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Transgenes and Transgressions:

Scientific Dissent as Heterogeneous Practice

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Abstract: Although scholars in science and technology studies have explored many dynamics and consequences of scientific controversy, no coherent theory of scientific dissent has emerged. This article proposes the elements of such a framework, based on understanding scientific dissent as a set of heterogeneous practices. I use the controversy over the presence of transgenic DNA in Mexican maize in the early 2000s to point to a processual model of scientific dissent. 'Contrarian science' includes knowledge claims that challenge the dominant scientific trajectory, but need not necessarily lead to dissent. 'Impedance' represents efforts to undermine the credibility of contrarian science (or contrarian scientists) and may originate within or outside of the scientific community. In the face of impedance, contrarian scientists may become dissenters. The actions of the scientist at the center of the case study, Professor Ignacio Chapela of the University of California, Berkeley, demonstrate particular practices of scientific dissent, ranging from 'agonistic engagement' to 'dissident science'. These practices speak not only to functional strategies of winning scientific debate, but also to attempts to reconfigure relations among scientists, publics, institutions, and politics that order knowledge production.

> [C]ontroversies over science and technology are struggles over meaning and morality, over the distribution of resources, and over the locus of power and control.
>
> (Nelkin, 1995: 445)

> You do not become a 'dissident' just because you decide one day to take up this most unusual career. You are thrown into it by your personal sense of responsibility, combined with a complex set of external circumstances. You are cast out of the existing structures and placed in a position of conflict with them. It begins as an attempt to do your work well, and ends with being branded an enemy of society.
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> -Václav Havel[1]

[1] Self-described 'dissident' in communist Czechoslovakia, the first president of the Czech Republic, and the first recipient of Amnesty International's Ambassador of Conscience Award in 2003.

Introduction

In December 2003, five-hundred students, faculty, and community members attended an event on the campus of the University of California, Berkeley entitled, 'The Pulse of Scientific Freedom in the Age of the Biotech Industry'. The panel discussion starred four scientists whose research had challenged the safety of agricultural biotechnologies during an era in which the industry possessed significant political and economic momentum (Gottweis, 1998; Charles, 2001; Kloppenburg, 2004 [1988]). The panelists—who had never worked together and represented four different sub-disciplines of biology—were not invited because of the overlapping *implications* of their research, but because of the challenges they faced in defending the legitimacy of their science. Their stories included personal intimidation, removal of research funding, professional reprimands, coordinated smear campaigns, ostracism and isolation, specious challenges on 'technical grounds', and unprecedented sanctions by respected public and quasi-public scientific institutions.[2] Taken together, they portrayed a disturbing pattern of attempts at scientific suppression as defined by Martin (1999a),[3] but this analytical category falls short of understanding the complexity of scientific dissent as a practice. Indeed, while these scientists suffered numerous attacks, they were hardly 'suppressed'—not only had their controversial research been published in elite scientific journals, but they were speaking out in public about their perceived unjust treatment.

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[2] Such actions, especially within the agricultural sciences associated with land grant universities, have a long history, as noted by Charles Hardin in *Freedom in Agricultural Education* (1955): 'The writer knows of no college of agriculture in which some professor has not been subjected to pressure—attempts to get him fired, to silence him on an issue, to force retraction of a publication, to require that a controversial manuscript be reviewed by representatives of an affected interest, or simply to protest enough so that he will think twice before he repeats the "offense"' (p. 86). The ubiquity of such behaviour may stem from what Lacy and Busch (1982) call "the commodity orientation of research" as agricultural science became institutionalized in the early to mid-20th century (p. 406).

[3] Martin (1999a) defines suppression as 'the exercise of power against dissent' and offers three strategies to distinguish suppression from 'actions taken for legitimate reasons'. He notes, however, that 'Attacks on scientists are almost never characterized, by the perpetrators, as suppression of dissent. For an investigator to use such a label, or even to seek details about cases, can be interpreted as demonstrating bias.'

Just as democratic reformers wrestle with the tension between honoring conflicting political interests and deploying coherent policy, so also do scientific institutions struggle with how best to incorporate and respect marginal opinions (and opinion holders) without paralyzing the machinery of knowledge production and undermining the social authority of science. Dissent functions as both integral and disruptive to the body politic and to the body of scientific knowledge. Yet, literature in science and technology studies has paid scant attention to scientific dissent. Despite the impressive litany of conceptual breakthroughs afforded by engaging scientific controversies as research sites (e.g. Collins, 1981; Nelkin, 1984; Shapin & Schaffer, 1985; Clarke & Montini, 1993; Gieryn, 1995; Wynne, 1996), scientific dissent has remained relatively undifferentiated and at times invisible. Scholars have typically invoked dissent as a *position*—obligatory to prove the existence of scientific controversy—rather than as a *practice*. In addition, few scholars have tackled the complexity of scientific dissent within arenas of major political and economic importance (see, however, Martin, 1981; Epstein, 1996; Krimsky, 2003). Furthermore, analyses of scientific dissent have largely ignored the power differentials among the actors and institutions that comprise technoscientific arenas of public concern.

Unlike the more benign 'disagreement', dissent highlights the emergence of minority views in the face of more dominant scientific trajectories.[4] This implicit imbalance of power, even if indicated only by relative numbers of believers, raises the specter of the epistemological tyranny of the intellectual majority. Scholarship has recognized such outcomes as frequent and expected events in the practice of science: entrenched theory staving off revolutions by ignoring or absorbing anomalies (Kuhn, 1996 [1962]); exclusionary boundary-work performed to protect professional status rather than risk engaging with a disruptive idea (Gieryn, 1999); and outright

[4] Inspired by Fleckian thought styles, Gramscian hegemony, and Martin's (1999a) scientific/technical orthodoxies, dominant scientific trajectories create momentum for one set of questions, methods, and approaches, while discouraging others—at times to the point of making alternatives impossible to conceive.

intellectual suppression by those with institutional authority (Martin, 1999a). This article takes seriously such actions and proposes a conceptual framework for understanding both the precursors to, and the heterogeneity of, practices of scientific dissent.

I explore each of three phases of a processual model by engaging a case study of highly politicized and publicized scientific controversy: the purported 'contamination' of Mexican maize by transgenic DNA. The first phase, *contrarian science,* describes David Quist and Ignacio Chapela's (2001) research that sparked the controversy and how it contested mainstream scientific assumptions and powerful political and economic forces. The second phase, *impedance*, refers to the myriad efforts by those within and outside of the scientific community to challenge the credibility of the contrarian research and researchers. The third phase and main focus of this paper, *scientific dissent*, reflects Quist and Chapela's choice to respond to impedance in particular ways. Specifically, I distinguish between two conceptual categories of scientific dissent. The first, a*gonistic engagement*, includes behaviors reflecting conventional strategies within the scientific community (e.g., building evidence, recruiting scientific allies, and negotiating disciplinary territory). In contrast, *dissident science* represents explicitly political practices that merge intellectual struggle with social action (cf. Collins & Pinch, 1979)—a politicized version of scientific dissent that both challenges knowledge claims and calls for some degree of reform in the relationships among science, politics, and publics. Such behavior often provokes sanction by the scientific community, making it appear illogical or self-destructive in a narrow view. But understood within the context of social struggles to produce knowledge and credibility for political ends, dissident science represents a powerful strategy to influence scientists, publics, and institutions.[5]

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[5] Scott Frickel (2004) addresses some of these issues (e.g., reconfiguring the science/politics boundary) through the lenses of organizational, neoinstitutional, and social movement theories. Offering a typology of organizations that emerges from studying the environmental justice movement, he concludes that 'in certain contexts credible research and effective activism can be (and perhaps should be) seen as mutually constitutive' (p. 465).

Conceptualizing Scientific Dissent

Increasing interdependence between public research institutions and private firms create important questions about the practice of scientific dissent in universities and government agencies (e.g., Owen-Smith & Powell, 2001; Kleinman & Vallas, 2006). Scientific controversies in arenas with high economic or political import (e.g., toxics, weapons systems, biotechnology, climate change) routinely integrate struggles over facts with questions about conflicts of interest (e.g. Garrety, 1997), academic freedom (e.g., Krimsky, 2003), and regulatory science (e.g., Jasanoff, 1990; Wright, 1994). What have remained relatively unexamined, however, are the normative expectations of scientific dissenters; how should they respond when threatened, misunderstood, attacked, sacked from their jobs, or simply challenged in a scientific journal? Rather than seeing such behavioral responses as detours from the task of knowledge production, I analyze these actions as *integral to the practice of science*. This strategy requires reconceptualizing both the emergence and heterogeneity of scientific dissent.

The proposed framework draws together sources that might seem at odds with each other, taking inspiration primarily from the work of Thomas Gieryn and Brian Martin. Gieryn's (1999) focus on boundary-work calls attention to the process through which struggles for credibility define what counts as science and non-science. He recognizes that such struggles continually reify, reconstruct, and reconfigure boundaries of legitimacy, autonomy, and jurisdictional authority (p. 15-17). His insights not only provide a useful language to understand the stakes and strategies of scientific dissent, but also suggest how boundary-work has the potential both to establish 'truth' (mapping claims within boundaries of credibility) and to alter systems of knowledge production (reconfiguring the character and placement of boundaries). For the purposes of this paper, I identify five key boundaries. First, linguistically, contrarian science exists in relation to a dominant scientific trajectory—implying a boundary (however unstable) that separates mainstream intellectual activity from marginal thought. A second and

circumscribing boundary marks the contested line of credibility that determines whether a knowledge claim (marginal though it may be) earns the imprimatur of Science (Gieryn's science/non-science boundary). A third boundary provides normative separation between 'acceptable' and 'unacceptable' ways to earn scientific credibility (see Collins & Restivo, 1983). The ongoing negotiation of this last boundary, which distinguishes agonistic engagement from dissident science, not only has implications for what becomes legitimate science, but also represents a struggle over the proper means of knowledge production (the roles of non-experts, connections to political and social movements, and so forth). The fourth and fifth boundaries serve to separate science from politics and scientists from publics. These rhetorical boundaries operate in a constant state of tension—preventing improper influence from 'polluting' science while keeping science relevant to the values and politics of society (Gieryn, 1999: 182).

Brian Martin's thirty years of studying scientific suppression (Martin, 1981, 1999a) and the phenomenon of whistleblowing more broadly (Martin, 1999b; Martin & Rifkin, 2004) provide a key foundation for conceptualizing scientific dissent. He advises dissenters both to understand the systems of power in which they operate and also to consider their choice of tactics. Specifically, he delineates strategies for scientists who have been attacked: 'mimic orthodox science', 'aim at lower status outlets' for publication, 'enlist patrons', 'seek a different audience', 'expose suppression of dissent', and 'build a social movement' (Martin, 1998). More generally, his work on 'backfire' outlines ways in which marginalized actors can exploit unjust or repressive tactics used by more powerful forces in a kind of 'political jiu-jitsu' (Martin, 2007). While versions of some of these categories appear within my own framework, I extend Martin's analysis in two ways. First, I offer more precise language to describe the emergence of scientific dissent, including its necessary precursors. Second, by introducing the analytical categories of dissident science and agonistic engagement, I engage more deeply with ongoing negotiations to reconstruct the boundaries between science and politics, and between scientists and publics. The

resulting processual model thus presents instances of scientific dissent as sites where the systems and cultures of knowledge production take shape.

Precursors: Contrarian Science and Impedance

The harbinger of dissent, contrarian science goes against dominant scientific trajectories. Contrarian scientists challenge accepted theories, introduce revolutionary methods, expose inconsistencies in assumptions, and blur traditional disciplinary boundaries. Depending upon one's political and intellectual position, such challenges may infuriate, motivate, or provide reassurance.[6] As such, contrarian science is potentially disruptive, but conducted and deployed with at least some hope of convincing a mainstream scientific community of a new fact or approach. With varying degrees of naiveté about the likelihood of spurring scientific controversy, contrarian scientists present their findings in the form of collegial contributions, without *necessarily* desiring or intending to become active dissenters.[7]

When scientists and other interested parties challenge contrarian science, the first sparks of controversy appear. Potential targets of criticism include research methodology, interpretation of data, application of theories or models, the credibility of the contrarian scientists, the appropriateness of the research question or forum of announcement, and the implications of the findings for policy and action. In the language of boundary-work, mainstream actors employ diverse means to exclude the particular contrarian claim or scientist from the zone of legitimacy offered by Science. I invoke *impedance* to refer to these processes that prevent knowledge claims from becoming accepted as scientific facts and knowledge-makers from becoming credible

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[6] Contrarian scientists need not be 'right', either from the perspective of a future scientific consensus (e.g., nicotine is addictive) or any particular value system (e.g., racial discrimination is unjust).

[7] Opponents may accuse contrarian scientists of 'activist-orientations,' but this reveals little about 'true' intentions and more about efforts to reduce the credibility of contrarian scientists (i.e., boundary-work). In fact, as Martin (2007) asserts, 'whistleblowers' (a more general term that overlaps with the category of contrarian scientists) often see themselves as 'just doing their job' (p. 67) and 'are shocked and surprised by reprisals' (p. 73). 'It is common to hear them say, in retrospect, "I was naïve"' (p. 73).

spokespersons for truth (Latour, 1987). I use the term to allude to electrical resistance—impeding flow—suggesting both the dynamic quality of the interactions between scientific proponents and opponents of the mainstream position and the 'heating up' of controversy with higher power contrarian claims and stronger efforts to challenge them.

Scientific Dissent: Agonistic Engagement and Dissident Science

When contrarian scientists respond,[8] they do so in the context of full-blown scientific controversy (contrarian science that has sparked impedance). While opponents may disagree about which side initiated the controversy—assigning responsibility for the first 'move' may itself be a topic of dispute—this conceptual framework distinguishes the initial contrarian contribution (which need not necessarily be challenged) from the practice of scientific dissent (i.e., responses to impedance). There are clearly many ways to describe these possible responses, and here I present two conceptual categories: agonistic engagement and dissident science.

Contrarian responses that respect the conventions of scientific communication in the struggle over facts define the category of agonistic engagement, a concept that brings together Gilbert and Mulkay's (1984) notion of the 'empiricist repertoire'; Latour and Woolgar's (1986 [1979]) reference to science as an 'agonistic field', which itself draws upon Bourdieu's (1975) extensive discussion of the 'scientific field'; Collins and Restivo's (1983) description of structural conditions that favor scientists who behave like 'saintly politicians' (rather than 'robber barons'); and ideas from political theory. In *The Return of the Political* (1993), Chantal Mouffe envisions a new democratic order using the term 'agonistic pluralism'. This model of engagement respects the need for disagreement and controversy as a path to negotiated

[8] Impedance may be powerful enough to preclude a response by a contrarian scientist. This may reflect an event of intellectual suppression or the scientific inadequacy of the original findings (indicating that the boundaries of science have been properly patrolled).

governance, but redefines the approach to conflict by shifting how opponents perceive one another:

> [W]ithin the context of the political community, the opponent should be considered not as an enemy to be destroyed, but as an adversary whose existence is legitimate and must be tolerated. We will fight against his ideas but we will not question his right to defend them. The category of the 'enemy' does not disappear but is displaced; it remains pertinent with respect to those who do not accept the democratic 'rules of the game' and who thereby exclude themselves from the political community (p. 4).

For Mouffe, agonism represents an attractive alternative to 'antagonism', which disrupts communal norms of constructive engagement by creating enemies rather than opponents. Importing the idea of agonistic engagement into controversy studies creates a way to categorize responses that adhere to the 'rules of the game' of scientific debate.[9] Importantly, agonistic engagement reifies these structures (rules) by reinforcing assumed boundaries between politics and science (keeping science objective and apolitical, ruling out ad hominem critiques) and between scientists and publics (see, for example, Gieryn's [1999: 17] boundary of autonomy). Accordingly, agonistic engagement downplays any political motivations and implications of contrarian research and impedance to it (defending the legitimacy of Science even while scientists attack a particular piece of science), and stakes out the civil, 'higher' ground of constructive engagement over data, methods, and interpretation. These practices encompass a set of familiar behaviors and rhetorical strategies described in science and technology studies (Merton, 1973 [1942]; Latour, 1987; Kuhn, 1996 [1962]), but which do not encompass more severe forms of dissent. Agonistic engagement generally satisfies expectations in scientific fields, evidenced by a lack of criticism of this strategy even by opponents who disagree with the content of the claims.

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[9] While I view these rules as constructed, and therefore contestable and malleable, at any given moment they present themselves as structures commanding a degree of respect. Daniel Kleinman (2003) makes a similar argument to gain analytical traction in the structure vs. agency debate with regard to the formation and consequences of networks of scientific practice (also see Collins & Restivo, 1983).

Dissident responses also defend contrarian claims, but in contrast to agonistic engagement violate the norms of scientific communication. Beyond Gilbert and Mulkay's (1984) 'contingent repertoire' (which calls attention to personal and inter-personal dynamics in the production of science), dissident science explicitly acknowledges the politics within and around scientific controversy, and advocates new relationships among scientists, the public, interest groups, and academic institutions. Unlike Mouffe's antagonism, dissident science focuses less on the creation of enemies than on reforming relationships that control knowledge production.[10] Thus, dissident scientists combine intellectual struggle with social action, incorporating a variety of strategies: emphasizing the political nature of scientific controversy, calling attention to the institutional contexts that produce—or inhibit—research, enrolling non-traditional allies to form alternative sources of legitimacy, and shifting the terrain of debate away from fact-making to envisioning alternative social orders for conducting research.

As a final point of clarification, it is important to distinguish dissident science from the more general phenomenon of politically-engaged scientists. Kelly Moore (1996), for example, demonstrates how groups of scientists constructed new political voices by organizing 'public interest science organizations' (such as the Union of Concerned Scientists) outside of traditional professional and academic societies (also see Frickel, 2004). The relevant insights into strategies of scientific dissent are numerous: 1) scientists, like other citizens, have political preferences and values that guide their actions; 2) bringing like-minded scientists together increases their political influence and reduces the risk of marginalization; and 3) scientists constantly must balance the tension between representing themselves as disinterested and relevant experts. These points illuminate the complex relationship between politics and science that scientists must navigate,

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[10] Such efforts to upset the established scientific order carry significant risk; Bourdieu (1975) differentiates between 'succession strategies' (similar to agonistic engagement) and 'subversion strategies, which are infinitely more costly and more hazardous investments which will not bring them the profits accruing to the holders of the monopoly of scientific legitimacy unless they can achieve a complete redefinition of the principles legitimating domination' (p. 30).

but dissident science refers specifically to the behavior of scientists who have become politically engaged over particular knowledge claims that they themselves have advanced. Consequently, dissident science channels controversy from factual concerns to epistemological and political concerns, but always maintaining links with the origins of controversy (contrarian science and impedance).

Methods

In several respects, my methods employ a symmetrical approach (Barnes & Bloor, 1982; Bloor, 1991); on other levels, they remain necessarily asymmetrical. In the symmetrical tradition, while I have certainly wrestled with the 'technical' arguments that inform various phases of the controversy, my analysis does not depend on the veracity of contrarian claims—whether Mexican maize 'actually' contains transgenes is immaterial to providing a social explanation for the practice of scientific dissent.[11] This approach follows Simon (2002), who investigates a community of dissenting scientists who have continued to conduct research on cold fusion nearly a decade after cold fusion was soundly rejected by mainstream scientists. By studying the practice of scientific dissent *after* the closure of controversy, Simon extends what he sees as the analytical limit of controversy studies (p. 19). The scholarly value of paying attention to scientific dissenters thus does not depend upon them being 'right'.

Also in the symmetrical tradition, I have not assumed a prior boundary between 'appropriate' and 'inappropriate' means of challenging (impeding) contrarian science. In other words, my framework for understanding the emergence of scientific dissent does not neatly divide scientific controversies that involve scientific 'suppression' from those that reflect the 'proper' policing of the boundaries of science. Instead, I focus symmetrically on the experience

[11] In fact, the most recent peer-reviewed study found *no evidence* of transgenic maize in an extremely broad sampling across the highlands of Mexico (Ortiz-Garcia, et al., 2005). This study, predictably, has not escaped criticism (Chapela & Quist, 2005).

of the contrarian scientist—a necessarily relative perspective—to explore the heterogeneity of the practice of dissent. While I do not deny the political and epistemological value of normative analyses of impedance among scholars (Martin, et al., 1986; Krimsky, 2003) and investigative journalists (Monbiot, 2002; Rowell, 2003), I avoid making normative distinctions between varieties of impedance, treating them all as a single category.[12]

In other respects, this work is purposefully and necessarily asymmetrical. Indeed, I have not approached the *controversy* symmetrically. As Simon (2002: 14) recognizes, the study of marginalized science highlights the methodological quandary of Latour's oft-repeated advice for studying controversy: 'We do not try to undermine the solidity of the accepted parts of science. We are realists as much as the people we travel with …. But as soon as a controversy starts we become as relativist as our informants' (Latour, 1987: 100). Critically, as STS scholars we must acknowledge that our selection of informants and whom we travel with (not always the same people) have immense repercussions on our access to and interpretation of data. In fact, while my lack of symmetry in this regard built a high level of trust with Quist and Chapela,[13] their scientific opponents displayed various degrees of suspicion toward my efforts to interview them. I have thus been open not only to the criticism of asymmetry, but also to partisanship. In this context, as Martin (1991) argues, simply *paying attention* to dissenters in highly politicized scientific controversies becomes an act of partisanship since dominant actors seek to silence the

[12] Following this symmetrical strategy enables further consideration of complex boundary-work: how dissenters (and their allies and opponents) classify and critique instances of impedance.

[13] In 1998, a group of first-year students in Environmental Science, Policy, and Management, including Quist and myself, founded Students for Responsible Research. Collectively we challenged our college's proposed alliance with Novartis (see note 16), and I frequently served as a spokesperson. I also co-organized a working group of scholars who published two partisan responses to the controversy over transgenic maize in Mexico (Worthy, et al., 2002; Worthy, et al., 2005).

debate altogether.[14] In other words, the severe political, economic, and institutional asymmetries that define the landscape of this controversy prevent a perfectly symmetrical investigation.

My data collection involved three complementary qualitative strategies. First, as a participant-observer, I attended multiple events and meetings that dealt with the Mexican maize controversy and the associated controversy over the tenure case of Chapela. Second, I conducted extensive interviews with the authors of the published study and semi-structured interviews with a number of their critics and supporters. Third, I examined the scientific literature, mass media, and various web sites that addressed the Mexican maize controversy. I analyzed and organized my data in the qualitative data analysis software, *ATLAS.ti* ™.

Contrarian Science – Transgenes in Mexican Maize?

In October 2000, David Quist, a graduate student from the University of California, Berkeley, traveled to Mexico to run an educational workshop on transgene detection in maize. The exercise was part of an ongoing research and capacity-building relationship between the UC Berkeley laboratory headed by Ignacio Chapela (Professor of microbial ecology in the Department of Environmental Science, Policy, and Management) and UZACHI (Union de Comunidades Zapoteco Chinanteca, a scientific initiative involving indigenous groups in Oaxaca, Mexico). Quist and Chapela assumed that the highlands of Oaxaca would be free of transgenic maize, especially given the Mexican moratorium that had prohibited the planting of transgenic maize since 1998. Nevertheless, they saw the value of teaching the technique as an educational tool that might have practical utility in Oaxaca sometime during the next decade. Quist ran the protocol the night before demonstrating the technique to workshop participants. His

[14] One potential informant declined to be interviewed, explaining in an email: 'Quist and Chapella's [sic] paper did not seem controversial to me. I thought it's [sic] major conclusion was self-evident, and it's [sic] second conclusion was based on faulty science. There's not much more that I can tell you, and I'm sure you've heard this already. Just add my vote to the self-evident + bad science camp. I hope the sad Quist and Chapela story is not your only thesis topic.'

positive controls and water negative controls were 'behaving', but the local samples showed a 'faint signal', suggesting the presence of transgenic DNA.[15] What had begun as a demonstration project had suddenly raised an experimental question: *had transgenic DNA already entered remote populations of maize landraces in Oaxaca?*

Quist returned to the U.S., aware that proving the presence of transgene flow into Mexican maize would potentially have significant cultural and political implications. Such results would not only undermine the existing moratorium on planting genetically-modified (GM) maize in Mexico—calling into question institutional and technical capacities to control the movement of GM crops (and transgenic DNA, more precisely), but also would likely ignite a cultural and social debate among Mexicans about the definition of 'purity' in their national heritage crop (maize). Back in their university laboratory, Quist and Chapela conducted an expanded analysis of the Oaxacan samples and concluded that transgenic DNA had 'introgressed' into landraces of Mexican maize. They submitted a manuscript to *Nature* in March 2001, which went through four rounds of fairly acrimonious peer review that spanned nearly eight months.

The publication appeared as a 'Letter to *Nature*' on 29 November: 'Transgenic DNA Introgressed into Traditional Maize Landraces in Oaxaca, Mexico' (Quist & Chapela, 2001). The authors first addressed the claim of introgression, describing their analysis and also citing an investigation by the Mexican government (initiated after Chapela shared his preliminary findings with Mexican officials) that corroborated their data. The letter's secondary claims relied on a technique to explore the *genomic context* of DNA sequences—in this case a common transgenic promoter. Their analysis suggested that sites of insertion were diverse and that the 'transgenic DNA construct seemed to have become re-assorted and introduced into different genomic

[15] Interview, David Quist, 10 October 2003.

backgrounds' (Quist & Chapela, 2001: 542). Quist explained in a press release, 'If this contamination was the result of a single gene transfer event, we would expect to find the transgenic DNA in a consistent location on the criollo genome. Instead, we're finding it at different points along the genome' (University of California, 2001).

Given that the manuscript was indeed published in a premier scientific journal, why should we consider Quist and Chapela's research as an example of *contrarian science*? First, the primary finding disrupted scientific assumptions related to GM crops. As reported by the *New York Times*, the result took 'researchers by surprise' by indicating 'that crop genes might be able to spread across geographic areas and varieties more quickly than researchers had guessed' and that native varieties of Mexican maize were no longer 'pristine' (Yoon, 2001). Second, as reported by the *San Francisco Chronicle*, the transgenic 'contamination' of Mexican maize flew in the face of the moratorium enacted in 1998 on the planting of GM maize in Mexico, a policy motivated by a 'government worried that cross contamination would pollute one of the world's last repositories of native varieties of corn' (Kay, 2001). In other words, this was not supposed to have happened—an assumption shared even by Quist and Chapela prior to their collection of samples for the workshop. Third, Quist and Chapela's study used a molecular approach for understanding an ecological phenomenon. Prior field trials had measured 'safety' at a more limited temporal and spatial scale, ignoring downstream effects of widespread commercialization of GM crops (Rissler & Mellon, 1996); in contrast, the *Nature* letter presented a call for a new scientific perspective on the ecology of genes. Fourth, the research question and methodology embodied in the search for the genomic context of foreign transgenes (the secondary findings) challenged dominant wisdom among molecular biologists who assumed that transgenes would introgress only as intact and stable constructs without experiencing a high degree of rearrangement (Christou, 2002). Finally, and perhaps most significantly, Quist and Chapela's publication challenged the mainstream narrative of agricultural biotechnology as *precise and*

under control, key arguments against increased regulatory oversight of GM crops and for continued global commercialization (e.g., Biotechnology Industry Organization, n.d.). As an anti-biotech NGO reported in the wake of the *Nature* paper, 'Pro-industry and pro-GM academics went ballistic. News that a Center of Genetic Diversity [Mexico] had been polluted with GM traits could crush industry hopes that the European Union would end its de facto GM moratorium' (Food First, 2002). In sum, Quist and Chapela published a piece of contrarian science—research that disrupted technical assumptions, introduced novel approaches to research, challenged the efficacy of enacted public policy, and, most broadly, threatened a technoscientific project enjoying broad scientific, political, and economic momentum.

Impedance – Challenging Chapela

While it remains beyond the scope of this article to critically analyze the myriad forms of impedance, Chapela's practice of dissent only makes sense in the wake of the opposition that he faced.[16] The breadth of the challenges to the legitimacy of his findings and to his credibility as a scientist was stunning:

- Alleged personal threats by the Mexican Biosafety Commissioner prior to publication of the data. According to Chapela, Fernando Ortiz Monasterio brought him to an abandoned floor of a government office building in Mexico City and accused him of 'creating a really serious problem.' Attempting to dissuade Chapela from publishing his data, the minister invited him

[16] Chapela's prior experience in the politics of biotechnology certainly played a role in influencing his practice of scientific dissent. For example, after leaving his position as a scientist for Sandoz (a Swiss pharmaceutical company) to join the faculty at UC Berkeley, Chapela found himself in a precarious position. As the head of his college's faculty executive committee, he had grave concerns about a proposed $25 million collaborative research agreement between Novartis Agricultural Discovery Institute (Sandoz and Ciba-Giegy merged in 1996 to form Novartis, a 'life science' firm) and UC's Department of Plant and Microbial Biology (PMB). Despite his junior status, he refused to rubber-stamp the deal and instead spoke out publicly—sparking a campaign joined by students, faculty, and community members; discussing the dangers of university-industry partnerships in the media; critiquing the corporate agenda of agricultural biotechnology; and raising the ire of administrators and PMB faculty who viewed the contract as a shining example of leveraging private assets for the public good (Press & Washburn, 2000). Thus, unlike the average 'whistleblower' (see note 7), one could argue that Chapela was not 'naïve', a difference he later explicitly drew between himself and the other scientists at the 'Pulse of Scientific Freedom in the Age of the Biotech Industry'.

to join a team of four corporate scientists that 'was going to show the world what the reality of GM was all about' (quotations from Rowell, 2003: 152; also see Smith, 2003: 221-24). Ortiz Monasterio acknowledged meeting Chapela, but denied threatening him in any way (BBC Radio 4, 'Seeds of Trouble', 7 January 2002, cited in Rowell, 2003: 153). While the character of their meeting remains controversial, Ortiz Monasterio did publicly reveal Quist and Chapela's discovery at a September 2001 meeting of the Codex Alimentarius Commission (an international food-safety organization), breaking the traditional embargo of research under peer review (Dalton, 2001).

- Additional tests by the International Maize and Wheat Improvement Center (CIMMYT) that failed to find transgenic DNA in maize samples taken from the same geographic area during the same time period (CIMMYT, 2002).
- An editorial in *Transgenic Research* that tore apart Quist and Chapela's methodology and analysis (Christou, 2002).
- A sign-on letter of nearly one hundred pro-agbiotech scientists organized by the AgBioWorld Foundation that said, in part, 'It is important to recognize that the kind of gene flow alleged in the *Nature* paper is both inevitable and welcome' (AgBioWorld Foundation, 2002).
- Disparaging emails circulated on AgBioView (a scientific listserve supported by the AgBioWorld Foundation) that were posted by scientists who did not exist. Two investigative journalists eventually tracked these faked identities to the Bivings Group, a public relations firm frequently hired by Monsanto that specialized in viral marketing—an advertised service to conduct a PR campaign that presents the client's position as 'an uninvolved third party' (Matthews, 2002; Monbiot, 2002; Rowell, 2003: 155-60).
- Five technical critiques submitted to *Nature*, two of which the editors published in April 2002 (Kaplinsky, et al., 2002; Metz & Fütterer, 2002) alongside a 'reply' (Quist & Chapela, 2002). *Nature* also included an editorial note that withdrew support from the original

publication (Nature Editor, 2002a)—an unprecedented act that fell short of retracting the paper (Nature Editor, 2002b) but sharply undermined the legitimacy of Quist and Chapela's research.

- A protracted battle over tenure between Chapela and the UC Berkeley administration that frequently referenced the legitimacy of the *Nature* paper (e.g., see Abate, 2002; Dalton, 2003; Dalton, 2005b).

As a group, these episodes of impedance challenged Chapela's professional legitimacy and the credibility of his and Quist's research. They also offer further evidence that the controversy over transgenes and Mexican maize was never simply a 'scientific controversy' in the narrow sense, but that media, corporate agents, and political actors contributed to a context that quickly transgressed the boundaries of agonistic science. How then did Chapela respond to these challenges? In other words, in what ways did Chapela's practices change from a *contrarian scientist* (whose approach and empirical results challenged mainstream scientific and political beliefs) to a *dissenting scientist* (whose work and professional status had become embroiled in uneven struggles over scientific legitimacy, political power, and social consequences)?

Agonistic Engagement – Quist and Chapela's Initial Response

Early efforts by Quist and Chapela to defend their research reflected strategies of agonistic engagement, scientific dissent that falls within the norms of conventional scientific discourse. I briefly discuss two such strategies: disputing facts and providing additional evidence; and invoking claims of disciplinary territory.

Dispute Facts and Provide Additional Evidence

Albeit somewhat reluctantly, Quist and Chapela accepted *Nature*'s demand for additional data to support their original claim, and they spent significant time crafting responses to letters of critique (Quist & Chapela, 2002). They participated in good faith with the clear goal of

defending their claims in a key forum for natural scientists (the pages of *Nature*). Likewise, in official letters composed during the early stages of his tenure case, Chapela gave detailed explanations of how his previous research had become accepted over time, in order to rebut claims that his work had always provoked controversy:

> It took a decade for the work in my dissertation to be fully accepted, but now scholarly meetings are convened and books written on the topic. I believe that a similar path awaits my more recent discoveries, and *I am eager to hear from confirmatory, rectifying or disproving work* following on the original research from my laboratory. (Chapela, 2003b)

Chapela thus positioned himself as a scientist ready and willing to accept the ongoing knowledge created by the 'march' of science toward truth—discursively invoking what Gilbert and Mulkay (1984: 91) refer to as a 'truth will out device'. In this manner, he dissented from accepted beliefs but embraced the normative process within science of allowing evidence to define what is considered truth.[17]

Claims of Disciplinary Territory

In Quist and Chapela's published 'reply' in *Nature*, they responded to some technical criticism by staking out new disciplinary territory, or at least differentiating their approach from that of their critics. They wrote: 'As altered DNA species should also be an important focus of ecological research, we disagree with our critics who assume that only intact transgenes are worthy of attention in our study' (Quist & Chapela, 2002). Although presented in a context that referred specifically to the criticism of their failure to find whole transgenic constructs to prove introgression, this sentence asserted in an understated way that an entire new focus of ecological research was at hand. Quist and Chapela thus responded to impedance by rebutting a scientific assumption that they categorically rejected for expressing a limited perspective.

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[17] This insight echoes Gieryn's (1999) observation that boundary-work reifies the significance and strength of the boundary even when it attempts to shift that boundary's position.

In the same letter, Quist and Chapela further defined their approach as being outside of conventional microbiology or genetics. The authors made three related claims: 1) conventional tools of microbiology and genetics were unavailable given the scale of their inquiry, which emerged at an ecological scale far beyond the controlled environment of a laboratory; 2) the complexity of their research environment eliminated the possibility of using more obvious and traditional methods to show the presence of transgenes—a claim that the nature of their question, rather than the inadequacy of their methodological approach, drove their unconventional technical choices; and 3) calls for a specific methodology revealed their critics' inexperience in even considering the type of question Quist and Chapela had constructed (Quist & Chapela, 2002). Together, these claims attempted to overcome challenges to Quist and Chapela's research by attempting to construct a novel field: *transgenic ecology* (Chapela, 2003b).

As suggested by these examples, dissent that exhibits primarily agonistic tendencies does not quell controversy, just as Mouffe's agonistic pluralism does not envision democracy without conflict. The strategies discussed above invite further cycles of controversy involving technical claims, credibility of allies, and disciplinary boundaries. Regardless of how disturbing the controversy becomes to scientific or lay audiences, when parties respect the rules (agonistic engagement) they reinforce the broad outlines of acceptable scientific conduct. Indirectly, these strategies further the performance of science as an empirical, apolitical, and expert (non-public) method. Agonistic strategies thus support a narrow focus on controversial knowledge production that backgrounds the political and institutional context.

Dissident Science – Intellectual Struggle Joins Social Action

Agonistic engagement may be a sufficient account of how many scientific controversies unfold, but it only describes a portion of the possible responses scientists can use when engaged in defending against impedance. Indeed, Chapela's actions went well beyond agonistic

engagement to include many examples of dissident science. While I do not mean to imply a discrete line between agonism and dissidence, the descriptions below embody strategies that appear to violate the norms of scientific discourse. The question that emerges is: how do such violations both serve as functional responses to impedance and also challenge conventional perspectives on the practice and politics of science?

This section presents three performances of dissent that include many features of dissident science. In the first event, 'Open Office Hours', Chapela staged a quasi-protest outside of UC Berkeley's main administration building during his quest for tenure. The second, 'Black Canvas', centers on an art exhibition that explored the arena of biotechnology. Chapela was invited to speak on a panel associated with the exhibition, and while this context was not precisely scientific, Chapela's choice of participating in absentia violated conventional expectations of a scientist. For the third event, Chapela brought three additional dissenting scientists together for a public discussion entitled 'The Pulse of Scientific Freedom in the Age of the Biotech Industry'. This explicit performance included some agonistic responses by the four scientists, but as a whole represented a dissident challenge to the political, scientific, and academic context of agbiotech.

Open Office Hours

In September 2001, just months before the appearance of his controversial *Nature* publication, Chapela began his application for tenure at UC Berkeley. Within a year his file reflected the endorsement of his department chair, his dean, his department's faculty, all twelve external referees who submitted letters, and the campus ad hoc expert committee. Beginning in November 2002, however, the theretofore smooth process became turbulent: the chair of the expert committee secretly resigned and denounced his committee's report; the Vice Provost insisted on procuring an additional three external letters (one of which recommended against

tenure); concerns emerged about a conflict of interest on the university's tenure-review committee (Abate, 2003); and on 5 June 2003 the Budget Committee issued a preliminary recommendation to *deny tenure* (Chapela, n.d.).

Facing the termination of his academic contract at the end of June 2003, Chapela had received no official word from administrators on the status of his tenure application or the likelihood of a contract extension. In response, on 26 June at 6:00 A.M., Chapela set up an 'open office' outside of California Hall, UC Berkeley's main administration building. He remained there for five days straight, twenty-four hours per day. In part, Chapela presented himself as the dutiful, dedicated professor. His email announcement declared:

> In the face of such lack of transparency and accountability [surrounding my tenure case], I choose to hold office hours in public, in the open, and in the midst of our beautiful campus. I do so in celebration of my vocation and my time at Berkeley, and not in the expectation that such an action will change the course of the decision process, whatever that might be. (Chapela, 2003a)

To some degree, Chapela carried this agonistic posture throughout the event. He encouraged visitors to browse his library of books; gave impromptu lectures to groups of undergraduate and high school students; sponsored an outdoor lecture and slide-show (projected onto the side of California Hall); and participated in countless intellectual discussions about topics ranging from the biology of genetic engineering, to the economics of global agricultural trade, to corporate-university relations, and to the peculiarities of the tenure process in a public university.

Moving beyond agonistic practices and with implicit connections to activism, Chapela simultaneously engaged in what I term dissident science. In his formal announcement of the Open Office Hours, he presented himself as a victim of a corrupt academic process:

> It has been suggested that the extraordinary delay in reaching a decision on my tenure case without ostensible reason may be the result of, even retribution for, my advising our campus, academe, the government and the public against dangerous liaisons with the biotechnology industry, as well as my concerns regarding the problems with biotechnology itself. (Chapela, 2003a)

In an interview the day before he began, Chapela described a conversation with David Noble, a colleague and radical critic of corporate influence on science and technology. They drew

parallels between Julia Butterfly Hill sitting in a redwood tree to protect the forest from the timber industry and Chapela sitting on campus to protect the public university from the biotech industry.[18] He struggled, however, to maintain control of the symbolism of his actions, feeling overwhelmed at one point with efforts by activists who had come to support him:

> The first day, Greenpeace and PANNA [Pesticide Action Network-North America], all these NGOs showed up with all their flyers and all their posters and they started plastering the place with messages and symbolism and photos. I was diplomatic to them because many of them are my friends, but as soon as they left I just pulled everything off and made it disappear. I did not want any symbology more than what I could control.[19]

This careful control of staging revealed the depth to which Chapela understood the performance as his opportunity to communicate his own message. Although perhaps in harmony with the NGO activists in terms of political stance on GMOs, Chapela sought to preserve his identity as a professor.[20] Dissident science may embrace repertoires of action that resemble political protest, but simultaneously attempts to maintain links with credible scientific institutions.

Black Canvas

Several months after the Open Office Hours, Chapela engaged in another performance of dissident science. The curator of a Berkeley Art Museum exhibit entitled, *Gene(sis): Contemporary Art Explores Human Genomics*, invited Chapela to participate in a panel discussion with a pro-biotechnology scientist and three artists. As the program began, Chapela's chair remained empty. Unbeknownst to the organizers of the event and the other speakers, Chapela had decided not to appear in person, but instead to have a statement read in his absence. Halima O'Neil, a student from Chapela's department, carried in a large black canvas to rest in Chapela's chair. When it was Chapela's turn to speak, the moderator proceeded to read aloud the

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[18] Interview, 25 June 2003.
[19] Interview, 21 October 2004.
[20] Gieryn's (1999) theory of boundary-work highlights the strategic costs of scientists aligning themselves with 'non-scientific' allies such as activists. Dissenters face controversy over not just the veracity of their claims, but the culturally negotiated maps that define membership in realms of credibility.

manuscript, entitled ‘Black Canvas’ (Chapela & O'Neil, 2003). The reading began with a polite, yet sarcastic introduction:

> I am thankful for the efforts to get us to talk, thirty years into the age of the transgenized biosphere, about what it is that we have been doing to ourselves, to our medicalized, medicated ecology, in this last quarter-century. As if we had any idea about it. I am thankful for your unjustifiable trust in my knowledge of microbial ecology, as if that knowledge really gave me anything to say about the cultural consequences of the transgenization of our internal and exterior environment.

Chapela went on to accuse two of the exhibits as hoaxes—artistic renderings that gave the illusion of scientific accomplishment—and then proceeded with a complex interweaving of famous historical works of art and three Spanish words to make claims about the social project of biotechnology. He closed by justifying his absence in terms of the *Gene(sis)* exhibit’s bias toward the promotion and celebration of biotechnology: ‘Much as I would have liked to paint with you … I was handed a black canvas upon which my colours cannot play …. I believe my absence is useful, and perhaps forgivable in its impolite inability to dialogue with you today’. During the question and answer session, some audience members harshly criticized Chapela’s physical absence—taking offense and questioning his commitment to the issues at hand.

Pulse of Scientific Freedom in the Age of the Biotech Industry

Three months after Black Canvas, Chapela staged another performance of dissident science: a public forum at UC Berkeley entitled, ‘The Pulse of Scientific Freedom in the Age of the Biotech Industry’ (hereafter, the Pulse Event). Three other dissenting scientists appeared on stage with him: John Losey, the Cornell entomologist who published the infamous study showing the potential for GM corn pollen to kill monarch butterflies (Losey, et al., 1999); Arpad Pusztai, a senior scientist from the Scottish Rowett Institute who was sacked after announcing that his rat-feeding experiments with GM potatoes showed immune suppression and other disturbing health effects of genetic modification (see Arthur, 1998; Ewen & Pusztai, 1999; Rowell, 2003); and Tyrone Hayes, a UC Berkeley biologist whose research demonstrated toxic

effects of atrazine, a major herbicide produced by Syngenta, a large biotechnology firm (see Hayes, et al., 2002b; Hayes, et al., 2002a; Blumestyk, 2003; Pierce, 2004). Chapela and his guests thus had all published research that challenged the health or environmental safety of products commercialized by the agbiotech industry, and each told his story of attempts by industry and government to suppress or discredit his results. Their discussion attracted a live audience of nearly five hundred, and the event was webcast around the world in real-time.

The scientists on the Berkeley stage sought legitimacy for their research in a public venue, but it was not an evening of fact-building in the traditional sense. Nor was it an evening of like-minded, marginalized scientists discussing their current work and recommending important directions for future research in assessing the risks of agbiotech. Instead, by focusing on the broad notion of *scientific freedom*, the Pulse Event argued that the political and economic momentum of the agbiotech industry had suppressed and discouraged contrarian science. This assertion offered an alternative explanation for the harsh treatment of the four scientists' research other than as proper policing of the boundaries of credible science. As a self-conscious strategy to showcase patterns of scientific suppression, the Pulse Event argued that powerful social forces had interfered with the 'normal' practice of science, nearly producing scientific martyrs.

Michael Pollan, a recent addition to UC Berkeley's journalism faculty and a well-known contributor to *New York Times Magazine*, introduced the Pulse Event (for examples of his writings on biotechnology, see Pollan, 1998, 2001b, 2001a). Pollan framed the discussion within the context of the growing intolerance of dissent and diversity in American politics, mentioning, for example, how the Dixie Chicks (a musical group) were 'excoriated' for criticizing President Bush. Pollan guided the audience both to sympathize with the panelists and to view their

scientific controversies in a broader political context.[21] In great theatrical style, Pollan introduced the panel as the 'Dixie Chicks of the Life Sciences'.

While each of the four scientists exhibited both agonistic and dissident behavior during the Pulse Event, my focus within this article remains on Chapela. Speaking after his guests, Chapela announced that he would avoid talking about the specifics of his work, and would instead try to 'transcend' these stories. Chapela also refrained from discussing the details of challenges to his work (a key topic for Losey, Pusztai, and Hayes) or the peculiarities of his bid for tenure.[22] Instead, he described himself as 'an academic mutt' and celebrated his experience as a scientist who had worked with NGOs, industry, and indigenous communities. He spoke of his enthusiasm for his interdisciplinary department that challenged the rhetorical boundary between science and politics, 'where people are actually proposing that you can do science, and you can do serious thinking about that higher level of problems, that politics are part of science, that policy is something we can think rationally about'. This portrayal focused on shifting the frame of conversation away from personal stories of suppression and toward the historical and political context for suppression.

To this end, Chapela described two historical developments to situate the Pulse Event conversation, referring to them as two 'tragedies'. The first dealt with his perception of the changing discipline of biology 'that is being narrowed, channeled down to just one way of looking at the world'. The second tragedy addressed the withering of the public university as an institution that harnessed science for the public good: 'We are watching … the loss of an

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[21] Pollan commented, 'What we don't know is how many others have been silenced or intimidated into simply not asking troublesome questions, not designing controversial experiments...My fear…based on my own experience as a journalist…is that the population of such scientists is large and growing.'

[22] Chapela did take the opportunity to announce publicly that the administration had officially denied his tenure (bringing an audible hiss among the live audience). Coincidentally, *Nature* had just released their online version of the next day's journal that included a news article extremely critical of Chapela's tenure review and decision (Dalton, 2003). Subsequently, Chapela filed both a formal appeal and a multi-pronged lawsuit (Dalton, 2005b); in response, the university eventually reversed its decision and awarded Chapela tenure, retroactive to June 2003 (Dalton, 2005a).

intellectual commons—a public sphere, that used to be, that has been paid by the public for many many years'. Borrowing from the *Nature* article that detailed the break of confidentiality in his tenure case (Dalton, 2003), Chapela asked how a place such as UC Berkeley could become 'hijacked so easily?' He referred to his university as a 'ship of truth seeking … that is being looted and pirated left and right', asking whether it had been adrift, vulnerable to pirating, or just in need of repair. He rejected these passive explanations and offered:

> I would claim that this is a ship that has been purposefully and consciously captained and steered into the shoals where it can be pirated. I would posit, and I know that this is uncomfortable for many of us, but we have been too much of a willing crew. I think it's really easy to go after Novartis and Monsanto, and we should go after them because they deserve it. But there is a cultural opportunity that we give, that we make possible for them. It's not Monsanto, not Novartis that took my tenure away. It's us. There's something intrinsic in the institution.

This passage and Chapela's subsequent call for a public 'rudder' for this ship captured the complexity of his argument. Chapela made it clear that the cause of the loss of scientific freedom was not simply improper external intervention by Novartis and Monsanto. He argued instead that we—the professors, the students, and the public—had neglected our duty to hold science accountable.

Strategies of Dissident Science

Chapela's performances of dissident science spoke to his credibility as a professor and scientist in the context of an opposing and dominating scientific trajectory (at the level of critique). While none of the three events engaged deeply with the technical aspects of the *Nature* letter, each argued for contextualizing this "scientific" controversy in order to undermine the impedance that Chapela had faced—a non-agonistic strategy to restore legitimacy. In addition, the events challenged conventional relationships among science, politics, and publics (at the level of meta-critique). As such, his actions represented both strategic defenses of contrarian science and institutional interventions that carried political and professional risk. These are the stakes of dissident science.

Expose the Opposition

The first dissident strategy involves intentionally exposing challenges to the legitimacy of contrarian scientists and their work. Creating a narrative that discredits impedance on the basis of its origin, character, or severity differs greatly from the expectation that scientists would respond to attack with yet harder 'facts'. For example, the metaphor of the 'open office' served to expose the closed, secret, and presumably illegitimate impedance to Chapela's tenure. At the Pulse Event, although Chapela did not dwell on the particulars of controversy over his research, the act of gathering four dissenting scientists on one stage—linked primarily by the implication that similar forces had impeded each of their work—followed the strategy of exposing a distinct pattern of opposition.

In one sense, this rhetorical approach differs little from attacks on contrarian scientists that focus on their identities and affiliations rather than the quality of their scientific claims. Dissident scientists employing this strategy thus jeopardize their public status as above the ignoble practice of mudslinging. The strategy holds promise, however, by appealing to an audience beyond the scientific community with a narrative of justice and fair play. Revelations that taint the motive or source of impedance not only reduce the demand for technical responses to particular criticisms, but also begin to frame the social context as so stacked against contrarian science that the entire field of impedance becomes discredited—despite protests from particular opponents who wish to claim that *their* critiques come from appropriate and unbiased perspectives (see, for example, Kaplinsky, 2002).

Make Politics Explicit

A related strategy involves making the political context of science more explicit, without necessarily focusing on particular examples of impedance. This carries a slightly lower risk of creating the impression of a scientist resorting to politics in self-defense. For example, Gieryn

(1999) describes the career of Sir Albert Howard who advocated an intensive organic model for Indian agriculture. What began for Howard as both an effort to improve agricultural productivity and an intellectual struggle against a scientific community immersed in a chemical model of agriculture, gradually became an explicitly political fight against industrial agriculture. This transition from scientist to 'science-statesman' demonstrates the propensity for dissent to reveal the embeddedness of science within larger political economies.

Black Canvas included many similar references to the corrupting influence of biotechnology corporations on the science produced inside and outside of industrial laboratories. Chapela's manuscript, read by the panel moderator, made the additional jump to claim that this influence had even permeated a local police force:

> Earlier this year in St Louis Missouri, Monsanto's town, I sat in a panel at the Biodevastation conference next to an empty chair. Sarah Bentz, who should have been there to speak, had been picked up - together with more than twenty others - by the City Police on her way to the conference, eventually charged for carrying her vitamin C in her pocket. (Chapela & O'Neil, 2003)

Statements such as this suggest an overwhelming climate against contrarian science in agbiotech without directly attacking challenges to particular research. Nevertheless, it remains a dissident move by framing science as explicitly circumscribed and permeated by political concerns.

Expand the Network beyond the Scientific Community

While recruiting additional allies with scientific credibility remains an agonistic move (for example, providing citations in rebuttals), Chapela reached well beyond the scientific community for support. From one perspective, this strategy represents nothing more than building power through an extended network. More critically, however, such moves challenge the narrow definition of scientific legitimacy, as defined in conventional scientific circles, by incorporating other sources of expertise to build credibility.[23] For example, Chapela announced

[23] Epstein (1996) traces the complementarities between activism within the early AIDS movement and the scientific community's attention to dissenting opinions about the aetiology of AIDS.

his Open Office Hours at a dinner hosted by the International Forum on Globalization as part of an activist-led protest to the USDA's ministerial meeting on agricultural technology in Sacramento in June 2003. His written announcement, emailed later that night, represented a collective process of writing with colleagues and friends in the social sciences and humanities.[24] In an interview the month before the Pulse Event, Chapela described the support network he had cultivated:

> [T]hese organizations are coming out to provide precisely an umbrella to be able to speak under …. Most whistleblowers die, but not all. I do see a very big difference between myself and people like Pusztai or even John Losey … and the difference is that I've been active in the world of NGOs, in the world of activism, outside academia, in such a way that when I become a whistleblower, if you want to call me that, within academia, I have a network to fall back onto without dying, where I don't become dead morally. ... If I was relying only on my colleagues here [inside the university] for moral support, I don't know where I would be.[25]

Thus, Chapela drew a connection between the ability to be an effective dissenter (or whistleblower, in his terms) and a support network that transcended the conventional scientific community.

Tension over unconventional networks of support for dissenting scientists has the potential to create a positive feedback loop. If impedance originates within the legitimate scientific community, and dissenters respond by recruiting non-traditional allies, those new connections can serve as further evidence to fuel impedance *based on those affiliations*. For example, in responding to charges of conflict of interest, an author of one of the critiques in *Nature* brought up Chapela's position as a board member of the Pesticide Action Network-North America as an indication of potential bias (Kaplinsky, 2002). If such accusations further marginalize the dissenter, he may seek more protection and support from realms outside of the scientific community. In this way, dissident behavior can become self-reinforcing, a pattern especially apparent in the Chapela case.

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[24] Interview, Ignacio Chapela, 30 June 2003.
[25] Interview, 6 November 2003.

Involve the Public (Autonomous Boundary-work in Reverse)

Gieryn's (1999) typology of boundary-work includes the practice of scientists defending their autonomy to define realms of inquiry as belonging to the domain of science, thus positioning themselves as the key experts to choose questions, conduct research, and draw conclusions from evidence to produce 'truth'. Indeed, many scientific institutions reinforce this boundary between scientists and laypersons that keeps the public in a dependent, non-participatory relationship with science (e.g., tenure processes, scientific advisory boards, peer review, governmental funding requirements). Conversely, taking the previous strategy of expanding networks of support to the extreme, dissident science can appeal broadly to concerned citizens. This potentially *weakens* the boundary of scientific autonomy by involving the public actively in knowledge production.

Chapela's response to a question during an interview about the meaning of democratizing science reveals the complexity of boundary-work involving the public in science-making:

> [With regard to]'democratizing science', I would turn it around a little and say it's more about incorporating science and scientists into the operation of society. We have worked for many years in exactly the opposite direction … building this myth into the training of a scientist, that says that whatever crosses your imagination is fine …[and has] nothing to do with your life experience, your state in life, and your connection to other people.[26]

Chapela thus challenged the mythical notion of scientific freedom unfettered by connections with or responsibility to anything other than curiosity (see Polanyi, 2000 [1962]). In effect, he argued for re-embedding scientists in a social context—*reducing* their autonomy from the public—in order both to counterbalance the growing connections between corporations and scientists and to align the practice of inquiry with identities that emerge from community. At a deeper level, this approach denied the possibility of scientific autonomy in the Polanyian sense and argued that the

[26] Interview, 5 November 2004.

relevant question was not primarily the degree of absolute autonomy but rather *which* connections scientists had to various communities.

In November 2004, Chapela held a fundraising event to launch the Pulse of Science Fund. Much like the environment he created at the Open Office Hours, he aimed for a participatory experience rather than coming 'to get something, or just give money'. The program allowed for extensive conversation; pads of paper were displayed for the contribution of ideas; attendees had unsupervised access to his tenure case file; and poster displays showcased the various events he had organized. He recalled:

> What I wanted to achieve was to be able to show a track record ... I think people started getting the feeling that, oh, so that little thing he did with the canvas thing [Black Canvas], and that little thing he did with the brochures there, and sitting outside the chancellor's office [Open Office Hours], are not disarticulated. They're actually part of—it's becoming like a track record of publications. It's part of my vitae.[27]

In considering his public actions as part of his professional curriculum vitae, Chapela revealed deep assumptions about the role and judgments of the public in providing legitimacy. The traditional boundary of scientific autonomy would make such a presentation not only professionally irrelevant but *irreverent*, by supposing that laypersons had the capability and right to engage with the practice of science-making.[28]

Adopt Repertoires of Social Movements

Many of Chapela's actions had great resonance with social movement tactics. His Open Office Hours, although framed as 'office hours', resembled a five-day vigil. The *Daily Californian*'s headline to describe the event certainly echoed this perspective: 'Professor Camps Out in Front of California Hall in Protest' (Wittmeyer, 2003). Black Canvas also reflected the

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[27] Interview, Ignacio Chapela, 3 December 2004.
[28] Likewise, Gieryn (1999) describes how Sir Albert Howard engaged a 'populist epistemology' (p. 330), turning to the public as a new source of scientific credibility.

strategy of protest—refusing to participate as expected and instead arranging for a performance that critiqued the entire exhibit as a corrupted context for conversation.[29]

On 9 December 2004, with his tenure officially denied, his contract extension ending at the close of the semester, and awaiting the results of an appeal of the tenure decision, Chapela taught his presumed last class as a UC Berkeley professor. Supporters packed the room, announced plans to submit petitions and demands to the administration, and donned colorful armbands. From the classroom, the mix of students, faculty, and concerned citizens marched to the front of California Hall and rallied with signs, chants, and speakers protesting the impending loss of Chapela as a faculty member. It was clear to participants in that event that a campaign was being waged to overturn the denial of tenure and that Chapela was a central figure rather than simply the object of a social movement surrounding him.

While adopting social movement repertoires creates opportunities for building diverse sources of power that may influence the context and practice of science, this extreme departure from agonistic engagement carries high risks in terms of undermining legitimacy. For example, *Nature* used the word 'rally' to describe the Pulse Event (Knight, 2003).[30] Chapela had aimed to stage the Pulse Event with a high degree of scientific and political legitimacy, but an editorial decision—perhaps a misunderstanding, perhaps reflecting political bias, perhaps based upon historical knowledge of Chapela's actions—re-framed the event for *Nature*'s readers as belonging squarely within a social movement. This upset Chapela, not because he would refuse

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[29] Although beyond the scope of this paper, social movement theory offers many resources to understand how and why particular forms of protest emerge within certain social contexts—focusing, for example, on political opportunities for mobilization and influence, mobilizing structures, and framing processes (McAdam, et al., 1996; Meyer, 2004). While these conceptual tools have been developed primarily for analyses of organizations and coalitions, one could apply such ideas to an individual scientist's repertoire of action.

[30] This upset Chapela enough to contact Jonathan Knight, the author of the article, to question his use of the descriptor (Interview, Ignacio Chapela, 13 January 2004). Knight responded that he had not, in fact, used the word 'rally' in his submission to his editor. Knight admitted that he was shocked at the word choice and knew instantly that it would upset readers who supported Chapela. Knight explained that the short turnaround time of publication prevented the standard practice of an author seeing a copy of the edited article before publication, and he hypothesized that his editor had simply made a misinformed choice. He emphatically defended the integrity of *Nature*'s news division (Interview, Jonathan Knight, 2 June 2004).

to participate in a rally, but because he understood that the language of activism could undermine scientific credibility among the readers of *Nature*.

Shift the intellectual terrain of debate

A key feature of dissident science involves shifting the intellectual terrain of debate from controversy over technical facts to a challenge of the very institutional boundaries and power structures that define scientific legitimacy. In this sense, dissident science synthesizes intellectual struggle and social action. Chapela's actions display at least four moves that attempted to redefine the landscape of his particular controversy. These moves, while strategic, exhibit a certain tension. They imply the need for protecting contrarian science from outside encroachment (in praise of autonomy), even while Chapela's dissident tactics function *outside* the boundaries associated with the institutional autonomy of science.

Move #1: *The academic-industrial complex hinders the production and dissemination of contrarian science.* By gathering four contrarian scientists together whose stories of impedance constantly made reference to the tight relationships between the biotech industry and scientific organizations, the Pulse Event implied that the academic-industrial complex had serious implications for the practice of contrarian science.

Move #2: *Creating space for contrarian science is an issue of academic freedom.* Both Pusztai and Chapela used the term 'academic freedom' in relation to their perception of improper challenges to contrarian research (Pusztai, 2000). This rhetorical move shifted attention away from questions around the technical quality of their work to the patterns of impedance across the field of contrarian science in agbiotech. The risk of this strategic shift involved appearing to be unwilling to engage the technical details and stand up to the organized skepticism expected within the scientific community.

Move #3: *The politics surrounding agbiotech cannot be disentangled from the practice of science.* The Pulse Event as a whole foregrounded the national trend toward intolerance of dissent as relevant for understanding the impedance to contrarian science in biotechnology. This type of dissident claim runs the risk of upending the essential status of science—the view that science is trustworthy by consistently remaining well-insulated from economic and political pressure.

Move #4: *The boundary separating the public from science-making has become problematic, both from a political point of view and from the perspective of the quality of knowledge production.* Chapela worked to draw the public, or at least segments of non-credentialed scientists, into his work. He emphasized this theme in his critique of the public university as adrift because of a lack of public accountability. Beyond complaining, however, Chapela came to advocate for safe spaces for the public and science to intimately connect. Beginning with the symbolic and discursive space of his Open Office Hours, developing further during the Pulse Event, and culminating in the launch of the Pulse of Science Fund, Chapela envisioned ways for the practice of science to occur within the context of communities:

> **Pods, cocoons and other places**. [bold in original]
> On November 21st, I will announce the creation of a space of support [the Pulse of Science Fund], quite simply, of uncompromising questions and their questioners (that which some of us understand as Science). In the absence of a university able to confront a time of catastrophic loss in diversity, I want to weigh in not by advocating reform, but by helping build safe spaces where inquiry could take place. (Chapela, 2004)

Chapela thus attempted to create new institutional spaces for his vision of science connected to oft-excluded publics.

Discussion

This article has begun to articulate the emergence and heterogeneity of scientific dissent, focusing upon the conceptual categories of agonistic engagement and dissident science. Agonistic engagement respects conventional norms of scientific discourse and involves

producing additional facts, assembling the support of scientific actors and institutions, and emphasizing the importance of disciplinary boundaries in assigning expertise. Dissident science integrates struggles over scientific authority with social action to reconfigure relationships among science, politics, and publics. Table 1 summarizes some of the key differences that emerge from this framework.

Table 1: Agonistic Engagement vs. Dissident Science

	Agonistic Engagement	**Dissident Science**
Source of epistemic authority	Adherence to norms of scientific community.	Ability to expose biased assumptions of mainstream science and convince a diverse community of scientists and laypersons of the significance and credibility of contrarian research.
Negotiating the boundary of scientific credibility	Respects the boundary where it is, attempts to demonstrate that contrarian science belongs within that boundary.	Challenges the enforcement of the boundary as corrupt, although does not challenge the absolute need for such a boundary. Attempts to introduce other factors to determine credibility beyond technical measures (e.g. institutional context, affiliation).
View of public	Eventual consumer of science.	Force of accountability, participant in setting priorities, jury for politicized controversies.
View of politics	Political interference in the practice of science should be minimized. Science and politics should be segmented (temporally, institutionally), with scientific results informing political decision-making.	Politics permeates science; calls for segmentation are rhetorical, not practical.
View of scientific freedom	Classic. Scientists should be free from contextual constraints as they conduct their research. Applying this norm as a lens to view controversy can uncover ‘interest-based science’, science that has been corrupted by its association with a particular politics.	Complex. The quest shifts from eliminating ‘outside’ interests to embedding science in institutions organized to promote the public interest. Transparency and participation become paramount in lieu of erecting ever-stronger boundaries between science and publics.
Impact of intellectual suppression	Force of marginalization that must be countered with facts.	Fuel to the fire of controversy that must be countered with stories and facts.

	Agonistic Engagement	**Dissident Science**
Role of activism	Detracts from scientific credibility.	A social force that can and should be integrated with science-making, especially as a counter-balance to other sources of power in society (corporate interests, for example).

While the Chapela case suggests that scientists enjoy a degree of flexibility in drawing from these two categories of dissent, each represents a degree of coherency, both in terms of strategy and philosophical stance.[31] Further work might address the personal and contextual motivations for pursuing agonistic engagement or dissident science, question their relative efficacy in different circumstances, and explore dissenters' abilities to move back and forth between divergent strategies during episodes of controversy.

While this article presents scientific dissent as a kind of boundary work (an attempt to move persons and claims within a boundary of scientific credibility), boundary work also emerges in the struggle to designate dissenting strategies as proper (e.g. 'rational', 'normal', 'fact-based') or improper (e.g., 'activist', 'bought-and-paid-for', 'party-line', 'ideological'). The location of this boundary is a matter of social construction and contestation in the same way that actors attempt to differentiate modes of impedance as acceptable or egregious depending on contextual understandings and strategic goals. Rhetorically, all parties tend to essentialize science to some degree as a trusted path to knowledge, seeking to insulate scientists from corrupting influences (whether activist, ideological, or industrial). What differs, however, is the treatment of dissidence, named as such or implied. For example, supporters *and* opponents of

[31] Allen (2004) offers a fascinating comparison between two scientists who adopt contrasting strategies, loosely corresponding to my categories of agonistic and dissident science, in their efforts to protect a Louisiana community from a toxic waste site: one whose 'version of public science includes actively constructing networks and alliances that intentionally blur the boundaries between local and cosmopolitan knowledge as well as between science and politics' (p. 437), and the other who refused to participate in the citizens' lawsuit because she did 'not want her objective science to be tainted by the appearance of bias' (p. 441). Allen's analysis shows how agonistic and dissident strategies can emerge on the same 'side' of an issue, but also create conflict and even undermine one another in practice.

Chapela categorized him as dissident (as having infused his science with politics). For his supporters, this was socially responsible, as it exposed the corruption of the current academic-industrial complex—dissidence being required to overthrow the regime.[32] For his opponents, however, dissidence was scientific treason—a departure from scientific discourse for political ends that undermined the authority of science broadly.

A comprehensive discussion of the relationship between politics and science (whether mainstream, contrarian, or dissident), and scientific legitimacy is beyond the scope of this paper, but a few words are in order. Broadly speaking, I would suggest that the alignment of scientific orthodoxy with dominant political and economic forces may render invisible the politics of mainstream science. For example, molecular biologists who collaborate with agbiotech companies seldom face charges of conducting politically-motivated science. Yet, these collaborations are no less political than the anti-toxics movement or the organic agriculture industry; the latter, however, are more likely to surface as markers of noteworthy political affiliation among agricultural scientists.

An underlying double standard exists: mainstream science, when linked to mainstream politics, may simply appear apolitical.[33] This has tremendous significance for understanding the enactment of scientific controversies in politically-charged arenas such as global warming, environmental justice, and genetic testing. The power dynamics (economic and political) that

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[32] In his work on water fluoridation controversies, Martin shows the flipside of this narrative. Pro-fluoridationists, who represent the mainstream and consider anti-fluoridation science a ruse for ideologues, accept and promote the duty of pro-fluoridation scientists to engage in political campaigns. They justify this apparently paradoxical stance by referencing the existence of anti-fluoridation campaigns that demand a *political*, not just a scientific, response (Martin, 1991: 62).

[33] Brian Martin called attention to this idea in comments on an earlier draft of this paper. He offered the timely example of how state terrorism remains a virtual non-topic in comparison to the historically much less deadly non-state terrorism (also see Martin, 2007: 162), which has become a major research focus across many disciplines with the national investment in 'Homeland Security'. 'The underlying theme is that being aligned with power is acceptable, even admirable, because the powerful are the good guys (or have truth on their side, in the case of science), whereas doing the same things as a challenger is terrible' (Brian Martin, personal communication, 14 August 2006).

surround such controversies create an uneven landscape not just for the emergence of contrarian science, but also for the practice and judgment of scientific dissent.

Central to this dynamic between power and the production of knowledge is the struggle to separate science from politics, and scientists from publics. The move from agonistic engagement to dissident science challenges the classic and perhaps manufactured viewpoint that such a separation is both desirable and possible. Accordingly, the dissident perspective claims the political as deeply entwined with the practice of science on multiple levels—respecting the political context in which science making occurs, acknowledging the 'internal' politics of negotiating legitimacy among scientific actors and institutions, and heeding the political implications of scientific results (for example, knowledge, ignorance, or technology). With appeals for measured public involvement, dissident science alters boundaries between experts and laypersons in the production of knowledge. The agonistic perspective fears this as a pollution of expertise, but dissident science envisions expertise less as a container to be protected than as a fiery social process of integrating fact and value struggles.

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