of capitalism' is an important first step toward theorizing the implications of biotechnology for the society-nature relation, it is equally important to understand this development within the context of the qualitative shift that has occurred in the capitalist labour process since the early 1970s. Biotechnology is a central means of production in a novel form of the labour process through which nature is being produced as an 'information commodity', society as 'global capitalism', and nature as 'design'. A critical political economy of biotechnology must strive to understand these changes in the processes, relations and ideologies of capitalism so that it might contribute to the struggle for their transformation.

Of course many of these shifts are still in their nascent stages and the point here has not been to delineate them in any detail; rather, the goal has been to suggest that the level of abstraction at which the PNT is posited tends to obscure them, making it inadequate as it stands for fully grasping the unique implications of biotechnology for the society-nature relation. What is required as a supplement to the PNT is a theoretical framework that, while likewise concerned with the processes through which nature comes to be constituted as a social reality, places more emphasis on the actual practices through which the society-nature relation is achieved and maintained. In the final part of the paper I suggest the value of the tradition of artifactual constructivism in this regard.

Artifactual Constructivism and Biotechnology

Like the production of nature thesis, artifactual constructivism (AC) (Demeritt 1998) takes as its point of departure a critique of the society/nature dualism at the heart of modern thought. The work of Bruno

Latour (1991) and Donna Haraway (1984, 1997), in subtly different but complementary ways, challenges the foundational status of 'nature', focusing instead on the complex processes through which it becomes constituted as a reality. Their work shares with the PNT a concern not only with understanding the ways in which nature comes to be conceived as such, but with the processes through which a 'natural world' is actually produced, or 'constructed', as a material object that is always 'social', but nonetheless 'real'. Indeed, central to the tradition of artifactual constructivism is a critique of these very distinctions insofar as they are considered politically dubious and obstacles to the pursuit of 'situated' knowledge. Like the PNT, artifactual constructivism demonstrates how nature is always already social by delineating the processes through which it becomes produced as both an epistemological category and an 'objective reality'.

The two traditions differ considerably, however, in their conceptualization of these processes. While the PNT remains content with an analysis of the labour process at a particularly high level of abstraction, AC focuses on the more concrete, everyday practices through which the society-nature relation is constituted. Of specific interest are the material-discursive practices of 'technoscience', a term intended to convey the degree to which science, rather than a value-neutral pursuit of 'truth', is itself a cultural practice located within a certain power structure and infused with particular norms, values, and interests. For Haraway, the term also suggests the historical 'implosion' of science and technology that has rendered traditional distinctions between science as the pursuit of disinterested knowledge, and technology as the 'social' application of that knowledge, meaningless (1997: 68). The products of technoscience, rather than 'natural', 'objective truths' that somehow exist independently of 'society' or 'culture', are 'hybrids', or mixtures of the "technical, textual, organic, historical, formal, mythic, economic and political dimensions of entities, actions, and worlds." AC traces the complex 'networks' of technoscientific practice from which these hybrids emerge, and attempts to determine how and why certain of their characteristics come to be deemed 'natural', and others 'social'.

This analytical focus on the material-discursive practices of technoscience is reflected in a sensitivity to the important changes in the society-nature relation that have occurred since the early 1970s. While the emphasis on commodification in the PNT tends to obscure these changes

by reducing the production of nature to the 'logic of capitalism', the notion of 'hybridization' in AC illuminates the degree to which the concept of 'nature' has become truly problematic of late. For AC, the world is and always has been composed of a complex network of humans and non-humans whose 'social' and 'natural' attributes are thoroughly 'mixed-up'; in short, we inhabit a world that is constructed through a set of material-discursive practices. The world is thus constituted by 'hybrids' and only becomes divided into 'nature' and 'society' through a process of negotiation and regulation, what Latour calls 'purification'.

Throughout the 'modern' period the networks of humans and non-humans were relatively limited and the process of hybridization was easily rendered invisible by the 'modern constitution';⁸ however, an unprecedented proliferation of hybrids made possible by recent technoscientific transformations in the information and biological science has increasingly revealed the futility of any attempt to draw a static, ahistorical boundary around 'nature'. Everything from thinking machines, to frozen embryos, to mice designed to develop cancer challenge our conception of what counts as natural. Of course science and technology have always been about 'hybridization', hence Latour's argument that 'we have never been modern'; however, with the proliferation of hybrids since the early 1970s, this process has become much more explicit, refusing containment within a simple society/nature dualism.

Rather than merely dissolving 'nature' into a 'social' category, however, AC is sensitive to the degree to which an unprecedented proliferation of hybrids has effected a simultaneous transformation of 'society'. While the PNT does recognize the degree to which the production of nature as a commodity perpetuates capitalist social relations, these relations remain, for the most part, the 'social' context within which the production of 'nature' takes place. To use Latour's language, the PNT does not fully embrace the 'second principle of symmetry', which requires that the 'social' be explained with reference to the same material-discursive practices through which 'nature' is produced. As Latour suggests, a truly 'symmetrical' constructivism must strive to understand the ways in which the technoscientific construction of 'nature' is simultaneously a construction of 'society'; that 'society', rather than a foundation, is itself produced and maintained through material-discursive practice. The recent shifts in technoscience have thus rendered the notion of 'society' as problematic as that of 'nature' insofar as the proliferation of hybrids

has revealed the degree to which 'society' resides in and is literally held together by 'things'. Of course societies have always been produced through material-discursive practice; but again, with recent technoscientific transformations this has become much more explicit, further rendering a modern society/nature dualism ineffectual to grasp the society-nature relation.

Finally, an emphasis on the discursive dimension of the practices of technoscience makes AC more sensitive than the PNT to the important changes in the way nature is being experienced and perceived with the unprecedented proliferation of hybrids. Rather than assuming an 'ideology of nature' reflective of the commodification of nature within the context of capitalist social relations, AC is more concerned with the role that experiences and perceptions of nature play in determining what counts as 'social' and 'natural' in the first place. At the same time as the proliferation of hybrids has revealed the degree to which 'societies' and 'natures', rather than ontological categories, are themselves the products of technoscientific practice, it has revealed these practices to be as much 'discursive' as 'material'.⁹ It has become increasingly apparent that developments in technoscience are to a great degree fostered by experiences, understandings, and normative claims regarding society, nature, and what it means to be human. Current developments in information and biological sciences are being facilitated by a novel discourse that dissolves 'nature' and 'society' into a flow of information and foresees human beings transcending their 'natural' existence in a future without contradiction and struggle (Silver 1997). An emphasis on technoscience as a set of concrete, material-discursive practices thus brings into focus important changes in nature, society and discourse that remain relatively obscured in the PNT.

When situated within the context of these shifting technoscientific practices, biotechnology takes on new significance. As a central component of these practices, biotechnology has been integral to the unprecedented proliferation of hybrids that has rendered modern conceptions of society and nature so problematic. An unprecedented manipulation of the reproductive capacities of living things at the molecular level constitutes a qualitative leap forward in the process of 'hybridization'. Genetically engineered organisms are designed in their very molecular structure, thereby making any *a priori* attempt to identify their 'natural' component, as opposed to their 'social' one, futile. These organisms thus

also reveal the degree to which 'society', rather than the context within which things are produced, literally resides in, and is held together by, these 'things'; in short, the degree to which in producing nature we simultaneously produce ourselves. And never before has the discursive dimension of technoscientific practice been more visible than in the case of biotechnology. Rather than an obdurate object standing opposed to 'society', nature is viewed as entirely reducible to a genetic code that can be stored, manipulated, and transmitted at the whim of the molecular biologist. Locating biotechnology within the technoscientific practices of hybridization thus bring to light its unique role in revealing the degree to which 'society' and 'nature', and the distinction between them, are products of material-discursive practice.

An analytical sensitivity to role that biotechnology is playing in these current shifts in technoscientific practice raises some interesting possibilities for a biopolitics. Whereas the PNT locates the potential for alternative productions of nature within a wider transformation of capitalist social relations, AC advances a more 'micro' politics of responsibility. In revealing the degree to which the boundary between society and nature is produced and maintained through the concrete, material-discursive practices of technoscience, AC suggests the potential for a more responsible, self-conscious form of these practices. Of course there is no outline for a 'better' society-nature relation provided, and this lack of normative direction is a strength of the argument insofar as any such normative claims would inevitably involve an appeal to the kind of society/nature dualism that has proven so problematic. Appeals to the universality of either pole of this relation to justify a particular production of the other are as politically dubious as they are logically inconsistent; they obscure the degree to which both 'society' and 'nature' are always already infused with material-discursive practice and therefore inherently political. A biopolitics, rather than focusing on keeping the two separate – a futile endeavour from the outset – should concern itself with encouraging a more responsible, self-conscious production of hybrids. Biotechnology, in facilitating an unprecedented proliferation of these hybrids, reveals the need for such a politics of responsibility more than ever before. Thus, in focusing on the material-discursive practices through which the society-nature relation is constituted, AC points to biopolitical possibilities of more immediate relevance than simply 'waiting for the revolution'.¹⁰

At the same time, a 'politics of responsibility' is bound to appear rather thin to those confronted with the structural constraints imposed by an increasingly global, information-based form of capitalism; and indeed, the analytical approach of AC has certain limitations that must be addressed if it is to be useful for a political economy of biotechnology and a global, biopolitics. Primary in this regard is AC's tendency to abstract technoscientific practice within the 'lab' from wider political economic relations and processes. While it is indeed the case that changing technoscientific practices since the 1970s have had important implications for the society-nature relation, these changing practices must be located within the context of a shift to a new global, information-based form of capitalism. A driving force behind this shift has been an increased subordination of science and technology to the requirements of capital accumulation, an historical process that has received surprisingly little attention in the AC literature. A focus on the 'lab' as the primary site at which 'worlds are made', while effectively directing attention to the material-discursive practices through which the society-nature relation is constituted, tends to obscure the degree to which the 'lab' has itself become incorporated into the capitalist labour process. As a central component in the shift in technoscientific practices since the 1970s, the development of biotechnology has been shaped by this process of incorporation and as an instrument of production reflects the requirements of accumulation in both its form and function. The implications of biotechnology for the society-nature relation cannot be grasped independently of these developments.

Nevertheless, a focus on the material-discursive practices through which the society-nature relation is constituted, if conceived within the context of an increasing subordination of science and technology to the capitalist labour process, can provide for a nuanced and penetrating political economy of biotechnology that avoids recourse to a simple society/nature dualism. First, it allows for an appreciation of the unique role being played by biotechnology in producing nature as a material-discursive reality, while not losing sight of the process of commodification as the driving force behind its development. Second, it directs attention to the ways in which biotechnology, as a central component in the shifting material-discursive practices internal to the labour process, is producing a new form of society, while still maintaining a focus on capitalism as the primary structuring dynamic of contemporary life. Finally,

such a focus on the material-discursive practices internal to the capitalist labour process would allow for a greater sensitivity to the more subtle changes in the way the society-nature relation is being experienced and perceived without losing sight of the wider ideological context within which these more subtle changes are occurring. In short, such an approach would enable political economy to grasp the unique implications of biotechnology for the society-nature relation within the context of capitalist development, without recourse to a simple society/nature dualism.

Such an approach to the political economy of biotechnology can likewise infuse a global biopolitics that, while sensitive to the unique threats of biotechnology, refuses to rely on illogical and inherently conservative appeals to a 'nature' distinct from the various forms of its social appropriation. The primary threat of biotechnology lies in its unprecedented intensification and extension of the process of commodification, its role in the globalization of capitalist social relations, and in the ideological reduction of the world to a flow of information subordinated to the will of the molecular biologist. This is not of course to say that the 'environmental' threats of biotechnology are unimportant. The important point to be made, however, is that these 'environmental threats' cannot be conceived in abstraction from the current shift in the material-discursive practices through which the society-nature relation is constituted. Research and development in genetic engineering is driven more by the profit motive than by any hubristic attempt by science to 'dominate' or 'control' nature. While commodification may not be the only process shaping the biotechnological production of nature, the degree to which science and technological development have become subordinated to the interests of capital surely makes it the dominant one, and increasingly the only politically relevant one. A politics aimed at combating the threats posed by biotechnology, rather than protecting 'nature' from biotechnology, must focus its attention on encouraging those material-discursive practices that might foster a responsible and self-conscious employment of biotechnology to produce more human(e) forms of nature and society. Insofar as the social relations and processes of capitalism systematically impede the pursuit of such practices, they must be the object of critique and transformation.

Notes

1. Notwithstanding attempts by industry and government to depict current biotechnological developments as continuous with those in the past (e.g. Canadian Biotechnology Strategy Secretariat (1998)), this distinction is well established in more critical analyses (e.g. Kenney (1984)). For the remainder of the discussion here the term 'biotechnology' refers to these developments in 'new' biotechnology.
2. An illustrative example of this 'transgenic production' is the creation of spider-goat hybrids whose 'milk' contains the protein for spider silk that can be used as a stronger and lighter replacement for steel. See www.nexia.com.
3. Many of these attempts can be found in the pages of the journal *Capitalism, Nature, Socialism*.
4. As Smith argues: "No part of the earth's surface, the atmosphere, the oceans, the geological substratum or the biological superstratum are immune from transformation by capital. In the form of a price tag, every use-value is delivered an invitation to the labor process, and capital – by its nature the quintessential socialite – is driven to make good on every invitation" (1984: 56).
5. Hence we see the paradoxical emergence of a 'return to nature' movement at the very moment when such a 'nature' is most in doubt. See also Vogel, 1988
6. MacNaghten and Urry (1995) have called for the development of a 'sociology of nature'. A political economy of nature would be one that while emphasizing the 'sociality of nature' emphasizes the materiality of the process of its production within the relations and processes of capitalism.
7. Most of the more popular debate over biotechnology has concerned issues of food and human genetic engineering. Examples of condemnation can be found in Tokar (2001). Praise for biotechnology, particularly as it relates to human genetic engineering, can be found in Silver (1997). For an accessible and somewhat more critical discussion of the popular discourse surrounding developments in biotechnology, see Rifkin (1998).
8. For an explanation of the role of the 'modern constitution' in rendering hybrids invisible, thereby allowing for their proliferation, see Latour (1991).
9. This of course raises the issue of whether the distinction between the two is useful at all. I assume that Haraway's use of the hyphenated 'material-discursive', like her many other hyphenated and 'imploded' terms, is intended as a refutation of a 'vulgar' materialism. Even a cursory glance at the "Theses on Feuerbach", however, would suggest that Marx's materialism was always 'discursive' insofar as "the chief defect of all hitherto existing materialism is that the thing, reality, sensuousness is conceived only in the form of the object of contemplation, but not as sensuous human activity, practice, not subjectively"(Marx 1970: 121).

10. While an exploration of the specific 'content' of this biopolitics is beyond the scope of this discussion, democratization of technoscience policy, greater public control over the research generated in university and government labs, greater professional autonomy amongst scientists at the point of production (e.g. through unions or professional organizations), and greater cooperation between the 'developed' and 'developing' world in the development and employment of biotechnology, among others, would be key components.

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