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**Biotechnology and the Politics of Truth:**
**From the Green Revolution to an Evergreen Revolution**[1]

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## Abstract

*This paper investigates why and how issues around the diffusion of GM technologies and products to developing countries have become so central to a debate which has shifted away from technical issues of cost-benefit optimisation in a context of uniform mass production and consumption in the North, to the moral case for GM crops to feed the hungry and aid 'development' in the South.*

*Using comparison between agricultural biotechnology and the 'Green Revolution' as a cross cutting theme, the contributions of this paper are threefold. Firstly, by analysing biotechnology as a set of overlapping frames within a discursive formation, four frames are identified which summarise key challenges presented by biotechnology era. Secondly, the use of Foucault's concept of bio-power to synthesise key themes from the frame analysis illuminates the 'revolutionary' nature of the biotech revolution. Thirdly, the potential of actor-network theory to provide a tools for the empirical study of processes of (re)negotiation of nature/society relations in the context of agricultural biotechnology controversies is explored.*



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## Introduction

This paper investigates why and how issues around the diffusion of genetically modified (GM) technologies and products to developing countries have become so central to a debate which has shifted away from technical issues of cost-benefit optimisation in a context of uniform mass production and consumption in the North, to the moral case for GM crops to feed the hungry and aid 'development' in the South. This has led to a revival of discourses from the Green Revolution era of 1965-80, in which high yielding crop varieties and an associated technology/policy package were exported via an international network of agricultural research institutes and donors to Asia and Latin America.

During the 1990s, increasing resistance among consumers in several EU countries towards GM products forced the European parliament to reverse its earlier support for the biotech industry; and to chart a new course which included a five year (1998-3) de facto moratorium on the release of GM crops (European Commission 2003), precipitating a transatlantic trade dispute and leading to the development of an alternative regulatory framework to the product-based approach favoured by the US government and the biotech industry (Newell and Glover 2003, Levidow et al. 2000, Levidow and Murphy 2003). With the EU moratorium succeeded by a framework incorporating requirements for traceability and labeling, many developing countries are reluctant to grow GM crops for fear of contaminating non-GM crops for EU markets. In this scenario, only China and India have domestic markets large enough to test GM products without risking exports (Glover 2003). The acceptance of GM products by the Indian public therefore has significance for the global biotech industry, particularly those corporations that have already invested in India's biotech sector. The launch, at the annual Royal Society conference in 2002, by Indian scientists, of a nutritionally enhanced GM potato (or *protato*) therefore deserves analysis as a window into the complex web of national and transnational actors and interests contesting issues around agricultural biotechnology and development.

Using comparison between agricultural biotechnology and the ‘Green Revolution’ as a cross-cutting theme, the contributions of this paper are threefold. Firstly, by analysing agricultural biotechnology as a set of overlapping frames within a discursive formation, four frames are identified which summarise key challenges presented by biotech era. Secondly, the use of Foucault's concept of bio-power to synthesise key themes from the frame analysis illuminates the 'revolutionary' nature of the biotech revolution. Thirdly, the potential of actor-network theory to provide a tools for the empirical study of processes of (re)negotiation of nature/society relations in the context of agricultural biotechnology controversies is explored, and applied to the *protato* case.

**Revisiting the 'Green Revolution'**

Many of the arguments surrounding the biotech 'revolution' and development are reminiscent of debates around the Green Revolution. According to critics, both are based on neo-Malthusian reasoning about the relationship between population and food production, each proposing a new 'technological fix' (Goodman and Redclift 1991, p. 142) to intensify production (Nature 2002); squeeze out small farmers and increase inequality[2] (ActionAid 2003, Shiva 1989), and threaten biodiversity through the promotion of monocultures (ibid).

The Green Revolution 'lies at an important intersection … between the historiographies of technology and US foreign relations' (Cullather 2004, p. 228). The term 'Green Revolution' was first used in 1968 by USAID administrator William S. Gaud; and was first debated by the US congress in 1969[3]. The resulting initiative was shaped by geopolitical priorities of the time, to contain communism by increasing food production to keep pace with population growth. The Green Revolution therefore represented a convergence between neo-Malthusian thinking about population growth and social and political instability and a prevailing technicist orientation to socio-economic problems.

> 'Green', of course, was implicitly opposed to 'red' and was signaling, like a flag, that social reform was not necessary, since technical means in agriculture (evoked

[2] Detailed empirical studies and analyses of the political economy of the Green Revolution, conducted in the 1970s, provided a substantial indication that the introduction of the technologies produced (or at least exacerbated) increased inequality and accelerated processes of class polarisation and proletarianisation in rural Asia and Latin America (cf. Pearse 1980, Frankel 1971, Griffin 1979).

[3] '…discussed before the US House of Representatives at the Subcommittee on National Security Policy and Scientific Development, of the Committee on Foreign Affairs. The title given to the publication of the proceedings was *Symposium on science and foreign policy: The Green Revolution*' (Spitz 1987, p. 56).

> by ‘green’) alone were supposed to solve the problem of hunger’ (Spitz 1987, p. 56).

There are broadly two meanings of the Green Revolution. A first, more narrow meaning refers to ‘specific plant improvements notably the development of high yielding varieties (HYVs) of rice and wheat’ (Griffin 1979, p. 2)[4]. In 1970 Norman Borlaug[5] was awarded the Nobel Peace Prize for ‘having set in motion a worldwide agricultural development, … the ‘Green Revolution’….Borlaug’s ‘miracle wheat’ doubled and tripled yields in a short period of time. Similar increases were soon achieved with maize, and, at the International Rice Research Institute (IRRI) in Philippines, with rice’ (Glaeser 1987, p. 1):

> They [the HYVs] were introduced in several Asian countries in 1965, and, by 1970, these strains were being cultivated over an area of 10 million hectares. Within three years, Pakistan ceased to be dependent on wheat imports form the United States. Sri Lanka, Philippines and a number of Latin American countries achieved record harvests. India, which had just avoided a severe famine in 1967, produced enough grain within five years to support its population. Even after the 1979 drought, grain imports were not necessary. India had become self-sufficient in wheat and rice, tripling its wheat production between 1961 and 1980 (ibid).

A second, broader meaning refers ‘to a broad transformation of agricultural sectors in developing countries, to a reduction in food shortages and undernourishment, and to the elimination of agriculture as a bottleneck to overall development’ (Griffin 1979, p. 2). It is through this second meaning that the Green Revolution converged with nation building and development objectives of newly independent states towards modernisation and industrialisation. In South and Southeast Asia in particular, the formula of food self-sufficiency, modernisation and technicism found resonance with a ‘new generation of populist leaders, whose slogans emphasised developmentalist, rather than redistributionist goals’ (Cullather 2004, p. 245).

The Green Revolution was a public sector initiative, coordinated through an international network of governmental and inter-governmental agricultural research and policy

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[4] This ‘technology’ definition requires qualification, however. The tendency to describe Green Revolution technology in terms of HYVs alone has resulted in misleading claims for its ‘scale neutrality’. In fact, it was a technology ‘package’ which required farmers to make several concurrent changes if they were to produce the ‘optimal conditions’ necessary to achieve the stated yields, a feature which led to a strategy of targeting ‘progressive farmers’ (Pearse 1980, p. 181, Glaeser 1987, pp. 1-2).

[5] American botanist, Director of Division for Wheat Cultivation at CIMMYT in Mexico

institutions[6], which became established during the period 1965-80. However there is no doubt that in the longer term, the US agricultural private sector benefited from a process that 'furnish[ed] a means to penetrate and discipline markets' (Cullather 2004, p. 228) and thus helped to create the conditions for the 'biotech revolution', which began in the 1990s.

This biotech 'revolution' is taking place against a very different set of global forces. It is private sector-led (Seshia and Scoones 2003), reflecting the changing balance between states and markets in a neo-liberal era (Goodman and Redclift 1991, p. 180; Strange 1996). Development goals of self-sufficiency have been displaced by a return to the logic of global competitiveness based on comparative advantage. Public sector agriculture research institutes are under-funded and increasingly reliant on public-private sector partnerships. The global governance of biotechnology is driven by private sector concerns for deregulation and strengthened intellectual property rights regimes (Newell and Glover 2003).

These developments have been contested, however, with new actors entering debates on agricultural technology and policy, providing their own assessment of its risks and uncertainties. Non-government actors in particular have been successful in exposing gaps in public accountability and taking on a new role of public regulation (Newell and Glover 2003, p. 26). Key elements of continuity and change between the two eras are summarised below.

**Green revolution and agricultural biotechnology eras: Changes and continuities**

***Continuities***

- Promotion of 'scientific revolution' in agriculture; a 'technological fix'[7] applied to complex socio-economic realities.
- Promotion of monocultures to intensify production.
- Food shortage presented as a supply problem rather than a distribution problem.

[6] In particular, the CGIAR (Consultative Group on Agricultural Research), an international network of national agricultural research institutes – such as CYMMIT in Mexico, IRRI in the Philippines and IARI in India, with strategic direction provided by IFRPI in Washington

[7] Goodman and Redclift (1991, p. 142).

- High barriers to entry tend to squeeze out smallholders and increase inequality.
- Legitimised by neo-Malthusian discourses.

***Changes***

- High levels of uncertainty and risk surrounding transgenic technologies, new issues such as bio-safety.
- Ownership and control: from public sector to private sector.
- International context: from cold war and national food self-sufficiency to neo-liberal globalisation and competitive exports.
- A wider range of actors influencing and contesting policy.

## Framing biotechnology

The emphasis of this section shifts to agricultural biotechnology, while retaining the theme of comparison with the Green Revolution. A discourse analysis approach is used to go beyond some of the more obvious continuities and discontinuities, by analysing biotechnology as a set of (partially overlapping) frames within a discursive formation.

A discursive formation is a historically situated system of institutions and discursive practices (Dreyfus and Rabinow 1983, p. 73), establishing a set of relations in which 'some things frame others, some things are regarded as less questionable than others, some issues and perspectives colour the way others are apprehended, discussed and acted upon' (Appadurai 1990, p. 209). The extent to which statements or 'speech acts' have meaning depend on their place within a 'discursive formation that specifies their truth conditions' (Dreyfus and Rabinow 1983, p. 58).

Framing involves 'matters of inclusion, exclusion and attention, including how the burden of proof is distributed, and the perception of alternatives and constraints' (Gasper 1996, p. 47). Framing is a 'core discursive activity'; it is 'through frames... (that) facts, values, theories and interests are integrated' (Apthorpe 1996, p. 24]. The following paragraphs discuss a set of frames, or ‘taken-for-granted assumptional structures’ (Schon and Rein 1994, p. viii) that are employed by the biotech industry, governments of 'knowledge-based economies' and the scientific community to make truth claims about the benefits of GM crops for populations, particularly in developing countries.

This frame analysis highlights how discourses on biotechnology have emerged at the confluence of a number of transformations: discursive and non-discursive, political, institutional, economic and technological, which combined to produce a discursive formation and 'regime of truth' (Foucault 1980, p. 131), as a recombination of both old and new discourses, establishing 'multiple of forms of constraint' (ibid. 131) on the production of truth about biotechnology, structuring the field of action of businesses, scientists, administrators and farmers.

***Technology has its own trajectory***

One of the ways in which biotechnology is framed is as evidence of the inevitable, constant advance of science and technology, which is politically neutral and always beneficial (Hannigan 1995, pp. 170-1). Within this frame, biotechnology presents a technological answer to the problem of global hunger by promising higher agricultural productivity. Questions of inequities and inefficiencies in distribution of food and the uneven access to resources for food production are framed out, as is the politics of food sovereignty. The problem is framed as purely a matter of supply; the solution to which is the technological improvement offered by biotechnology:

> 'The twenty-first century needs another Green Revolution to elevate global food production.... the only way to expand production is by developing a technology that increases output per unit of input' (Nature 2002, p. 679).

Moreover, any risk of unintended negative consequences of GM technologies is dismissed on the basis that 'ongoing technological development of other GM lines will almost certainly ameliorate the problem if it emerges' (ibid. p. 669).

This frame enables promoters of GM crops to polarise the debate as being between those in favour of 'sound science' and opponents who are 'using politics to stop science' (Hannigon 1995, pp. 170-1), drawing on a ‘balance metaphor’, which ‘presumes that a controversy only has two sides’ (Levidow 2005). Moreover, by restricting discussion of alternatives to comparisons with unrealistic options such as a return to the 'huntergatherer lifestyle' (Nature 2002, p. 671, pp. 701-3), excluding from debate the many local examples of viable alternatives (Hogg 2000, pp. 19-34), biotechnology is framed as the solution to which there is no alternative.

***In the national interest***

This frame, equating the interests of a domestic biotechnology sector with the national interest, has been key to the convergent articulation of the interests of states, capital and science, with biotech sectors positioned as strategic to the national interest of knowledge-based economies engaged in a global technological race (Newell and Glover 2003, p. 5).

The emergence of biotechnologies coincided with the 1980s farm crisis, which challenged the ‘productivist’ agricultural model (Goodman and Redclift 1991, pp. 126-128). These technologies enabled a 'unified transformation' of the complete cycle of food production for the first time, creating the possibility for capital investment in seed production and reproduction (ibid. pp. 90-91). Or, to paraphrase Marglin, the need for a new mode of production provided the impetus for the emergence of a particular kind of technology (Marglin 1990, p. 246). However, it was a change in law that created the ‘ordered environment’ (Jasanoff 2005, p. 189) necessary to encourage capital investment. The affirmation by the US Patents and Trademarks Office (PTO) in 1985, of the precedent set by the successful appeal by Chakrabarty and General Electric, opened the door to the patenting of life forms as 'information', and to new possibilities for the privatisation of knowledge. Subsequent developments in US intellectual property law provided the template for instruments of international harmonization of intellectual property protection, such as TRIPS (Bowring 2003, pp. 92-3).

In this context, private sector leadership of agro-biotechnology development has been 'conferred not by default but by design, supported by complementary public funding' (Goodman and Redclift 1991, pp. 179-180). This is part of a broader shift 'from state authority to market authority (which) has been in large part the result of state policies...It was handed to them on plate, and moreover, for reasons of state' (Strange 1996, pp. 44-45).

In the knowledge economies of US[8], Europe and Japan, 'the imagery of global markets and high technology combined powerfully with neo-liberal policies to devolve control over the research agenda and deployment of agro-biotechnology to the corporate, that is to say multinational, sector' (Goodman and Redclift 1991, p. 180). This has been reflected both within knowledge economies in the alignment of 'national interest' with interests of high tech industry, in particular the biotech sector (Newell and Glover 2003, Scoones 2003); and the reframing of 'development' from a state-led, inward-oriented development model to a neo-liberal, outward-oriented model (Seshia and Scoones 2003). Mytelka (2000) has identified the following characteristics of what she calls knowledge-based networked oligopolies, of which the 'life sciences' conglomerate[9] is a prime example: First, they are composed of networks of firms (rather than a single company); second, they collaborate in the control over the evolution of new knowledge; third, 'their focus is less on creating static size barriers to entry than on shaping the future boundaries of an industry, and the technical trajectories, standards and rules of competition within them'[10]. The emergence of these networked oligopolies signify a new phase in networked global capitalism, replacing traditional notions of competition between firms (Rifkin 1998, pp. 207-216, Karamanos 2002) and between states (Newell and Glover 2003).

***Biotechnology is natural***

This frame has been important for reassuring the public about risks and uncertainties around GM products. It does this by emphasising continuity with older technologies (such as the hybrid crops of the green revolution) (Visvanathan and Parmar 2003, p. 2716, Conway 1997, pp. 140-1) and even ancient culinary practices such as curd and breadmaking (Deccan Herald 2003) to demonstrate that 'biotechnology is merely an extension of nature and therefore safe' (Hannigan 1995, pp. 170-1). In this case naming is an important part of the framing, with the more encompassing term 'biotechnology' preferred to the term 'GM' which has already generated controversy. Biotechnology is

[8] A recent statement from the US Department of State on 'Agriculture and Biotechnology in US Foreign Policy' is a clear example if this (US Department of State:2002).
[9] Pistorius and van Wijk have called the major corporations involved in GM crop research and development, including Monsanto, Bayer-Aventis, Syngenta, Dupont, 'crop development conglomerates', (Pistorius and van Wijk 1999); increasingly, these corporations are referred to by generic term of the 'life sciences' industry, reflecting a range of interests including chemical, pharmaceutical, agricultural processes and products.
[10] The promotion of the TRIPS regime is illustrative of this third characteristic.

presented as 'a benign, neutral science, built on concepts and practices handed down through the ages' (ibid.).

This emphasis on continuity obscures a transition that is taking place in the social construction of nature within post-industrial societies, from a mechanical frame (which reflected social Darwinism) towards a cybernetic frame, in which life is framed as information (Eder 1996, pp. 39-46, Rifkin 1998, pp. 200-2, Visvanathan 1996, pp. 310-2). This cybernetic state of nature both reflects and legitimises the two emerging trends of networked global capitalism and biotechnology as a new mode of production (Rifkin 1998, pp. 200-2, Heller 2001, p. 406); which converge in the notion of the 'life sciences' industry. In particular, the concept of life as information has been key to the acceptance of the idea of life forms as intellectual property, and the practice of patenting genetic resources. These points are summarised in the following table.

***Table 1: Mechanical and Cybernetic States of Nature***[11]

| | **Mechanical state of nature** | **Cybernetic state of nature** |
|---|---|---|
| Images of life and nature | Nature as machine<br>Life as machinery (utility)<br>Invested in species<br>Assembled from parts<br>Passive beings resulting from process of random selection | Nature as computer<br>Life as information (complexity)<br>Invested in genes<br>System of transformations<br>Dynamic, self-organising processes |
| Concept of evolution | 'Survival of the fittest'<br>Competition and struggle<br>Governed by the 'invisible hand' of natural selection<br>Occurs over long periods of time | 'Survival of the best informed'<br>Improvements in data processing capacity, speed of response, complexity of organisation<br>Can occur suddenly and rapidly |
| Form of capitalism | Competition is 'natural'<br>Firms compete with each other<br>Principle of natural selection reinforces Adam Smith's 'invisible hand' of the market<br>Division of work in nature legitimises division of labour in industrial production | Information gathering and processing is 'natural'<br>Firms collaborate in a network-based global economy<br>New forms of commerce evolving, based on knowledge exchange within embedded networks |
| Technological | Factory production | Genetics and biotechnology |

[11] Author's elaboration; a synthesis of concepts drawn from the following sources; Rifkin (1998, pp. 202-216), Eder (1996, pp. 39-45), Karamanos (2002) and Mytelka (2000)

| | | |
|---|---|---|
| manifestations | Engineers calculate, transform and recombine parts of nature<br>Natural resources as factor of production | Scientists produce nature according to theoretically designed knowledge<br>Genetic resources as data input |

*An 'evergreen revolution'*[12]

This is an overarching frame which has been key to holding together apparently contradictory discursive elements – old and new, conveying continuity and change - recombining the frames ‘technology has its own trajectory’, (a reconstructed notion of) ‘national interest’ and ‘biotechnology is natural’ with discourses on biodiversity conservation; all under the banner of an ‘evergreen revolution’.

In so doing, this frame facilitates the convergence of interests, values and facts represented by the biotechnology and biodiversity discourses, reflecting both the shift from public to private funding and control of agricultural research (Seshia and Scoones 2003, Newell and Glover 2003) and construction of an environmental 'crisis' of biodiversity loss. This frame incorporates the cybernetic state of nature, presenting biodiversity as genetic information and equating biodiversity conservation with the realisation of its market value in a global market (Flitner 1998, p. 147). From this perspective, seeds are raw materials that can be genetically improved in the laboratory to increase their market value, replacing the multifunctional role of seeds as the means of production and reproduction (Shiva 1993, Kloppenburg 1988).

Within this frame, GM crops are promoted as a means to promote sustainable agriculture with increased productivity while 'saving land for nature' (Nature 2002). This reflects interests of the life sciences industry to protect forested areas, as the repositories of as yet unknown genetic resources, for future 'mining' (Flitner 1998, Visvanathan 1996, p. 314). Scientific discourses on agriculture combine an imperative to preserve remaining 'wilderness' areas with pre-existing neo-Mathusian narratives (carried over from the Green Revolution), presenting the case for agricultural biotechnology as addressing both socio-economic and ecological concerns:

[12] This term is borrowed from M.S. Swaminathan, father of India's green revolution (Seshia and Scoones 2003, p. 13).

> 'The application of scientific knowledge to agriculture has yielded extraordinary dividends...Unless we can pull off a second green revolution, increasing yields but limiting it to land currently used for farming, there will be further deterioration of natural habitats and biodiversity at a rate that could even threaten the further existence of humanity' (Nature 2002, pp. 668-9).

A similar set of imperatives is set out in Gordon Conway's proposal for a Doubly Green Revolution (1997). Conway argues for a 'shared vision' that integrates the complementary (rather than conflicting) objectives of sustainable agriculture, drawing on ecological concerns and household level livelihoods analysis, with the techniques of molecular biology and genetics (Conway 1997, p. 182).

**Continuity between the eras: The 'folktale narrative'**

The exclusion of the complex political, social and economic dimensions of the question of access to food in favour of the simplified notion of 'feeding the world' as a global project fits well with Roe's conceptualisation of the 'folktale narrative' (Roe 1991). As in the Green Revolution, the 'problem' to be solved is the need for higher yields, so that the global food supply is able to keep up with population growth. GM crops (previously the HYVs) are the 'hero', overcoming the 'recalcitrance of nature' by rationalising it, through a philanthropic act of technology diffusion (Visvanathan 1996, p. 321). Resistance to GM crops may have presented unexpected obstacles, but these are characterised as the elite concerns of European consumers and Western environmental groups who would deny hungry populations in developing countries the benefits of GM products (RFSTE 2003, US State Dept 2002).

Each part of this narrative can be contested. The identification of food supply as the problem is consistently challenged by the existence of warehouses full of undistributed food (Sharma 2003). Secondly, the actual performance of the 'hero' has been mixed in comparison to the claims, as evidenced by the often disappointing results of GM crop trials in comparison to available alternatives (deGrassi 2003, ActionAid 2003, p. 21). Thirdly, the polarised picture of philanthropic science meeting elite interests obscures a far more complex web of values and interests; in which directions in GM crop research and development reflect the interests of capital, not smallholders or consumers

(ActionAid 2003, pp. 19-21, Kloppenburg and Burrows 2001, p. 104), and resistance to GM crops includes not only Western groups and interests, but also farmers' movements in developing countries (RFSTE 2003, Visvanathan and Parmar 2003).

Marglin has argued that 'the cloak of science was crucial' to creating consent around a model of agricultural development based on genetics (Marglin 1996, p. 210). Moreover, Green Revolution failures or disappointing GM crop yields do not reduce the potency of the narrative, since such narratives 'thrive on disappointment' (Gasper and Apthorpe 1996, p. 9), as this provides the justification for the next intervention. Roe argues that the reason why such narratives endure is that policymakers need simple, general narratives to work with; the way to challenge them is to produce counter narratives (Roe 1994, pp. 40-41).

**Discontinuity between the eras: The extension of 'bio-power'**

While the persistence of the 'folktale narrative' provides the thread of continuity between the Green Revolution and biotech eras, it is Foucault's concept of 'bio-power' (1976, pp. 133-159) that illuminates the discontinuity between the eras. In particular, the extension of bio-power to the management of nature at the molecular level helps to understand the 'revolutionary' nature of the biotech era; in which a new phase of capitalism and scientific discourse are shaping contemporary understandings of society and nature in such a way as to legitimise an emerging social order and accelerate the reproduction of capital.

Bio-power, or power over life was identified by Foucault as a form of 'power-knowledge' (Foucault 1980, pp. 109-133) which 'linked the various political technologies of the body, discourses of the human sciences and the structures of domination' (Dreyfus and Rabinow 1983, p. 184). In particular, the spread of bio-power, from 17$^{th}$ century onwards, saw the human sciences evolve in a mutually constitutive relationship with the administrative capacity of the state and the requirements of industrial capitalism.

Bio-power evolved around two poles. The first was the human species or population. In order to render populations manageable, they were divided into scientific categories, studied and regulated, in terms of reproduction, hygiene, birth, health, life expectancy and mortality (Foucault 1976, pp. 143-5). The second pole was the human body as a machine, 'as an object to be manipulated' (Dreyfus and Rabinow 1983, p. 134). The body became an object of disciplinary power, 'perfected in workshops, barracks, prisons and hospitals' (ibid. 135), whose goal was to produce a 'docile body', docile and at the same time productive. The combined effect of bio-power around these two poles was a 'parallel increase in usefulness and docility of individuals and populations' (ibid.).

In summary, what was at stake during the early stages of industrial capitalism was the alignment of bodies and populations to the reproduction of capital. Bio-power was an essential element in the development of capitalism, which 'would not have been possible without the controlled insertion of bodies into the machinery of production and the adjustment of the phenomena of population to economic processes' (ibid. 141). At the same time, it spread 'under the banner of making people healthy and protecting them' (Dreyfus and Rabinow 1983, p. 196).

The extension of bio-power to the management of nature had been evolving slowly in Western Europe since the late 19$^{th}$ century, but gathered pace during the 1960s and 1970s with the publication of various conferences[13] and publications[14] concerned with ecological 'limits'. In order to render nature manageable, it was produced as 'environment' (Escobar 1995). A profusion of disciplines and techniques emerged, including the disciplines of environmental management and techniques of environmental impact assessment, reinforced by legislation and the establishment of national environmental protection agencies.

The recent acceleration in the extension of bio-power, however, is from the species level to the molecular level. Based on research on the human genome project and developments in genomic medicine; Rose and Rabinow draw attention to a shift in focus

[13] Such as the UN Conference on the Human Environment (UNCHE) in Stockholm in 1972.
[14] For example Carson (1962) and Meadows et al (1972)

from gross characteristics (such as intelligence or personality) to 'illness conditions', specific deficiencies which led themselves to probabilistic calculation and technical intervention (Rose and Rabinow 2003, pp. 30-33). A parallel to this can be found in plant biotechnology, which aims to improve on genetic deficiencies in plants. In this case, the new disciplines of molecular biology and genetics can be understood as the transformation of biology by the reductionism of physics, which:

> '...re-set the future course of biology [leading to] the ratification of a new set of beliefs', in 'the incontrovertible value of simplicity, ....the unitary character of truth,....the simultaneous equations between power and knowledge and between virtue and power.... With life relocated in the genes, and redefined in terms of informational content, the project of 'refashioning life'... [was] recast as a manageable and do-able project' (Fox Keller 1995, pp. 62-3).

In summary, the conditions for the emergence of biotechnology as a discursive formation included the reallocation of the lead role in agricultural research from the public to private sector, supported by neo-liberal state policies and the concomitant availability of capital and a reconstructed concept of 'national interest' synonymous with corporate interests. Biotechnology, or more specifically molecular biology co-evolved with these political and economic transformations, through extension of bio-power to nature, and from the species level to the molecular level. In particular, the new technologies enabled the appropriation of the *reproduction* of nature, facilitating the 'unified transformation' of the agricultural cycle for investment (Goodman and Redclift 1991, pp. 90-1).

**Actor-networks, knowledge and agricultural policy**

The previous section used discourse analysis to give a broad-brush picture of the discursive landscape, and the framing devices available for debating agricultural biotechnology. This section now turns to the empirical study of specific interventions. In particular, how to study the processes of (re)negotiating nature/society relations in the context of specific agricultural biotechnology interventions and controversies, given that agricultural biotechnology artifacts are 'quasi-objects'; simultaneously material, social (produced from interests), and discursive (subject to being framed in different ways) (Middendorf 2002, p. 243, Goodman 1999, p. 30).

Goodman argues that it is necessary to replace the 'modernist ontology', with its nature/society dichotomy, in order to analyse properties of agro-food networks (Goodman 1999). One approach that attempts to develop a new ontology is actor-network theory (ANT). ANT has emerged from the field of science studies (in particular, Latour 1987), which provided new insights into the co-construction of knowledge and networks. ANT posits hybrid networks that include both human actors and non-human agents (or 'actants'), bridging the nature/society divide and with the notion the heterogeneous *collective* (Goodman 1999, p. 25).

Basic premises of ANT include the following (Middendorf 2002, pp. 179-183): *symmetry*, the study all entities (whether human, material or textual) in the same terms, so that any conceptual divisions and categories emerge as effects; the inclusion of *non-human agents* in hybrid networks; and the *collapse of the micro-macro distinction*, and its replacement with the idea of 'acting at a distance', so enabling the deconstruction of corporate actors (Middendorf 2002, p. 181, Law 1986). As a result, ANT analysis results in *empirically driven accounts of distributional outcomes* - how they come about, by the actions of which actors - in contrast to accounts that attribute such outcomes to 'external forces' (ibid. p. 182). An important general principle, therefore, is, not the rejection of categories and divisions of various kinds *per se*, but the avoidance of *a priori*, causal categories. Instead they are allowed to emerge from the empirical findings as effects.

ANT emphasises the situated agency of actors within networks, within which power circulates[15]. For example, scientists are often able to exercise 'strategic agency' (Long 2001, p. 241), enrolling other agents by presenting particular projects, policies or discourses as 'obligatory passage points' (Callon 1986, pp. 205-6), through which they must pass in order to achieve their goals. However, the durability of networks ultimately depends on whether the enrolled actors are able to mobilise wider populations to accept (or at least not to contest) the knowledge claims on which policies are based (ibid. pp. 214-20).

[15] This approach therefore draws on Foucault's analytic; but in this case conceptualises power in terms of the length and durability of networks (Callon 1986, Latour 1986).

The conceptual tools of ANT are therefore useful for the microanalysis of the co-construction and extension of actor-networks, knowledge and policy; as well as the creation of alternative actor-networks that generate counter discourses and contest policy[16]. This type of detail can reveal that 'unquestioned orthodoxies do not exist inevitably' and suggest that, at critical moments, things could have turned out differently. This approach opens up 'some of the contingency that surrounds knowledge and policy and the importance of small actions, or expressions of agency' (Keeley and Scoones 1999, pp. 20-21).

**Actor-networks in the Green Revolution and biotech eras in India**

India's experience of technology-led development did not originate in the Green Revolution, but had been an overriding feature of national development planning since independence (Seshia and Scoones 2003, p. 6). However, a confluence of events in the mid 1960s created an opening for new directions in Indian agriculture: a crisis over food production (following two wars and a severe drought); a change in government emphasis from industrial to agricultural modernisation following the death of Nehru, with Prime Minister Shastri appointing Subramanian (previously Industry minister) to the agriculture ministry; and the arrival of Norman Borlaug of CIMMYT[17] bringing the high yielding wheat varieties from Mexico (ibid. p. 12).

While structural explanations emphasise the geopolitical context of the Green Revolution, in which the US agricultural policy/technology mix was exported to India (and elsewhere in Asia) in furtherance of US economic and political interests; they may have been 'pushing against an open door' (ibid. p. 18). The story of the Green Revolution in India is one of convergence of two different agendas and discourses; between US concerns for containment of communism and population control, underpinned by neo-Malthusian discourses; and Indian priorities of national sovereignty and self reliance in food production, inspired by the ideals of *swaraj* and *swadeshi*[18]. Convergence was found in

[16] Other recent studies have applied ANT to GMO discourses in the UK (Bowler 2000), global food networks (Whatmore and Thorne 1997) and ecological movements in Colombia (Escobar 1998).
[17] The wheat development institute in Mexico, one of the key members of the CGIAR network of agricultural research institutes.
[18] Respectively, 'self rule' and 'of one's own country'.

the discourse on the 'food gap', that innovations in food production were needed to feed increasing populations.

In the event, the combination of a food crisis, a change of government and a prevailing 'modernisation' discourse which 'framed agriculture as a technical enterprise' opened up a 'policy space' (Grindle and Thomas 1991); in which an actor-network including M.S. Swaminathan (of IARI), B.P. Pal (Director of ICAR), Norman Borlaug and the 'miracle seed', became established and shaped India's Green Revolution. A defining characteristic of agriculture policy making at this time was the (unchallenged) co-construction of science and policy by this 'small science-policy network, supported by technical assistance and foreign aid, which established a powerful agricultural bureaucracy that in many ways still persists today' (Seshia and Scoones 2003, p. 14).

Changes and continuities between the discourses of the Green Revolution and biotech eras in India reflect the earlier frame analysis. Both frame the problem as a need for a 'science-based revolution', transforming 'backward', 'inefficient' agriculture into a new vision of modernity' (ibid.). However, the broader framework of 'development' has changed, with national sovereignty and self-sufficiency being replaced by international competitiveness in global markets. Economic liberalisation and WTO entry have led to a decrease in the capacity of the Indian State to fund and direct agricultural development. In this context, 'private sector companies (Indian and multinational) .. are the key players in the development of new seeds and biotechnology' (ibid. p. 9). Meanwhile, biotechnology is presented as a continuation of the Green Revolution; with 'biotechnology' broadly defined to encompass both genetically engineered and conventional hybrid crops (Dhar 2003, pp. 8-9). This assists promoters in framing biotechnology as 'natural', comparing it to traditional Indian culinary practices such as making bread and curd (Deccan Herald 2003).

While key individuals and institutes from the Green Revolution era remain influential, the biotech actor-network is far from the tight science-policy network of the Green Revolution era. The network promoting GM crops today is at the same time extended (globally and to additional sectors) and less durable, more vulnerable to challenge. In particular, the support of state governments[19], particularly the southern states of Karnataka, Andhra Pradesh and Tamil Nadu has been critical; for example, in ensuring that *Bt* cotton trials continued despite the level of controversy and protest (Dhar 2003, p. 25). Moreover, while there no national level biotechnology policy exists, several states have produced their own investor-friendly policies (for example Karnataka (2001), Andhra Pradesh (2001), among others).

**Contesting biotechnology: Alternative actor-networks**

Unlike during the Green Revolution era, proposals of the biotechnology science-policy actor-network have not gone unchallenged. Other actors have come into the picture, with different perspectives on biotechnology, its benefits and risks; creating alternative actor-networks in new 'policy spaces' (Grindle and Thomas 1991). This has opened up biotechnology to public scrutiny, in a way that the nuclear programme and the Green Revolution never were (Seshia and Scoones 2003, p. 20).

A critical moment for the establishment of an international actor-network opposing GM crops was the exposure, 'naming and framing' (Apthorpe 1996, p. 24) of 'terminator technology'[20] by civil society groups such as RAFI (now *etcgroup*). This created an *actant* that mobilised a highly successful campaign against the technology, forcing the biotech corporations to halt this research (at least temporarily). This campaign, bringing together local, national and international NGOs and activist groups in the North and South, and buoyed by extensive media coverage, became part of the emerging 'anti-globalisation' movement. In this way, the debate on biotechnology became part of the broader debate on globalisation and its impact on livelihoods (Seshia and Scoones 2003, Visvanathan and Parmar 2003).

On closer examination, however, debates and resistance around agricultural biotechnology confound the bipolar picture of forces 'for and against' the technology. In

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[19] The Union constitution of India allocates responsibility for agriculture to states [Dhar 2003, p. 25].

[20] One of a group of techniques (known as GURTS) that render GM seeds sterile, thereby preventing (physically, rather than through patents) farmer practices of saving and exchanging seed.

a mapping of ongoing biotechnology debates in India, Visvanathan and Parmar (2003) draw attention to NGOs (such as Gene Campaign) opposing the patenting of life forms but prepared to consider GM technology harnessed towards food sovereignty goals, and anti-GM campaigns mobilised less by the vulnerable 'small farmer' than by business interests opposing a new generation of technologies which threaten to erode earlier gains made during the Green Revolution era (ibid. 2721-3).

This more ambiguous scenario is well illustrated by the case of the *protato,* which in ANT terms is a 'quasi-object' that is simultaneously 'material, social and narrated' (Middendorf 2002, p. 243, Goodman 1999, p. 30). The *protato,* a genetically modified 'high protein' potato, was launched by Dr. Gorindarajan Padmanabam of the Indian Institute of Science (IISc) in Bangalore, at the annual conference of the Royal Society in December 2002 (The New Scientist 2003). It was presented as part of a new anti-hunger plan, a 15-year, 'three-pronged attack on childhood mortality' (ibid.). This launch sparked a high profile debate in the Indian and international media, with different groups generating different constructions of the *protato*:

1. As technology in the service of humanitarian goals, providing nutritious food to schoolchildren from poor families as part of an 'anti hunger plan' (The New Scientist 2003);
2. As an exemplar of 'patriotic science' (Abraham 1996), which could enable Indian science to 'win the race to produce the world's first functional GM food', ahead of similar innovations such as 'golden rice' (Vidal 2003);
3. As an opportunity for India to secure food sovereignty in the biotech era, at a critical juncture where India's biotech industry may be in the process of emerging 'from under the shadow of Monsanto' to assert itself as a world player (Dhar 2003, p. 25);
4. As a 'Trojan horse' (Sharma 2003a) to gain public acceptance for GM crops in the wake of controversies over the commercialization of *Bt* cotton[21], ironically paralleling the controversial launch of 'golden rice' (RFSTSE 2003, Pollan 2001; GRAIN 2001);

[21] For accounts of events and controversies around the commercialisation of *Bt* cotton in India, see Dhar (2003) and Shiva et al (1999).

5. As a choice between: nutritional and biological diversity, embodied in the Amaranth species; and the further spread of monocultures, embodied in the *Am 1* gene (extracted from the Amaranth plant for insertion into a potato species to produce the high protein *protato*) (RFSTSE: 2003).

These narratives fit within the frames identified earlier, ‘technology has its own trajectory’ (1), ‘the national interest’ (2 and 3), ‘biotechnology is natural’ (4), and the contested umbrella notion of the ‘evergreen revolution’ (5).

Networks have been forming around these alternative narratives of the *protato.* While positions of certain actors, for example several members of the Indian scientific establishment appear to be clear; other actors are presented with more of a dilemma. For NGOs such as Oxfam, do they enroll in a network supporting an anti-hunger plan (1), or forming around alternative visions of sustainability (5)? Similarly, does the NGO Gene Campaign enroll in a network around the potential for securing national food sovereignty in the biotech era (3), or one concerned about the further accumulation and patenting of genetic resources (5)? In each case, do they join one or more networks?

While the case for ‘patriotic science’ in the service of national food sovereignty (2 and 3) has been compelling (tapping into two enduring popular discourses of the modern Indian state), this has been set against a broader contestation of the ‘national interest’, in calls for a coherent national biotechnology policy[22] and improvements in neglected food distribution systems (Sharma 2003). In the same way as the campaign against the 'terminator seed', therefore, alternative actor-networks have used the opening provided by the *protato* launch to open up broader debates, generate alternative narratives and so challenge the way agricultural biotechnology is framed.

## Conclusion: Reframing biotechnology?

[22] For a review of debates around India’s need (or not) for a National Biotechnology policy, see Joshi (2003).

The claim that GM crops are a necessity to 'feed the world' remains pervasive and persuasive. This is despite the availability of a wealth of literature on the mistakes of the Green Revolution era, many of which are likely to be repeated in the era of agro-biotechnology.

Analysing biotechnology as a set of frames within a discursive formation sheds light on how such 'truths' are generated within a network of discursive practices in which new frames overlap with old ones. However, as with any discursive formation, it is constantly evolving. This is nowhere more the case than for biotechnology at the present time, where profound shifts in our understanding of the truth about nature are in the process of taking shape.

Any future biotechnology policy agenda depends on the outcome of contests over its 'naming and framing' (Apthorpe 1996, p. 24). Public debates in India over agro-biotechnology, recently crystallised in the *protato* debate, show attempts by competing actor-networks to reframe biotechnology, providing a reinterpretation of the benefits and risks and the 'facts' that support them.

However, while the authority of science is challenged more than in the past in today's 'risk society' (Beck 1992), public debate tends to be focused on understanding and controlling risks arising from new technologies, rather than the front end processes of scientific innovation itself (Wynne 2005). This can be seen in the way biosafety regulation has been opened up to participatory participation, but biotechnology policy has not (Glover 2003a). This is compounded in a neo-liberal era, for example in the UK, where broader moral and ethical issues are ruled out of a restricted, risk-management debate (Levidow 1998, p. 216).

Will these alternative facts disturb the truths about biotechnology in its present discursive formation, and find their way into policy? The summary table below shows how each frame presents itself both as a formidable challenge and as a new site from which to attempt the reconstruction of biotechnology and contribute to the renegotiation of democracy in a globalised, 'scientised'[23] world.

**Table 2: Challenging the frames: What is at stake?**

| Frame | What is at stake? |
|---|---|
| Technology has its own trajectory | Public accountability of ***science***<br><br>From controlling risks (biosafety) to controlling the drivers of innovation (biotechnology)[24] |
| In the national interest | Re-defining ***democracy*** in an era of neo-liberal globalization<br><br>Contesting the contract between neo-liberal policies and 'patriotic science'[25] |
| Biotechnology is natural | Truths about ***nature*** and the relationship between nature and society<br><br>Contesting the logic of patenting: life forms as information, nature as a 'gene mine'[26] |
| An evergreen revolution | Definition of ***sustainability*** as a guiding principle<br><br>Sustainable livelihoods based on sustainable, resilient agriculture[27] |

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[23] Borrowing the term from Habermas (Outhwaite 1994, p. 21). This has been developed by Foucault as 'political technology' (Dreyfus and Rabinow 1983, p. 196).
[24] Wynne (2005), Glover (2003a)
[25] Abraham (1996), Newell and Glover (2003)
[26] Flitner (1998), Bowring (2003), Visvanathan (1996), Rifkin (1998)
[27] Marglin (1996), Appadurai (1990)

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