Generating regulatory futures: From agbiotech blockages to a bioeconomy?

Book Section

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Generating regulatory futures: Beyond agbiotech blockages to a bioeconomy?

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INTRODUCTION: BEYOND BIOTECH BLOCKAGES?

Since the 1980s agricultural biotechnology (henceforth agbiotech) has been promoted as a symbol of European progress and political--economic integration. According to proponents, agbiotech provides a clean technology for enhancing eco-efficient agro-production. By the late 1990s, however, 'GM food' became negatively associated with factory farming, its hazards, and unsustainable agriculture. GM products have generally faced commercial and/or regulatory blockages to market access in Europe. To bypass the blockage, in 2005 agbiotech was re-launched as an essential tool for the Knowledge-Based Bio-Economy (KBBE). This agenda has promoted next-generation technologies to develop non-food uses of renewable resources.

This chapter addresses several questions:

- Despite support from powerful political-economic forces in Europe, why did agbiotech encounter strong blockages there?
- What was the European conflict about?
- What can be learned from this experience for other new technologies, e.g., next-generation biotech for a bioeconomy?

CO-PRODUCTION OF TECHNOLOGY WITH SOCIO-NATURAL ORDER

In the 1990s European controversy over agbiotech, proponents criticised opponents for unfairly targeting or blaming a benign technology as a symbol of wider issues, such as industrial agriculture and globalisation. As this complaint illustrates, proponents often draw distinctions between a technology and its context or consequences, while critics generally emphasise links between them. Indeed, technological controversy involves power struggles over how to define the issues at stake, even the nature of the technology. These definitional issues can be illuminated by the analytical concept of co-production, which in turn will help to address the above questions.

'Co-production of technology, nature and society' provides concepts for analysing links between the social and natural order. Science and technology can be understood as socio-technical hybrid constructs, ordering society in particular ways, while attributing that order to separate 'natural' characteristics (Jasanoff 2004: 21). In this process, people may relegate part of their experience to an apparently immutable, objective reality, as if it were given by nature.

Interactive co-production approaches study how such an order is potentially destabilised. They investigate conflicts around boundaries, for example, between un/changeable realities or natural/social realms. Interactive co-production emphasises contexts where these distinctions undergo challenge, amidst competing epistemologies. Through boundary-work, various everyday practices potentially make and stabilise those distinctions, e.g. between social and natural characteristics. For their authority, scientific claims depend upon such distinctions, within specific forms or changes of social order.

A co-production perspective can illuminate how technology provides a solution to a problem of socio-political order, without taking for granted a particular form (Jasanoff 2004: 18-19, 30). Concepts of objectivity and expertise remain important for legitimising regimes as democratically accountable. Such concepts affect how research results are taken up in public realms (e.g., as persuasive, biased, or inconclusive); how they are meant to 'solve' public problems; and how they are constructed to legitimise policy (ibid: 34). An interactive approach helps to explain how a socio-natural order is contested and changed.

At the nexus of social and natural order, there are several instruments of co-production:

- Making identities: Collective identities can help people to restore sense out of disorder, by putting things back into familiar places. These include categories and characteristics such as 'European', 'professional', 'intelligent', and so on. But these identities may also be contested or renegotiated in elaborating a different order.
- Making institutions: Institutionalised ways of knowing are reproduced (and potentially changed) in new contexts of disorder; they also serve as sites for testing or reaffirming a political culture. According to a model of market capitalism, for example, the human subject is able to form autonomous preferences, make rational choices, and act freely upon the choices so made; any exceptions are interpreted as a market failure, rather than a problem with the model.
- Making discourses: Languages are produced or modified in ways that promote tacit models of nature, society, culture or humanity. For example, discourses may define the boundary between promising and fearsome aspects of a technology – for example, links between 'un/natural' and 'un/safe' characteristics.
- Making representations: this includes the means of representation in diverse communities of practice; models of human agency and behaviour; and the uptake of scientific representations by other social actors (Jasanoff 2004: 38-41).

Drawing on an interactive co-production perspective, this article argues that agbiotech was originally promoted as a means to shape European political--economic integration around a specific socio-natural order, while also naturalising that order as an obvious future, even as an objective imperative. Civil society networks opposed and destabilised that potential new order, while also demanding alternative futures. Now agbiotech is being promoted within a wider agenda of a future bioeconomy, whose prospects likewise depend on reshaping the socio-natural order.

MAKING EUROPE SAFE FOR AGBIOTECH

From the 1980s onwards, agbiotech has been promoted as a technological saviour of agro-industrial systems: GM techniques were expected to improve crops for both economic competitiveness and environmental protection. The US innovation--regulatory model was adapted by the EU as a means to make Europe safe for agbiotech, within a specific socio-natural order, as this section will show.

Us Neoliberal Model

The global agbiotech agenda was led by the US agro-industrial complex and its government supporters. Long beforehand, these forces had turned agriculture into a rural factory of standardised commodity production, especially animal feed for global export. Transatlantic agrichemical companies developed agbiotech for further industrialising agriculture, along with the promise of alleviating its environmental damage through more efficient inputs, replacing natural resources with knowledge embodied in novel seeds.

Promotional language attributed beneficent powers to a biotechnologised nature. Key metaphors – of computer codes, commodities and combat – were invested in nature. Molecular 'information' was decoded and edited for precisely engineered novel organisms, providing 'value-added genetics'. 'Smart seeds' would overcome threats from a wild, disorderly Nature - for example, transgenes would precisely target pests and so protect crops (Levidow 1996).

In the USA, agbiotech was promoted as an imperative for new policies. These featured broader patent rights giving financial incentives to public-sector research institutes as well as the private sector, alongside trade liberalisation opening foreign markets to US agri-exports and intellectual property claims. In the name of 'product-based regulation', agbiotech has been regulated under previous product legislation (e.g. for plant pests, pesticides, etc.), within existing statutory-bureaucratic frameworks. Such arrangements symbolically normalised GM products as similar to conventional crops, while also minimising opportunities for public involvement.

In those ways, agbiotech was being co-produced along with neo-liberal models of the natural and social order, for further commoditising knowledge. By default, in the absence of any effective means to question the innovation, the US debate focused on possible risks – whether or how GMOs could be made predictably safe for the environment. More fundamentally, nature was being redesigned and made safe for agbiotech (Sagoff 1991). Likewise various institutional changes were making society safe for normalising and commercialising GM products.

European Adaptation of US Model

Since the 1980s the European Union (EU)'s integration project has likewise promoted biotech as a symbol of progress. By the early 1990s biotech further epitomised promises of a 'knowledge-based society', promoting capital-intensive innovation as essential for economic competitiveness and thus European prosperity (CEC 1993). Through such efforts, Europe would become 'the most competitive and dynamic, knowledge-based economy in the world' (EU Council 2000).

New policies were being designed for a 'competition state', directing resources towards the domestic capacity for global competitive advantage (Cerny 1999). This included efforts to attract private-sector investment, to subordinate public-sector research to private-sector priorities, to marketise public goods and to generate globally competitive knowledge. Such a state was promoted through agbiotech, as both an instrument and symbol of societal progress.

The US model of agri-industrial productivity was appropriated as an inevitable European future. Soon this became linked with a neo-liberal agenda emphasising economic competitiveness, projecting a unitary European interest. According to this narrative, eco-efficient technologies would bring a competitive advantage and thus societal benefits, but Europe risks losing these benefits through inadequate financial rewards or over-regulation. New policies sought to make Europe safe for agbiotech as normal products.

The EU agbiotech policy was also linked with a trade liberalisation agenda by invoking objective imperatives of global competition. In parallel, the European Commission promoted agbiotech as essential for economic competitiveness and thus for survival of the European agri-food sector as well as its techno-scientific capacities. By the mid-1990s EU--US discussions were identifying 'barriers to transatlantic trade', which must be removed through regulatory harmonisation, especially for biotech products as a test case (Murphy and Levidow 2006).

EU policies also extended proprietary claims on genetic resources but provoked opposition. At issue was the concept of 'biopiracy' – whether this meant unauthorised use of GM seeds, or rather 'Patents on Life' (i.e., patent rights on mere discoveries of common resources). The 'biopiracy' issue raised doubts among those on the Left and trade-union groups, which were otherwise inclined to support technological innovation as societal progress. After a decade-long conflict, a 1998 EC directive extended patent rights to 'biotechnological inventions'; this broadened the scope of discoveries or techniques which could be privatised (EC 1998). As public controversy continued afterwards, several EU member states failed or refused to incorporate the Directive into national law. The European Commission brought court actions against them, but such formal trials could not harmonise national rules, nor resolve the legitimacy problem.

Research and Development (R&D) policies created greater incentives for the use of GM techniques, partly by blurring the boundary between public and private sectors. In many EU member states, public-sector agricultural research institutes were allocated less state funds than before and were expected to substitute income from the private sector or from royalties on patents for GM techniques. The European Union's R&D funding priorities complemented that shift towards marketising hitherto 'public-sector' research (Levidow *et al*. 2002). As such research institutions became more dependent on private-sector financing, and critics challenged their scientific integrity as regards expert scientific advice on risk issues.

NGOs raised concerns that GM crops would stimulate agricultural intensification, undermine farmer independence and jeopardise rural livelihoods. In response, biotech lobbies framed any socio-economic disruption, e.g. farmers' loss of livelihood, as a means to renew democratic societies (SAGB 1990). Thus the market was idealised as a free, naturally beneficent regulator for enhancing and allocating societal benefits.

Technicist Harmonisation Agenda

Through EU decision-making procedures, regulatory criteria internalised biotechnological models of the socio-natural order. Under the EC Deliberate Release Directive, member states must ensure that GMOs do not cause 'adverse effects' (EC 1990) ; however, the scope of 'adverse effects' was left ambiguous, to be clarified for each product in its context. Some member states warned that GM crops could generate herbicide-tolerant weeds or pesticide-tolerant pests, but official EU risk assessments classified such effects as merely agronomic problems. This normative--regulatory judgement accepted the normal hazards of intensive monoculture, while also conceptually homogenising the agricultural environment as a production site for standard commodity crops. Through a technicist harmonisation agenda, Europe was being de-territorialised as a purely economic zone, devoid of cultural identities (cf. Barry 2001: 70).

Thus early EU regulatory procedures incorporated policy assumptions of the agbiotech promoters. Under 'risk-based regulation', societal decisions on agbiotech were reduced to a case-by-case approval of GM products, within a narrow definition of risks, placing the burden of evidence mainly upon the objectors. Each time the Commission proposed to authorise a GM product, it gained a qualified (2/3) majority in the comitology procedure representing EU member states, where dissent was marginalised.

As another controversial issue, NGOs and some member states demanded special GM labelling to ensure informed consumer choice. The European Commission initially rejected this request on several grounds: for lacking any scientific basis, unfairly impeding the internal market, and making the EU vulnerable to a US challenge under WTO rules. A no-labelling policy initially prevailed, despite significant dissent in all EU institutions.

All these regulations complemented the wider policy framework of higher productivity for economic competitiveness, as an expected benefit from agbiotech products. This agenda was depoliticised by invoking objective imperatives such as globalisation, treaty obligations and 'risk-based regulation'. By the mid-1990s, EC policies were making Europe 'safe' for agbiotech to achieve commercial success, while subordinating regulatory criteria to economic competitiveness.

In those ways, a distinctively European approach adapted elements of the US neoliberal policy framework for agbiotech. The technology was being co-produced along with a marketisation of nature and society, in the name of eco-efficiency improvements for agriculture. Regulatory procedures authorised 'safe' GM products, which could then enter the EU internal market as extra options for farmers. They would have the free choice to buy more efficient inputs for global competitiveness. As unwitting consumers of GM food, the public would effectively support a beneficial technology serving the common good of Europe. Within this model of rational market behaviour, members of various European publics had little scope to act as citizens.

PUTTING AGBIOTECH ON TRIAL, RESHAPING REGULATIONS

By promoting agbiotech within a neo-liberal framework, the EU system provoked great suspicion and even opposition, which grew from the mid-1990s onwards. Agbiotech was turned into a symbol of anxiety about multiple threats: the food chain, agro-industrial methods, their hazards, state irresponsibility and political unaccountability through globalisation. The controversy often gained large public audiences through the mass media, as well as active involvement of many civil society groups. They took up concepts from small activist groups as well as from high-profile campaigns of large NGOs. Together these activities developed citizens' capacities to challenge official claims and created civil society networks to which governments could be held accountable.

These activities criticised, used and eventually reshaped the EU regulations. Demands for accountability took the form of various formal and informal trials. These dynamics continuously expanded trials, defendants and arenas – what was put on trial, how, where and by whom. Such trials arose along three overlapping themes – safety versus precaution, eco-efficiency versus agro-industrial hazards, and globalisation versus democratic sovereignty – as shown in this section. (For more details and sources, see Levidow and Carr 2010).

Safety Claims Versus Precaution

Lab and field trials were intended to generate evidence of product safety, thus demonstrating a scientific basis for expert risk assessments, which in turn could justify commercial authorisation of GM products. Yet safety science became contentious. Expert safety claims underwent criticism for bias, ignorance and optimistic assumptions. Such criticism gained force from suspicion that public-sector scientists had lost any independence from agbiotech promotion.

When France led the EU-wide approval of Bt maize 176, its favourable risk assessment was widely criticised by member states as well as NGOs. When France further proposed to approve maize varieties derived from Bt 176 in 1998, Ecoropa and Greenpeace filed a challenge at the *Conseil d'Etat* (the French administrative high court) on several grounds: that the risks had not been properly assessed, that the correct administrative procedures had not been followed, and that the Precautionary Principle had not been properly applied. These NGO arguments gained some support in the court's interim ruling. Thus a government was judicially put on trial for failing to put a GM product on trial in a rigorous way.

When UK lab experiments claimed to find harm to rats from GM potatoes, the disclosure led to trials of other kinds. The project leader, Arpad Pusztai, questioned the safety of GM foods on a television programme. He was soon dismissed from his post and was then subjected to character assassination by other scientists. His experimental methods were criticised by a Royal Society report. International networks of scientists took opposite sides on that issue. NGOs put his employers and other persecutors symbolically on trial, by attributing their actions to political and commercial motives (Levidow 2002; Levidow and Carr 2010: 100-102).

When a Swiss lab experiment found that an insecticidal Bt maize harmed a beneficial insect (lacewing), expert authority was put on trial. Criticising the experiment, other scientists cast doubt on its methodological rigour and its relevance to commercial farming, as grounds to discount the results in the regulatory arena. In response, agbiotech critics reversed the accusation: they raised similar doubts about the rigour of routine experiments that had supposedly demonstrated safety. Potential harm to non-target insects remained a high-profile issue, attracting further research and expert disagreements. Citing scientific uncertainties, some regulatory authorities rejected Bt maize or demanded that its cultivation be subject to special monitoring requirements at the commercial stage, thus further testing safety claims and elaborating test protocols (Levidow and Carr 2010: 182-83).

In the latter two risk issues, surprising experimental results were deployed to challenge safety claims, optimistic assumptions and expert safety advice. When new evidence of risk was criticised for inadequate rigour or relevance to realistic commercial contexts, similar criticisms were raised against safety claims and their methodological basis. Regulatory authorities were put symbolically on trial for failure to develop adequate scientific knowledge for risk assessment, instead depending on companies for test data.

For the safety assessment of GM food, EU regulatory procedures and criteria likewise were put on trial. Under the EU's Novel Food Regulation, for example, GM products could be approved via a simplified procedure in cases where they had substantial equivalence with a non-GM counterpart. After such approval decisions about several foods derived from GM maize, Italy banned them partly on grounds that the decisions had inadequate scientific evidence to demonstrate substantial equivalence. The Commission sought to lift the ban and so requested support from the EU regulatory committee of member states in 2000, thus putting Italy on trial by its peers. But they instead sided with Italy, while also criticising the regulatory short-cut under the Novel Food Regulation (Standing Committee, 2000).

After this role-reversal, the Commission abandoned substantial equivalence as a statutory basis for easier approval of novel foods (EC 2003a). In risk-assessment procedures, substantial equivalence continued as a 'comparative assessment'; this was broadened to encompass more methodological issues, scientific uncertainties and types of scientific evidence (Levidow *et al*. 2007). Such comparison with conventional products has remained contentious among member states as well as civil society groups.

Globalisation Versus Democratic Sovereignty

Given that agbiotech promoters emphasised globalisation as an imperative for GM products, critics could portray them as a threat and agent of 'globalisation'. Since the mid-1990s field trials have been meant to demonstrate the agronomic efficacy and safety of GM crops, as well as the diligent responsibility of the authorities in avoiding any environmental harm. However, the fields were turned into theatrical stages for protest. They used an 'X' or biohazard symbol to cast agbiotech as pollutants and unknown dangers, thus justifying sabotage as environmental protection. When facing prosecution, activists used the opportunity to put the state symbolically on trial for inadequately evaluating or controlling GM crops, as a failure of responsibility.

Activists appealed to democratic sovereignty when carrying out and defending sabotage actions on field trials. The UK government implied that decisions about GM crops lay elsewhere, beyond its political control; this claim was denounced as an irresponsible, undemocratic surrender to globalisation. As a response to deferential regulatory decisions, such as the UK government's above, opponents defended sabotage as democratic accountability. Further to the French example above, in 1998 the WTO approved higher US tariffs against several specialty foods including Roquefort cheese, as compensation for lost exports of US beef. *Paysan* activists attacked MacDonalds as a symbol of WTO rules forcing the world to accept hazardous *malbouffe* such as hormone-treated beef and GM food. As defendants in court, *paysans* sought to put 'globalisation' on trial, represented by the French government as well as biotech companies.

Democratic sovereignty also became an explicit theme in judicial trials and regulatory procedures. When some EU member states explicitly refused to support authorisation of any more GM products in 1999 onwards, they were demanding precautionary reforms in EU rules and regulatory criteria. At the same time, this defiance was turned into a public symbol of European sovereignty versus globalisation driven by the USA.

Democratic sovereignty became general grounds to justify measures or actions restricting GM products at the national or regional level. By the late 1990s fewer member states were willing to support Commission proposals to approve new GM products. Some signed formal statements that they would refuse to do so. Lacking a qualified majority, in 1999 the EU Council effectively suspended the decision-making procedure for new GM products; this move was widely called the *de facto* moratorium. Meanwhile some member states also banned GM products that had gained EU-wide approval (Levidow *et al*. 2000).

The European Commission faced a dilemma: either ignore official procedures, or else authorise the products anyway without political legitimacy. To go beyond this dilemma, the Commission proposed more stringent criteria for risk assessment and market-stage monitoring in a revised Directive, which was eventually adopted (EC 2001). Although these more precautionary criteria were meant to accommodate dissent and so facilitate regulatory decisions, assessment criteria remained contentious after the EU-wide procedure resumed in 2003.

'Globalisation' also framed conflicts over GM labelling. The originator of GM soya, Monsanto, was denounced by various NGOs as a global bully 'force-feeding us GM food'. Before the European Commission approved GM soya in 1996, NGOs and some member states demanded mandatory labelling for all GM foods. However, this demand was rejected, with warnings that any such requirement would provoke a WTO case against the EU.

On this basis, the no-labelling policy became vulnerable to attack as globalisation undermining consumer choice and democratic sovereignty. Local protests at supermarkets demanded GM labelling and non-GM alternatives, in campaigns linked with Europe-wide consumer and environmentalist groups. By 1998 European retail chains adopted voluntary labelling of their own-brand products with GM ingredients. Companies variously labelled their products as 'contains GM' or as 'GM-free', in compliance with different criteria established by EU member states. Meanwhile NGOs carried out surveillance of GM material in food products, some not labelled 'GM', in order to protest against them and to warn consumers.

Together these regulatory inconsistencies and protests potentially destabilised the EU's internal market for processed food products. So the EU established more comprehensive standard criteria; these went beyond detectability and so required an audit trail of paper documentation. Eventually EU law required comprehensive GM labelling and traceability of GM material (EC 2003b), encompassing a broader range of products than before.

GM products also faced a commercial boycott. By the late 1990s, all European supermarket chains excluded GM ingredients from their own-brand products, rather than label them as 'GM'; some mentioned precaution and/or consumer choice as reasons. By now GM ingredients were relegated to animal feed from two main sources: imported GM soya was still used in some animal feed, though some suppliers advertised 'GM-free' meat or poultry; Bt insecticidal maize was (and still is) widely cultivated in Spain, where nearly all maize enters a common supply chain for animal feed. This agro-industrial system resembles the USA's. These exceptions prove the rule of agbiotech being co-produced with models of the socio-natural order.

Eco-efficiency Versus Agro-Industrial Hazards

Agbiotech began with a cornucopian promise. With precisely controlled genetic changes, GM crops would provide smart seeds, as ecoefficient tools for sustainably intensifying industrial agriculture. These promises were extended by the 'Life Sciences' project, featuring mergers between agro-supply and pharmaceutical companies, in search of synergies between their R&D efforts. Its narrative promised health and environmental benefits as solutions to general societal problems.

Critics turned agbiotech into a symbol of multiple threats. Productive efficiency was pejoratively linked with agro-industrial hazards; for example, the epithet 'mad soja' drew analogies to the BSE epidemic. Biotech companies were accused of turning consumers into human guinea pigs.

Through politically constituted cultural meanings, agbiotech was put symbolically on trial as an unsustainable, dangerous, misguided path. In France, critics cast agbiotech as *malbouffe* (junk food), as threats to high-quality *produits du terroir*. In Italy GM crops were cast as agro-industrial competition and 'uncontrolled genetic contamination', threatening diverse, local quality agriculture. Using the term *Agrarfabriken* (factory farm), German critics linked agbiotech with intensive industrial methods, threatening human health, the environment and agro-ecological alternatives. Institutions faced greater pressure to test claims that GM crops would provide agro-environmental improvements as well as safety.

Those informal trials shaped conflicts over regulatory criteria from the mid-1990s onwards. When EU procedures initially evaluated GM crops for cultivation purposes, they were deemed safe by accepting the normal hazards of intensive monoculture. This normative stance was portrayed as a scientific judgement, while casting any criticism as irrelevant or political. Yet such hazards were being highlighted by critics, framing risks in successively broader ways. Their discourses emphasised three ominous metaphors: 'superweeds' leading to a genetic treadmill, thus aggravating the familiar pesticide treadmill; broad-spectrum herbicides inflicting 'sterility' upon farmland biodiversity; and pollen flow 'contaminating' non-GM crops.

These ominous metaphors expanded the charge-sheet of hazards for which GM products were kept on trial. Moreover, these broader hazards would depend on the behaviour of agro-industrial operators, which consequently became a focus of prediction, discipline and testing. Regulatory procedures came under pressure to translate the extra hazards into risk assessments. In its risk assessment for GM herbicide-tolerant oilseed rape, Bayer claimed that farmers would eliminate any resulting herbicide-tolerant weeds and so avoid weed-control problems, but Belgian experts questioned the feasibility of such measures. Citing that advice, the Belgian national authority rejected the proposal to authorise cultivation uses, rather than invite the company to test extra hazards. So a proposal went forward only for food and feed uses, gaining EU approval on that limited basis (EC 2007).

GM herbicide-tolerant crops had been promoted as a means to reduce herbicide usage and thus to protect the environment. But UK critics portrayed more efficient weed-control as a hazard: broad-spectrum herbicides could readily extend the 'sterility' of greenhouses to the wider countryside, which would be turned into 'green concrete'. The UK government was widely criticised for ignoring the agro-environmental implications. The Environment Ministry eventually took responsibility and funded large-scale field experiments, to simulate and thus predict farmer behaviour in spraying herbicides. These trials were meant to facilitate the 'managed development' of such crops. But experimental results indicated potentially greater harm from some GM crops than their conventional counterpart (Champion *et al*. 2003). These results led to a regulatory impasse for GM crops that could have been approved by the UK. Through a more precautionary regulatory procedure, agro-industrial efficiency was cast as an environmental threat to be investigated and avoided.

From the UK controversy in particular, the EU system underwent pressure to broaden the potential effects and their causes that warrant evaluation. The *de facto* EU moratorium led to a revised EC Directive, which broadened risk-assessment criteria to encompass any changes in agricultural management practices, such as in herbicide spraying, as well as indirect and long-term effects (EC 2001). This broader scope potentially accommodated dissent into regulatory procedures, but public and expert debate continuously questioned safety assumptions. Broader accounts of harm meant greater uncertainty about whether GM crops could generate such harm in the agro-food chain, so risk assessments needed to anticipate human practices as well as their environmental effects.

Co-production of Biotechnologised Nature

In sum, an interactive co-production perspective can illuminate the early strategies for promoting agbiotech for a new socio-natural order, which was eventually destabilised by opponents. Agbiotech had been originally promoted as a clean technology enhancing natural properties: through precise genetic changes, GM crops would efficiently use natural resources to combat plant pests and to minimise agrochemical usage, thus developing sustainable agriculture. Such beneficent claims were challenged along several lines: safety versus precaution, eco-efficiency versus agro-industrial hazards, and globalisation versus democratic sovereignty. The entire development model – now called 'GM food', or *OGM* in Romance languages, or *Gen-Müll* (garbage) in German, etc. – was negatively associated with factory farming, its health hazards and unsustainable agriculture. The would-be new order was stigmatised as an abnormal, dangerous disorder.

Agbiotech was turned into a symbol, object and catalyst for multiple overlapping trials. The defendant symbolically on trial was expanded from product safety, to biotech companies, their innovation trajectory, regulatory decision-making, expert advisors and, government policy. Europe was told that it had no choice but to accept agbiotech, yet this imperative was turned into a test of democratic accountability for societal choices. In these ways, protest challenged the democratic legitimacy of a biotech-driven development pathway, as well as a European integration model for further commoditising natural resources and redesigning agriculture accordingly.

Opposition activities criticised, used, and eventually reshaped EU regulations. These were originally meant to marginalise citizens' involvement or to accommodate public concerns, in ways facilitating an internal market for agbiotech products, but instead the regulatory framework itself became more contentious. By the late 1990s agbiotech was being co-produced with representations of biotechnologised nature as suspect, potentially abnormal and warranting continuous surveillance.

DESIGNING NEXT-GENERATION BIOTECH FOR A BIOECONOMY

In the late 1990s, when European protest led to blockages of GM products, European plant science faced reductions in research funds from both state and private-sector sources. As a way forward, agbiotech was relaunched for a Knowledge-Based Bio-Economy (DG Research 2005). This KBBE vision extends mechanical and informatic metaphors from earlier biotech; cells become factories or micro-computers, especially as a basis for linking agriculture with the chemical industry.

> … biotech employs micro-organisms, such as yeasts, moulds and bacteria as so-called 'cell factories' and enzymes to produce goods and services. This implies developing and producing chemicals at the cellular level by exploiting and adjusting natural processes in living organisms to generate the substances and enzymes needed by industry (DG Research 2005: 9).

Soon the KBBE was officially defined as 'the sustainable, eco-efficient transformation of renewable biological resources into health, food, energy and other industrial products' (DG Research 2006: 3). In the Food, Agriculture, Fisheries and Biotechnology (FAFB) programme of the EU's Framework Programme 7, research agendas have been shifted towards non-food uses of renewable resources. As a novel development, entire systems are being redesigned for horizontally integrating agriculture with other industrial sectors, especially through molecular-level decomposition and recomposition of natural resources (Levidow, ed., 2011). Let us examine how this agenda potentially co-produces technology, nature and society.

Efficient Techno-fixes for Resource Constraints

EU-level research agendas have been driven by European Technology Platforms (ETPs). Invited by the European Commission, ETPs were meant to define research agendas that would attract industry investment, especially as means to fulfil the Lisbon agenda goal of 3 per cent GDP being spent on research (EU Council 2000; DG Research 2004). ETPs were mandated to involve 'all relevant stakeholders' in developing a 'common vision' emphasising societal needs and benefits. For the agro-food-forestry-biotech sectors, now seen as the KBBE, ETPs were initiated mainly by industry lobby organisations, with support from scientist organisations and COPA, representing the relatively more industrialised farmers.

The KBBE concept nearly equates sustainable development with more efficiently using renewable resources. In the dominant account, such resources become biomass or raw materials as interchangeable inputs into an industrial process. For example, the KBBE is 'the sustainable production and conversion of biomass into various food, health, fibre and industrial products and energy'; such conversion is also sustainable, being efficient, producing little or no waste, and often using biological processing, according to a consortium of European Technology Platforms (Becoteps 2011: 5). Likewise agriculture must provide 'competitive raw materials', according to a report for the EU Presidency (Clever Consult, 2010). In this new vision, agriculture provides raw materials that can be broken down into various components for further processing.

Eco-efficiency is sought in novel inputs, outputs and processing methods. Research seeks generic knowledge for identifying substances that can be extracted, decomposed and recomposed. From this baseline, more specific knowledge can be privatised: 'knowledge and intellectual property will be critical…' (Plants for the Future TP 2007: 9). Farmers become (or remain) purchasers of 'efficient' inputs, such as novel crops for enhancing soil fertility and thus productivity.

These remedies correspond to specific accounts of societal needs, whereby agriculture supplies biomass as raw materials for commodity markets. Along with food security, 'biomass as a renewable raw material for industry will be the basis of the coming integrated Bioeconomy' (Becotops 2011: 5). In the dominant narrative, greater pressure on natural resources and thus food insecurity comes from global market demand. For example, 'the worldwide demand for feed will increase dramatically as a result of the growing demand for high-value animal protein' (Plants for the Future TP 2007: 3). Somehow the increasing demand remains exogenous to the agro-industrial production system, which must accommodate the demand sustainably, i.e. more efficiently through technological innovation. For example: 'In the coming decades, we anticipate the creation of more efficient plants (able to use water and fertiliser more efficiently and to be self-resistant to pests), leading to more efficient farms and new economic opportunities' (Plants for the Future TP 2007: 5, 9).

As a specific model of the socio-natural order, then, greater efficiency is attributed to capital-intensive inputs (e.g. cell factories), as a basis for an expanding commodities market to become more sustainable and to enhance food security. Resource constraints can be turned into new commercial opportunities, while the agro-supply system can avoid responsibility for the greater demands on resources. Here sustainability means eco-efficient productivity through resources that are renewable, reproducible and therefore sustainable (Birch *et al*. 2010).

Mining Agriculture as New Oil Wells

To optimise renewable biological resources, molecular-level techniques become essential tools for identifying and validating compositional characteristics. As crucial knowledge, systems biology will predict effects of new genetic combinations:

> Systems biology will reveal how natural genetic variation creates biodiversity and, together with innovative genomic technologies, will cause a paradigm shift in how we breed plants in the future. It will replace trial and error with targeted and predictive breeding to deliver desired new traits and varieties… As systems biology requires massive quantitative genome-wide data, technologies – such as protein arrays – need to be developed to analyse simultaneously numerous possible parameters at multiple time points (Plants for the Future, 2007: 63, 66).

In this KBBE vision, next-generation agbiotech must be integrated with converging technologies, i.e. integrated with infotech and nanotech. These priorities were incorporated into the FAFB programme:

> Research will include 'omics' technologies, such as genomics, proteomics, metabolomics, and converging technologies, and their integration within systems biology approaches, as well as the development of basic tools and technologies, including bioinformatics and relevant databases, and methodologies for identifying varieties within species groups (DG Research 2006: 12).

Together these techniques link compositional characteristics with market opportunities, which are anticipated as value chains, a concept which helps to mobilise new commercial partnerships. In the dominant vision, technological-industrial innovation must horizontally integrate the agriculture and energy sectors: 'the production of green energy will also face the exceptional challenge of global industrial restructuring in which the very different value chains of agricultural production and the biorefining industries must be merged with the value chains of the energy providers' (Plants for the Future TP 2007: 33).

The search for lignocellulosic fuels illustrates how global market opportunities frame technical problems. As an evolutionary feature, lignin in plant cell walls impedes their breakdown and protects them from pests. From the standpoint of cross-sectoral molecular-level integration, however, lignin limits the use of the whole plant as biomass for various uses including energy. For agricultural, paper and biofuel feedstock systems, ‘lignin is considered to be an undesirable polymer’ (EPOBIO 2006: 27).

To overcome the limitation, plants are redesigned for new value chains linking agriculture with energy. ‘This larger-scale research effort was considered essential to achieve the foundation for designing *in planta* strategies to engineer bespoke [custom-made] cell walls optimised for integrated biorefinery systems’ (EPOBIO 2006: 34). GM techniques are used to modify the lignin content of wood, e.g. ‘to improve pulping characteristics by interfering with lignin synthesis’ (ibid.; Coombs 2007: 55).

More generally, plants are redesigned for a biomass processing industry. An ‘integrated diversified biorefinery’ would use renewable resources more efficiently via more diverse inputs and outputs, which can be flexibly adjusted according to global market prices. As an ideal of eco-efficiency, closed-loop recycling successively turns wastes into raw materials for the next stage. Agriculture becomes a biomass factory; residues become waste biomass for industrial processes. Horizontal integration is being promoted through new commercial linkages between novel crops, enzymes and processing methods.

In this vision, agriculture becomes future ‘oil wells’. An international conference on the biorefinery brought together diverse industries with a common aim to integrate biomass sources and products:

> Participants included members of the forestry, automotive, pulp and paper, petroleum, chemicals, agriculture, financial, and research communities…. It was noted by DOE and EU that both the U.S. and EU have a common goal: Agriculture in the 21st century will become the oil wells of the future – providing fuels, chemicals and products for a global community (BioMat Net 2006).

‘Oil well’ provides an appropriate metaphor for this agenda of genetically modifying plants and/or enzymes for conversion into various industrial products. Organisms become interchangeable raw materials to be ‘cracked’ like oil. This concept has been elaborated through compositional analogies to crude oil, thus reordering nature: ‘New developments are ongoing for transforming the biomass into a liquid "biocrude", which can be further refined, used for energy production or sent to a gasifier’ (Biofrac 2006: 21).

In the name of a common societal vision then, the dominant KBBE agenda potentially co-produces technology, nature and society along lines further commoditising resources. In this vision, converging technologies will unlock the beneficent natural properties of plants. Eco-efficient inputs will link environmental and economic sustainability.

Alongside that dominant account, others contend for influence. In an agro-ecological account of the KBBE, ecological processes enhance and integrate eco-efficiency. ‘Organic farming is a highly knowledge-based form of agriculture involving both high tech and indigenous knowledges and is based on the farmer’s aptitude for autonomous decision making’ (Niggli et al 2008: 34). Organic farming attempts to keep cycles as short and as closed as possible, in order to use biodiverse resources more efficiently. These practices enhance resource efficiency by enhancing internal inputs as substitutes for external inputs, while also maximising outputs. Residues are seen as media for recycling nutrients via ecological processes and so replenishing soil fertility (Schmid *et al*. 2009). Although this account remains marginal, it highlights the societal choices implicit in the dominant one.

CONCLUSIONS: LESSONS FOR FUTURE TECHNOLOGY?

Let us return to the initial questions: Why did agbiotech encounter strong blockages in Europe? What can be learned from this experience for other new technologies?

Agbiotech was initially co-produced with nature and society within a neoliberal globalisation framework. In turn, agbiotech was used to promote those policies by remaking discourses, institutions and identities. As a resource for GM crops, nature was invested with metaphors of codes, combat and commodities. In the mid-1990s, EU regulatory criteria internalised assumptions of agbiotech innovation by, for example, accepting the normal hazards of intensive monoculture, while also welcoming greater efficiency as an environmental benefit. Through a technicist harmonisation agenda, the European environment was conceptually homogenised for political-economic integration. Europe was being made safe for agbiotech.

GM products were reaching the commercial stage in a period when food hazards were widely attributed to agri-industrial methods, their profit-driven efficiency, deregulatory policies and official expert ignorance. So criticism of agbiotech resonated strongly with public anxieties. Agbiotech also acquired public meanings through EU policy frameworks: regulatory harmonisation, trade liberalisation and commoditisation of plant genetic resources. Together those policy frameworks provided a vulnerable target, thereby linking various opponents of agbiotech, agro-industrial development and neoliberal globalisation. This conflict was illuminated by an interactive co-production approach to strategies for imposing a specific future as an objective imperative, in turn provoking a broad opposition and demands for alternatives.

More recently, to bypass blockages of GM agro-food products, agbiotech has been promoted for non-food uses in a future European bioeconomy. This again invokes economic competition and natural characteristics (e.g. biocrude) as an objective basis for European political-economic integration along specific lines. In the name of overcoming constraints on natural resources, this would horizontally integrate agriculture with industry for global value chains in proprietary knowledge. European prospects for next-generation agbiotech depend on reshaping the socio-natural order according to such a bioeconomy.

From the experience of the European agbiotech controversy in the 1990s, commentators have drawn wider lessons, including some dubious ones. For example, 'The easiest way for the nanotechnology community to avoid the problems experienced in the deployment of biotechnology is to provide accurate information and encourage critical, informed analyses.' (McHugen 2008: 51) This attributes the earlier public controversy to a deficit of publicly available information, yet its reliability and accuracy were contested, in a context where greater knowledge generally led to greater opposition.

Another lesson often heard was that the next novel technology could become 'another GM' if the public is not adequately consulted at an early stage. Conversely, it is also said that greater public involvement or deliberation could help to avoid societal conflict over technological innovations. For example, 'Given the opportunity to deliberate on such innovations, the public voice can be expected to be measured and moderate' (Gaskell 2008: 257).

In their own way, those two distinct lessons each decontextualise technology from its political-economic agendas. From the 1990s agbiotech conflict, we could draw different lessons, albeit less comfortable ones:

- technology is always co-produced with a specific form of the socio-natural order, thus pre-empting other choices of societal future;
- societal conflict arises from such non-choices; and so,
- technology, information and even deliberation cannot remain credibly neutral in relation to those choices.

In sum: An interactive co-production perspective helps to illuminate the 1990s conflict over agbiotech and the possible lessons for future technoscientific developments. Europe was told that it must accept agbiotech, whose design and policy context potentially naturalised a specific future society, as if objectively required. Yet this supposed imperative was turned into a test of democratic accountability for societal choices.

Therefore, prospects for avoiding 'another GM' controversy – or perhaps for creating one – depend upon how a technological innovation models the socio-natural order and how state bodies attempt to promote that order. If a political-economic choice is represented as an objective imperative, then such an innovation may be successfully naturalised, stabilised and imposed. Or else opposition may destabilise and block that political-economic choice, so that the innovation can be co-produced (if at all) along different lines. Those potential outcomes pose either a threat or an opportunity, depending on one's aims.

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