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AGRICULTURAL BIOTECHNOLOGY, CORPORATE HEGEMONY,
AND THE INDUSTRIAL COLONIZATION OF SCIENCE

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

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* * * * *

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2002

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In 1942, Merton codified the normative structure of science as consisting of universalism, organized skepticism, disinterestedness, and communalism. Drawing on Etzkowitz’s (1989, 1996, etc.) arguments that a normative transformation has been occurring in some fields, this study examines the impacts of the relatively recent and massive increase in research funding from the private sector on the pace, path, and products of scientific research in agricultural biotechnology.

Krimsky et al. (1991) and Blumenthal et al. (1986a; 1986b) have shown that academic-industrial ties are notably high in agricultural biotechnology, thereby making it an ideal case for examining the impacts of industrial involvement on the subject and practice of science. Data for this study is thus based on 24 intensive, semi-structured interviews with prominent scientists actively involved in the public and scientific debates surrounding the field. Informants were sought whose situated knowledge could best speak to the question of the impacts of industrial involvement on the scientific ethos. This purposive sample provides a spectrum of perspectives on industry’s impact, and is representative of the realm of meanings surrounding agricultural biotechnology.

Findings demonstrate that all respondents, whether proponent or opponent of the current development of agricultural biotechnology, recognize that their field is in many
ways driven by commercial concerns. Specific factors explored in detail include: (1) ambivalence regarding industrial capital and resources; (2) frustrations regarding the marketing and promotion of the products of agricultural biotechnology; (3) the degree to which profit and commercial concerns are driving the science; (4) problems associated with the proprietary nature of the science and technology; (5) structural mechanisms of de facto censorship; and (6) problems associated with the emerging "academic-industrial complex."

This study verifies Etzkowitz's arguments that a normative transformation is occurring in science. Specifically, it seems clear that former boundaries between the two institutions are no longer being maintained, and disinterestedness and communalism are increasingly disappearing as elements of the scientific ethos. This is indicative of industrial colonization. Rather than a relationship of reciprocity and mutuality, the industrial definition of the situation is overwhelming the scientific. Other consequences for science include, but are not limited to: a loss of public legitimacy as an industrial program of research presents itself as a purely scientific endeavor; and stagnation at a relatively early level of biotechnological development due to the constraints of intellectual property. Recommendations are made for adaptations the university must make in order to sustain a vigorous program of research without sacrificing the scientific ethos to the demands of capital.
Dedicated to Jessica Maguire,
with whom I have tread this path.
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CHAPTER 1

INTRODUCTION

ENGINEERING FOOD, ENGINEERING COMPLIANCE:
CORPORATE HEGEMONY IN AGRICULTURAL BIOTECHNOLOGY

Put in its most bald form, the question is whether what has come to be called biotechnology will poison the well from which it sprang – academic science.

—Clifford Grobstein (1985:55)

A. 2 ½ Minutes of Honesty or Folly: The Case of Arpad Pusztai

On 10 August 1998, internationally-distinguished researcher Arpad Pusztai appeared in a 150-second interview segment on the British television show, “World in Action.” As one of the world’s leading authorities on lectins (a class of proteins), and with over 270 publications to his credit, he briefly discussed the tentative results of his safety studies on genetically engineered potatoes (Ewen and Pusztai 1999; cf. Kuiper 1999). Within two days, his 36-year professional career was all but over. His entire research program at the Rowett Institute (which had recently received a £140,000 grant from Monsanto) in Scotland was shut down, he was suspended and later fired, his data were seized, all his research grants—including those unrelated to the research at hand—were withheld, his
longstanding research team was disbanded, and a clause in his contract was invoked which threatened the loss of his pension if he did not remain silent for seven months. This gag order effectively prevented him from discussing his work or defending himself from the ensuing ruination of his scientific reputation by pro-biotechnology forces from around the world (Charman 2001; Clark 1999).

At the time, Dr. Pusztai and his research team were conducting the only independent scientific research anywhere in the world designed to test for either the health or environmental safety of genetically engineered crops. From a field of 28 others, he had won a $2.4 million grant to study the effects of genetically engineered lectin on rats. Biotechnologists were interested in lectins due to their pesticidal properties and thus the potential utility of inserting genes coding for these compounds into food crops. Previously an enthusiastic supporter of genetic engineering, Dr. Pusztai had not expected to find any negative results. However, three years of studies found that rats fed potatoes genetically engineered with a specific lectin developed changes in the size and weight of some of their vital organs, as well as weakened immunity. His two control groups, one fed ordinary potatoes and another fed ordinary potatoes supplemented with lectin (though not genetically engineered) showed no such results (Charman 2001; Clark 1999). Thus, he tentatively attributed the adverse reactions to the genetically engineered potatoes themselves.

When asked in the interview if the lack of safety testing for genetically engineered foods concerned him, Dr. Pusztai admitted that it did. Asked if he would eat his own genetically engineered potatoes, he said he would not, and went on to indicate that it was
unfair for people to be unknowingly testing this new technology in their own bodies (Charman 2001; see also Pusztai 2002). Later, in another interview regarding his experiences in the wake of that 2½ minute watershed in his career, Dr. Pusztai summarized that “if anyone dares to say anything even slightly contra-indicative, they are vilified and totally destroyed... If I, with my international reputation, can be destroyed, who will stand up?” (Lean 1999).

What is at issue here is not the validity of Dr. Pusztai’s research results or the rigor of his methodology; this has been amply debated by the experts in his field. Perhaps that is the only pertinent question from a biochemical perspective, but from a sociological standpoint the relevancy lies in the intense negative reaction—not from the public but by powerful financial interests—generated by this prominent scientists’ public discussion of the results of his research. After all, the scientists’ role in society has traditionally been to provide the objective, unbiased point of view, or at least to approach this goal. Intimidated from so doing, it is important to question whether the nature of science as a human activity has been fundamentally transformed.

B. Purpose of the Present Research

Some scholars have already argued that the institution of science has been undergoing a normative transformation in some fields (Etzkowitz 1989). Drawing on Merton’s (1942) pioneering codification of the normative structure of science as involving universalism, organized skepticism, disinterestedness, and communalism,1

1 These are discussed in greater detail in Chapter 2.
Etzkowitz argues that industry's increasing involvement in academic research has significantly altered these norms. Very little research, however, has explored the impacts of this transformation of the scientific ethos on the subject and practice of academic science.

Faulkner et al. (1995), Krimsky et al. (1991), and Blumenthal et al. (1986a; 1986b) have shown that academic-industrial ties are notably high in biotechnology (and especially agricultural biotechnology), thereby making it an ideal case for examining the impacts of industrial involvement on the subject and practice of science. To illustrate the current milieu under which agricultural science is practiced, Figure 1.1 shows the shift in research monies from predominantly public funds in the 1970s to predominantly private funds from the early 1980s to the present:

---

2 Furthermore, the potential ramifications of academic-industrial ties in agricultural biotechnology effect far more people than, for example, medical biotechnology. To illustrate: the products of agricultural biotechnology are intended for everyone who eats food, while the products of medical biotechnology are intended only for those who are already sick and who will consent to biotechnological therapies.
This situation should be seen as my point of departure. This dissertation will explore, through qualitative analysis, the industrial context of agricultural biotechnology and its impact on the institutions and ideals of science. Specifically, this dissertation will examine what impacts the massive involvement of industry in the development of these technologies has had on the pace, path, and products of scientific research in agricultural biotechnology.
C. A Preliminary Overview of Relationships between Industry and Science

The involvement of industrial interests in academia can be seen as a boon for certain fields of science in that it provides much-needed research funds to conduct expensive and time-consuming research. On the face of it, there need be no necessary conflict, or even hegemony, in this institutional interaction. And yet, the approach likely to be taken by industry towards academic science is dispassionately apparent in the following excerpt from *The Regulation Game*, called by the authors (two university professors sympathetic to industry) a “how-to” manual for corporations. Suggestions for controlling the content and direction of academic research are as follows:

This is most effectively done by identifying the leading experts in each relevant field and hiring them as consultants or advisors, or giving them research grants and the like. This activity requires a modicum of finesse; it must not be too blatant, for the experts themselves must not recognize that they have lost their objectivity and freedom of action (Owen and Braeutigam 1978, quoted in Ashford 1983:21).

If it is the case that such activities exist, they can be understood as *crimes against science*. Sutherland (1940) regarded crime as behavior that is harmful to society. Financial interests masquerading as disinterested science misrepresent their motivations.
and threaten to deflate the perceived credibility of science. The loss of science both as a human activity and a cultural product would constitute a great harm to society. Thus, to the extent that science is being taken over by corporate interests, sociologists should recognize this dynamic as criminal from the perspective of a social harm definition (see also Simon 2002; Schrager and Short 1978).³

While industry can hardly be faulted for fulfilling its fiduciary responsibilities to its shareholders and protecting its investments, it is nonetheless undeniable that this constitutes a considerable assault on the autonomy of science (however imperfect the actualization of that ideal may be). At the same time, although it might be unreasonable to portray those occupying corporate boardrooms as entirely devoid of sensitive thought, it is important to recognize that their thinking is necessarily constrained by their primary directive of profit maximization (Jackall 1988; Caldart 1983). Simply stated, corporate social actors are constrained by the requirements of their role position. Thus, when agricultural biotechnology firms are channeling billions of dollars into academic science annually, it is impossible not to imagine that these definitionally interested parties may be providing some direction, if not dictation, as to the nature of the questions being asked and the answers being advanced. With the growing emergence of these institutional interactions over the past twenty-five years, “the fabric of academic research could be slowly rewoven on industry’s loom” (Caldart 1983:30).

³ A comprehensive review of criminological debates surrounding definitions of crime is beyond the scope of this paper. This dissertation is primarily concerned with the impacts of industrial involvement on the subject and practice of academic science. The reader is merely invited to consider whether or not the results of these dynamics may be regarded as such for analytical purposes.
While research arrangements between industrial firms and universities are not necessarily entirely novel, "the types of university-industry relationships in biology are more varied, more progressive, more experimental, and more indiscreet than they had been in similar historical circumstances" (Krimsky 1984:3). The existence of large grants and/or contracts between industrial firms and universities is a prime example. These are not eleemosynary contributions, but financial investments. In exchange for research monies, industrial interests gain exclusive licenses for discoveries and patent rights. At the same time, faculty themselves have been entrepreneurially active in setting up their own firms to commercialize the products of their research, as well as serving on the boards of extant firms. As Krimsky et al. (1991:286; cf. Louis et al. 1989) describe the situation, "[faculty] with university and industry affiliation are becoming the rule rather than the exception... Many leaders in the field of molecular biology paved the way to entrepreneurship and serve as role models for younger faculty."

D. Importance of the Present Research

In their 1986 study on the impacts of university-industry research relationships in biotechnology on the university, Blumenthal et al. (1986b) conclude that such relationships are likely to become an enduring phenomenon in academia. Thus, they suggest finding ways to effectively manage these relationships in order to minimize any potential problems. "To accomplish this, we must first increase our understanding of the impact of [university-industry research relationships] on... university values, and the advance of science" (1366).
Despite this recommendation, very little research has been done on the nature of the impacts of industrial involvement on academic science. Indeed, theirs is one of only a handful of studies directly examining this topic at all, and there are virtually no recent studies in this regard. Furthermore, the extent of these relationships and their acceptance within academia has only grown over the past fifteen years, thereby providing a longer-term perspective. This study focuses the sociological lens on the nature of these impacts by drawing upon the lived experiences of scientists working within segments of academia heavily influenced by industry, namely, those disciplines associated with agricultural biotechnology. This approach to the topic is needed due to the relative dearth of knowledge on the ramifications of these institutional interactions.

This research is important in order to gain a more complete understanding of scientific-industrial conflicts of interest, consequent shifts in research direction, and the growing impediments to the free sharing of research findings. Moreover, this is an important area of research because the increasing comingling of science with industry carries the potential to delegitimize science in the public view. In Merton’s words, “[the] borrowed authority of science bestows prestige on the unscientific doctrine” (Merton 1973:277). Absent the maintenance of reasonable boundaries between industry and science, “such ties may indeed erode what is left of the image of the university as a detached institution able to provide relatively impartial, independent, and therefore credible expertise” (Nelkin 1984:26).
E. Scope and Limitations of the Present Research

Whereas Blumenthal's et al. (1986a; 1986b) and Krimsky's et al. (1991) studies provide an early examination of the width of the situation, this study provides a later exploration of the depth. In other words, the goal of this research is not to provide a broad survey of the dynamics of university-industry research relationships. Rather, my goal is to provide a detailed study of how the changing context of scientific practice is perceived and experienced by its practitioners. What are their perceptions of industrial involvement? What are their specific concerns and/or frustrations?

Earlier research has already been performed which demonstrates that the relationship between industry and academia is not entirely benign, and carries with it many challenges to traditional scientific values (Blumenthal et al. 1986a; 1986b). This dissertation provides an ethnographic exploration of the lived experiences of scientific social actors. It has been convincingly argued that biotechnology has spurred a normative transformation in those disciplines involved in its development (Etzkowitz 1989). What are the consequences of that transformation? What is the nature of scientific work under that transformation?

Thus, taken by itself, this dissertation may be somewhat limited in its overall generalizability. Survey-level research, drawing upon ethnographic details, is appropriate for examining the extent of the problem. That is not the goal here. Ethnographic research, supplemented by survey-level data, is appropriate for examining the permutations of the problem. That is the goal here.
F. Overview

This chapter has briefly introduced the growing industrial context of agricultural biotechnology research and provided the focus and scope of this research project. Chapter 2 provides an in-depth review of the literature on normative transformation in science and the ramifications of increasing industrial involvement. Chapter 3 provides a historical perspective on the process of the commodification of plant genetic material. Chapter 4 explicates the methodological approach taken in this research. Chapter 5 presents the findings of this research, centered around the voices of both proponents and opponents of the current development of agricultural biotechnology. Finally, Chapter 6 summarizes this research and concludes with a theoretical discussion of the implications of this normative transformation on the nature of science both as a human activity and a sociocultural product.
CHAPTER 2

GILDING THE IVORY TOWER:
NORMATIVE TRANSFORMATION IN ACADEMIC SCIENCE

If these business principles were quite free to work out their logical consequences, untroubled by any disturbing factors of an unbusinesslike nature, the outcome should be to put the pursuit of knowledge definitively in abeyance within the university, and to substitute for that objective something for which the language hitherto lacks a designation.

—Thorstein Veblen (1918:170-1)

In examining the impacts of industrial involvement on the subject and practice of academic research, it is necessary to appreciate a certain irony. The outstanding success of the university research enterprise—as exemplified by the vast expansion of the knowledge base since the early 1900s—virtually ensured that its commercial potential would not long go unnoticed by industrial entrepreneurs. In other words, the very successes of university research have fractured the ivory tower which ostensibly shields its practitioners from extra-social influences. At the same time, in order to remain globally competitive, science-based companies have had to resort to accessing sources of
knowledge and technology outside the firm, including other firms, government laboratories, and—not least of all—universities (Etzkowitz et al. 1998).

From the standpoint of the sociology of science and technology, this situation raises many questions about the normative structures of science. Science, as traditionally conceived, is alleged to be an island unto itself, driven by its own internally-generated questions and motivated by its own system of rewards. However, the increasing involvement of industrial interests in the conception, actualization, and publication of scientific research casts doubt on the assertion that science seeks only truth. Science, as traditionally conceived, is a social structure designed to maximize the possibilities of achieving this endeavor. But when science is funded by industry—not as an endowment but as an investment—then it becomes simply impossible to imagine that its questions are not driven by parties interested (and invested) in particular sorts of questions and answers. Nowhere is this more evident than in those disciplines devoted to the development of biotechnology, and agricultural biotechnology in particular.

This chapter provides an overview of the normative structure of science, followed by a discussion of normative transformation in science, the capitalization of scientific knowledge, and the impacts of industrial involvement on academic science.

A. The Normative Structure of Science

Merton's (1942) now-classic codification of the traditional norms of science has been generally understood as a reaction against the Nazi science of his period (Gieryn 1995). The colonization of the territory of science by politically-interested parties
signified for Merton "a frontal assault on the autonomy of science" (Merton 1973:268) which "led scientists to recognize their dependence on particular types of social structure" (267). The structure referred to here is the institutionalization of the scientific ethos, which Merton codified into four norms necessary for the extension of certified knowledge. Essentially, these norms patrol the boundaries of scientific autonomy, ensuring that no political, economic, or cultural intrusions compromise the conditions he argues to be necessary for the pursuit of truth.

The four social norms which constitute the scientific ethos are as follows. First, universalism requires that scientists evaluate knowledge claims using "pre-established impersonal criteria," such as current theoretical and methodological assumptions. This is intended to inoculate against biases on the basis of traits such as race, gender, nationality, and institutional affiliation. Second, organized skepticism proscribes against dogmatic assertions, urging the suspension of judgment until adequate evidence and argument become available. Third, disinterestedness channels the motivations of scientists away from self-interested or politically-interested behavior which would conflict with the institutional goal of science—the extension of certified knowledge. This norm is intended to free scientists from external influences on the direction of their inquiry. And fourth, communalism (or communism) requires that research results be shared. Intellectual property rights are limited to recognition and eponymization, and secrecy is the antithesis of this norm.

In defining science in such a manner, Merton ultimately created a set of criteria for demarcating the boundaries between science and non-science. In other words, any
knowledge-producing activity not occupying the territory defended by universalism,
organized skepticism, disinterestedness, and communalism is, in Merton’s view,
definitionally unscientific. This is a necessary assertion because, as Merton states, “[the]
authority [of science] can be and is appropriated for interested purposes” (Merton
1973:277). Thus (and to continue his example), regardless of substantive content,
interested purposes breach the regulative force of these norms and corrupt the ethos
necessary for scientific knowledge.

The “definitional tidiness” (Gieryn 1995:394) inherent in Merton’s theory of the
normative structure of science has had its share of critics, who have found fault both with
his characterization of the norms and the mechanisms of their operation (Barnes and
Dolby 1970; Stehr 1976; Latour and Woolgar 1979; Mulkay 1980; Gilbert and Mulkay
1984; Lynch 1984; Gieryn 1995). Merton’s norms are probably best understood as “the
official ideology of scientists, but only a crude indicator of their practices” (Chubin
1985:79), and this disjunction has been the basis of much critique. Of particular interest
is the criticism that Merton’s standardization of the scientific ethos has resulted in an
idealized and essentialist view of science (Gieryn 1995), and one which ignores the
processes of construction, interpretation, negotiation, and deployment of these norms.
That is to say, norms are not merely for discovery and definition by sociologists, but
available for interpretation and negotiation by actors in everyday life (Cicourel 1974).
Hence, Merton’s structural norms are not necessarily deemed invariably relevant or even
appropriate within scientific communities. There is an interactional level of
interpretation and negotiation which determines how the norm is actualized, if at all.
B. Normative Transformation in Science

The foregoing critique is impressively astute, but it leaves unaddressed the question of how the norms of science, however they are enacted, may ultimately be transformed. Etzkowitz has examined “the transformation of institutionalized expectations about how academic science is done” (1989:15). At least since the Uniform Federal Patent Policy Acts of 1980, which permitted universities to retain patents on the products of faculty research, disinterestedness and communalism have increasingly fallen casualty to what Etzkowitz terms “entrepreneurial science,” i.e., science pursued for profit, with results protected by intellectual property law. Hence, science and property, formerly independent or even opposed concepts, are becoming co-mingled concepts.

It is important to recognize that relationships between the university and industry are hardly novel. Practices such as scientific consultancy and industrial philanthropy have existed for some time. For the most part, however, boundaries between these institutional worlds were maintained. Control over the choice and direction of research topics was left to academic scientists, while control over the commercial opportunities of academic research remained in the hands of industry. Thus, aside from a few historical exceptions, the worlds of science and industry have largely been distinct.

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4 It seems a commonsense caveat to this discussion to assert that science rarely realizes its own ideals (Ashford 1983).

5 The Massachusetts Institute of Technology and the land-grant university system are notable exceptions (Etzkowitz 1989; Etzkowitz et al. 1998).
According to Etzkowitz (1989), the traditional scientific ethos described by Merton (1942) has been transforming due to external pressures such as shifts in federal funding patterns as well as policy changes regarding intellectual property. At the same time, this external context creates internal pressures to react to these changes. In other words, as soon as one institution engages in scientific entrepreneurial activities successfully, all similar institutions are suddenly compelled to either follow suit or to risk losing a potentially valuable revenue stream.

At least since World War II, industrial support of academic science constituted a small percentage of the total. However, inflation—combined with the lack of significant growth in federal research monies—created a stimulus for universities to establish closer relations with industry. This was not a mere happenstance, but a directed policy by the federal government to develop underutilized university research as an economic resource (Reams 1986). From the standpoint of the competitive imperatives of industry, financing university research became central to a strategy of renewal and growth (Goldhor and Lund 1983; Gerson 1987), and the university came to be viewed not only as a source for specialized training and expert advice, but also as a “factor of production” (Etzkowitz 1983:232). In other words, industry invests in universities (via research contracts with departments and/or joint ventures with faculty) expecting to achieve significant profit.

As already mentioned, the Uniform Patent Policy (as well as the Stevenson-Wydler) Acts of 1980 permitted universities to retain the patents on the products of federally-funded faculty research, which were theretofore owned by the federal government. From
the universities’ standpoint, then, this created a financial incentive for them to transfer knowledge to industry in the hopes of profiting from their newfound intellectual property.

Thus, it becomes apparent that structural changes in the nature of university funding facilitated a concomitant shift in the scientific culture, a normative transformation. The situation described above led an initially small number of academic scientists to form their own firms to both commercialize and further support their research (Etzkowitz 1983; Krimsky 1988). As well, universities entered into contractual partnerships with industry in order to finance the operation of the university. Hence, whereas the traditional ethos of science previously prevented such potential conflicts of interest, many administrators and academic scientists have reacted to the changing structural context and no longer consider these norms as necessary or applicable (Etzkowitz 1983).

A conflict of interest can be generally defined as an individual or organization occupying two roles, and using one role to gain an improper advantage in the other (Etzkowitz 1996), or being diverted from one group’s goals by involvement with another group (Webster and Etzkowitz 1998). Thus, as Webster and Etzkowitz (1998:63) state, “if the pursuit of disinterested knowledge is raised as the banner of the research university, then the receipt of private profit for research pursued is ipso facto a conflict of interest.” Given this, there has been an interesting transformation regarding the approach to conflicts of interest within academia. Whereas previously academic-entrepreneurial conflicts of interest were prevented by the traditional scientific ethos, today such conflicts of interest are being mitigated by a gradual process of role redefinition. Compatibility is

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6 Cf. Buttel 1989 for a challenge to the argument that biotechnology will be fundamental in revitalizing
being accomplished by transforming those norms which place academic science at odds with industrial entrepreneurship, that is, by redefining the appropriate role boundaries of the scientist. As Longino (1990:91) notes, "the overriding of epistemologically sound conventions...is simply a function of role conflict: individual scientists taking on roles governed by nonscientific values, for example, the commercial values governing the behavior of entrepreneurs."

Notably, this transformation has not occurred without opposition. To cite a prominent example, in 1980 the Harvard University administration proposed its financial participation in a firm based on a faculty members' research. This resulted in an escalating debate over university goals, the norms of science, and professional ethics (Bok 1982; Culliton 1982). The plan was ultimately dropped in 1982, but such collaborations are common today. Indeed, in 1988, Harvard University accomplished the same objective via an administrative procedure which removed the issue from direct purview by faculty. Essentially, the Harvard Corporation oversaw equity holdings in firms based on campus research, thereby leaving the academic side of the university legally uninvolved. However, given that the corporation depends on faculty to call their attention to research with potential commercial applications, the authenticity of this apparent separation is questionable (Etzkowitz 1996).

In sum, academic scientists in some disciplines have become frequently willing, even eager, to involve themselves in research programs aimed at commercialization potential. The norms of science have shifted, and even universities which had not previously
patented the products of their academic research were suddenly compelled to do so in the
wake of the soaring stock prices of biotechnology firms which originated in other
universities (Etzkowitz 1983). Ultimately, it seems that the modern research university
serves the functions not only of teaching and research, but of economic development as
well (Etzkowitz 1989), a trend that has been termed “the second academic revolution”
(Etzkowitz 1996:273).8

C. The Capitalization of Scientific Knowledge

According to Etzkowitz and Webster (1995) entrepreneurial scientists, i.e., scientists
who seek to profit from the results of their research, are no longer seen as deviating from
the institutional norms discussed above (cf. Ben-Yehuda 1986). Rather, they are
increasingly becoming the role models for their peers as capitalization displaces
disinterestedness as the background assumption of scientific activity.9 To elaborate,

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7 For example, Herbert Boyer at the University of California at San Francisco virtually became an
overnight multimillionaire after the company he co-founded, Genentech (based on work begun in his
university laboratory), went public in October 1980 and he sold some of his stock (Etzkowitz 1983).

8 The first change in the purpose or mission of the university was the shift from the professor as teacher to
the professor as teacher and researcher early in the twentieth century.

9 If this analysis is correct, then “publish or perish,” now an indicator of academic success, will
increasingly take on the additional dimension of the ‘profit or perish’ business ethic” (Markle and Robin
1985:77).

10 One particularly egregious example of the results of this normative displacement deserves mention here.
An anomalous leukemia patient was noticed by University of California researchers because he was not as
sick as would be expected. Investigating, they kept a sample of his spleen cells in culture and were thus
able to isolate an anti-cancer substance. Without informing the patient, they entered into a lucrative deal
with a private firm to manufacture this substance from the patient’s cloned spleen cells. Worse still, they
called the patient back repeatedly for “further treatment, which was actually further work on his spleen
cells in order to control the cell line for the manufacturing process” (Louis and Anderson 1998:60; see also
Caplan 1993).
whereas previously scientists achieved acclaim via eponymization (e.g., Einstein's theory of relativity), scientific credibility today "is increasingly tied to the ability to generate exploitable knowledge" (Etzkowitz and Webster 1995:487). Furthermore, secrecy in the form of partial disclosure or defensive patenting is displacing communalism as the normative approach to one's research. As Nelkin (1984:11) states, "[the] competitive situation created by the commercialization of molecular biology may be eroding the pattern of open communication and exchange of information essential in this field."

Thus, the "capitalization of knowledge" (Etzkowitz 1990), a practice that began with the appropriation and systematization of craft practices during the industrial revolution (Marx 1973), has recently begun to find its way into the halls of science.

Consequently, Merton's assertions regarding the culture of science are fast becoming something of a footnote in the history of science. According to him, "property rights in science are whittled down to a bare minimum by the rationale of the scientific ethic. The scientists' claim to their intellectual 'property' is limited to that of recognition and esteem" (Merton 1973:273). Evidence is accumulating that this boundary has quite been crossed. Scientists in many fields feel no obligation to either the norms of disinterestedness or communalism, and the long-term impacts of this normative transformation are uncertain and largely unexamined.

As Rosenzweig (1985:41) observed, "[if] language changes to accommodate new experience, it is not difficult to deduce the type of experience which underlies the term 'intellectual property.'" In other words, the concept of "intellectual property" stands very clearly at the nexus between science and capital. As originally conceived in 1793, the
patent system was designed to encourage and reward individual inventors by granting them a temporary monopoly on the marketing of their inventions. The logic behind the system reflected Thomas Jefferson's insight that "ingenuity should receive liberal encouragement," and described by Abraham Lincoln as "adding the fuel of interest to the fire of genius" (quoted in Nelkin 1984:13). Importantly, this system is grounded in the U.S. Constitution (Bremer 1985). The Fifth Amendment states, "No person shall...be deprived of life, liberty, or property, without due process of law; nor shall private property be taken for public use without just compensation." Furthermore, this generic clause is made more explicit in Article 1, Section 8: "The Congress shall have Power...[to] promote the Progress of Science and useful arts, by securing for a limited Times to Authors and Inventors the Right to their respective Writings and Discoveries."

By the 1930s, however, it was already being argued that large corporations had subverted the original purpose of patents, and were exploiting the system to accumulate patents and thereby monopolize an entire field. Recognizing this, Etzkowitz and Webster (1995) have suggested an alternative approach to intellectual property. Rather than merely protecting existing innovation, they argue that the intellectual property system should be viewed as a potential source of future innovation. This is, after all, the original purpose of patents, i.e., to encourage the dissemination of knowledge and maximize the possibilities for future innovation.

Regardless of the form in which it is actualized, the logic of patenting is central to proprietary rights. In an industry-driven and industry-dominated context, however, it is

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11 In addition to being an accomplished political philosopher, Jefferson was also a distinguished architect.
interesting to note how the logic undermines its original purpose. Innovation theory argues that technological innovation leads to economic growth, competitiveness, and employment, and hence enhances social and political stability. In order to sustain innovation, continual investment in research and development is required. Since investing research and development is costly and risky, patent protection creates the needed incentive to sustain innovation. Absent patent protection, investment in research and development is greatly reduced and economic growth collapses.

As McNally and Wheale's (1998) analysis reveals, this logic fails when applied to biotechnology. Patenting creates a temporary monopoly, which captures a particular field of invention and thereby acts as a disincentive for further corporate investment in that field. In other words, competition and investment are greater prior to the granting of a patent over a given inventive field. Once that field is patented, i.e., monopolized, the incentives for further innovation disappear. For example, Agracetus (formerly owned by W. R. Grace and Company; owned by Monsanto since 1996) was awarded a patent in 1992 by the U.S. Patent and Trade Office on all genetically-engineered cotton. In 1994, the same company won a patent from the European Patent Office on all genetically-engineered soybeans—a crop, notably, originally developed by Chinese farmers for the common good. As McNally and Wheale (1998: 313) state, "[these] 'species patents' and inventor (Krimsy 1991).

12 Indeed, it could reasonably be argued that in the same manner in which capital appropriated the knowledge of traditional craftspersons early in the industrial revolution, capital is appropriating the knowledge of traditional farmers today.

13 See Shiva (2000) for an in-depth discussion of the intersections between agricultural biotechnology and globalization. For now, realize that less than 1% of world patents are held by Third World nationals (Etzkowitz and Webster 1995).
have been likened in their effects to Ford being given a patent on the automobile." That is to say, innovation and invention are unsustainable in the absence of competition and investment.

With massive industrial investment in university-based agricultural biotechnology research, this dynamic has taken its place within academic science as well. It should be expected that while industrial funding may stimulate scientific research up to a point, it may also ultimately hinder it due to the limitations imposed by intellectual property law.

D. The Impacts of Industrial Involvement on Academic Science

Critics argue that the involvement of industry in academic science will increasingly shift research from basic to applied, as well as shift investigations from intellectual significance to commercialization potential (Noble and Pfund 1980), thereby "[casting] a shadow upon scientific objectivity" (Etzkowitz 1996:264). Others point out that there were similar fears about the consequences of government-sponsored research in the 1930s (Genuth 1987), and argue that an attitude of entrepreneurship could stimulate the advancement of knowledge as basic questions emerge from efforts at solving industrial problems. Additionally, at a pragmatic level, some have argued that industrial

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14 This parallel is imperfect, as federal funding tended to support scientific autonomy since research funds were largely controlled by committees of academic peers (Etzkowitz et al. 1998). However, as Krimsky et al. (1991) has found, and as this dissertation will further support, these peers increasingly represent not just the values of their scientific community, but the interests of their industrial collaborators as well. Nonetheless, government granting agencies are ultimately subject to the common good, at least insofar as the democratic process works (Caldart 1983).

15 For example, fundamental advances in the theoretical knowledge of semiconductor physics trace back to industrial efforts to overcome the limited capacity of mechanical telephone switching systems (Etzkowitz 1996).
sponsorship could help manage the uncertainties of government funding and create incentives for university research to be more relevant to society (see Ashford 1983).

Few studies, however, have examined the impacts of this industry-borne normative transformation on the subject and practice of academic science. A handful of older studies have examined the experiences of industrial scientists and the tension between the traditional scientific ethos and corporate culture (Marcson 1960; Kornhauser 1962; Glaser 1964; Cotgrove and Box 1970; Pelz and Andrews 1976). The general conclusion of this line of research is that while industrial scientists work under distinct conditions, where their research was largely directed by non-scientist administrators with eye toward profit maximization, their productivity and creativity did not necessarily suffer. Thus, scientific work was done, albeit outside of the traditional context of science.

More immediately relevant to the topic at hand is a pair of studies performed by Blumenthal et al. (1986a; 1986b). The following summary of their findings, supported by several others', paints a portrait of the situation created by the intensive interaction of science with industry, and prefigures some of the themes uncovered in the analyses to come.

In their first study (Blumenthal et al. 1986a), a 1984 survey of 106 randomly selected companies involved in biotechnology research, they found that 46% of these firms fund research in universities, with Fortune 500 companies significantly more likely to build university-industry research relationships than non-Fortune 500 companies. They estimated nearly two decades ago that industry funded as much as 25% of all

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biotechnology research in universities. By way of contrast, industry provided 3-4% of the total research expenditures to universities in the same period. Thus, industry provides a much greater proportion of the research funds in biotechnology than in other fields, a finding confirmed by Krimsky (1991) and Faulkner et al. (1995), thereby making it an ideal case for examining the impacts of industrial involvement on the practice of science.

Furthermore, these research investments were yielding substantial returns in terms of patent applications. Although industry-supported university research accounted for only 23% of these firms' patent applications, such industry-supported university research generated 4.2 times as many patent applications, per dollar invested, than company-based research over a five-year period.\textsuperscript{16} As well, 41% of these firms reported that their funding of university research has resulted in at least one trade secret, i.e., "information kept secret to protect its proprietary value" (Blumenthal et al. 1986b:1364), including publication in a patent application.\textsuperscript{17} The impacts of such inhibitions on the flow of scientific information constitutes a major theme of this dissertation.

Importantly, the major reason why companies invest their research and development dollars in university-based research, and not merely company-based research, is that it helps them keep current with significant new research. Secondarily, it reduces the costs of mounting research and development programs in new fields. Tertiarily—and aside from the already-discussed benefits of new licenses for products and/or processes—

\textsuperscript{16} See Blumenthal et al. (1986a:245) for caveats and limitations to these findings.

\textsuperscript{17} To obtain a patent, companies must disclose their proprietary knowledge, and patent infringement is costly to prosecute and difficult to detect. Consequently, companies sometimes prefer trade secrets as a means of protecting their intellectual property.
university-industry research relationships enhance the firm's public image and provide training and staff development for company scientists.

In terms of the impacts of these industrial linkages on the university, Blumenthal et al. (1986a) found that most university-industry research relationships were typically of a short duration (one year or less), and thus more likely to have a focus on applied research. Additionally, 32% of firms directly support (via grants and scholarships) the training of graduate students or postdoctoral fellows. One-third of these arrangements define the project that the student must work on and/or stipulate that the student must work for them during the summer or after completion of their academic training.

In a second study in 1985, Blumenthal et al. (1986b) surveyed over 1200 biotechnology researchers at 40 major universities in the U.S. This study reported that those receiving industrial support publish at higher rates, patent more frequently, participate in more administrative and professional activities, and earn a greater salary than their colleagues without industrial sponsorship (see also Louis et al. 1989).18 There is, of course, no causal link from industrial support to productivity here. What is probable is that more productive scholars were more likely to be funded in the first place.

Blumenthal et al. (1986b) also found some support for the criticism that industrial involvement in academic science may undermine the norm of communalism. Industrially-sponsored researchers were four times as likely as their non-industrially-sponsored colleagues (12% versus 3%) to report that their research had resulted in some

18 See Blumenthal et al. (1986b:1362-3) for caveats and limitations to these findings.
trade secrets. Such findings are not shared with the community of science, and it can be argued that this hinders the advance of knowledge. There is strong support of this point of view among biotechnologists: 68% of biotechnology researchers without industrial sponsorship reported that university-industry research relationships risked undermining intellectual exchange and cooperation within departments, while 44% of industrially-sponsored researchers concurred. Very significantly, there have been instances at scientific conferences in which a scientist refuses to give details of a technique because of proprietary concerns (Nelkin 1984). As one MIT molecular biologist has noted: “The atmosphere around biology department coffee pots has changed in the last few years” (quoted in Markle and Robin 1985:73).

Along this same line of concern, Krimsky et al. (1991) found that 49% of scientists on the National Science Foundation’s peer-review list of potential reviewers in biomedical sciences were affiliated with industry. This creates a potential incentive for pilfering innovative ideas to commercial enterprises. What is more, the very perception of such a threat may lead some scientists to bypass the system of peer review altogether, opting instead to directly seek commercial funds for the project. This dynamic can potentially undermine the integrity of the peer-review system. Krimsky (1984) has also

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19 Significantly, these estimates are conservative, as Blumenthal et al. (1986b) did not include schools of medicine and agriculture in the population from which they drew their sample. These schools are even more likely to have industrial involvement in biotechnological research.

20 The field of medicine has recently reacted against such conflicts of interest. In 2001, a dozen of the world’s most prominent medical journals, including the Lancet and the Journal of the American Medical Association, jointly announced that they would reject manuscripts submitted by authors who did not have control of either the data they used in their studies or the decision to publish the results (NEA Higher Education Advocate 2001).
suggested that because university-industry research relationships typically involve the most talented, prominent, and influential faculty, they carry the potential to bias the collective judgment or ethics of scientists in an entire field of research. As Longino (1990:80) describes this dynamic, "[when]...background assumptions are shared by all members of a community, they acquire an invisibility that renders them unavailable for criticism."

Furthermore, and supportive of Ashford's (1983) arguments, Blumenthal et al. (1986b) found that 30% of industrially-sponsored biotechnology researchers reported that the direction of their research was influenced by the likelihood of its commercial application, while 7% of their non-industrially-supported colleagues reported the same. Very significantly, 70% of industrially-sponsored biotechnology researchers are concerned that commercial involvement will shift attention toward applied research, and 78% of their non-industrially-supported colleagues agreed.

Growing conflicts of interest exist at the level of government as well. According to Krimsky et al. (1991), 37% of biologists or biomedical scientists in the National Academy of Sciences had formal ties to companies. This is cause for significant concern, as the National Academy of Sciences plays a major consultative role for Congress and other government agencies. Members frequently serve on panels charged with evaluating the health and safety concerns of new products or technologies. With such a preponderance of interest in the success of certain technologies, the voice of scientific objectivity is increasingly heeding the whispers of industrial interests.
These documented tendencies toward greater secrecy and interestedness in industrially-sponsored academic research demand deeper investigation. Krimsky’s (1991) research postulates that the profit motive is having an effect on the direction of research. This is consistent with Longino’s (1990:91) critique that “constraints...imposed by commercial requirements will surely produce a body of scientific knowledge that is different from what might have been produced under a different set of circumstances.” Webster and Packer (1996) have shown that commercial interests shape the speculations made in the concluding section of papers21 in order to ensure that no future patent application may be compromised. As Nelkin (1984:29) argues, “[problems] of secrecy and proprietary rights are inherent in these new relationships and hold serious implications for both academic science and the public interest.”

Aside from these critiques, however, there have been few studies exploring the ramifications of the growing association between academic science and industrial entrepreneurship. Moreover, most of these studies are between one and two decades old, and the present provides an opportunity to examine the results of industry-academic relationships over a longer term.

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21 Similar to this dynamic, a recent article in The Chronicle of Higher Education discussed a 1998 analysis of fifteen years of papers on secondhand smoke. The authors found that 94% of authors with some connection to the tobacco industry concluded that secondhand smoke was not harmful, while only 13% of authors with no link to the tobacco industry came to the same conclusion (Guterman 2002). It is not unreasonable to suppose that this dynamic is generalizable across industries and disciplines.
E. Summary

This chapter has shown how the success of the university research enterprise has led to increasing interest and investment by industry in the products of scientific research. This dynamic has fueled a transformation in the normative structure of science. In particular, Merton's (1942) norms of disinterestedness and communalism are becoming difficult to sustain in the presence of financial interest and intellectual property law. With a few notable exceptions (Blumenthal et al. 1986a; 1986b; Krimsy et al. 1991), very little research has looked into the impacts of this normative transformation. This dissertation addresses this shortcoming.
CHAPTER 3

PATENTING PATTERNS OF LIFE:
BIOTECHNOLOGY AS A TOOL OF CAPITAL ACCUMULATION

Technology reveals the active relation of man
to nature...[and] the mental conceptions
which flow from those relations.

—Karl Marx (1967)

Whereas the previous chapter revolved around the capitalization of scientific knowledge, this chapter discusses a related process: the capitalization of genetic material, and in particular the seed germplasm. Accordingly, this chapter begins with definitions, followed by a brief history of biotechnology, continues with the social context of agricultural biotechnology research, and ends with the commodification of seed germplasm.

A. Biotechnology Defined

Biotechnology is broadly defined by the Congressional Office of Technology Assessment (OTA 1984) as “any technique that uses living organisms (or parts of organisms) to make or modify products, to improve plants or animals, or to develop
microorganisms for specific uses.” With this definition, biotechnology can be understood to encompass human activities millennia old, including the fermentation of beer, the making of cheese, the baking of bread, and selective breeding. The ostensible antiquity of biotechnology, however, should be understood along with the fact that Webster’s (1996) dictionary dates the actual word around 1940-45, and that, according to Barben (1999), the term was first used around 1920. Hence, such an inclusive definition creates an impression of continuity with the past rather than an accurate articulation of its precise contemporary meaning.22

We can arrive at a more useful definition by way of distinction from what biotechnology is not. Differentiated from traditional plant breeding, which primarily uses sexual reproduction to generate and select for desired traits, agricultural biotechnology reduces plants to their molecular components and then attempts to transform plants by reformulating their molecular structures and functions (Busch et al. 1991).23 With this distinction in mind, the claim that biotechnology is millennia old is simply false and misleading. In truth, the techniques of modern biotechnology were perfected no more than thirty years ago, and the science behind it was begun eighty or so years ago. It is to this history that we now turn.

22 Disagreement over this definitional legerdemain was evident at a 1984 conference on “Biotechnology: Long Term Development,” in which European scholars emphasized its steady development (thereby minimizing the historical uniqueness of recombinant techniques), while American scholars emphasized the historical discontinuity of recombinant techniques (Markle and Robin 1985).

23 Blumenthal et al. (1986a) offer a technical definition of the “new biotechnologies” (and these are not limited to agricultural biotechnologies) as including “recombinant DNA technology, monoclonal antibody technology, gene synthesis, gene sequencing, cell or tissue culture techniques, fermentation technologies, large-scale purification, and enzymology” (242).
B. A Brief History of Biotechnology

In order to comprehend the current situation regarding biotechnology, it is necessary to place the technology in its proper historical context. No account of the historical process behind modern biotechnology can be complete without examining the history of molecular biology, the field that spawned the technology.

A relative late bloomer in the economic boom of the 1920s, molecular biology was born as the roaring twenties were growing hoarse. Its conception and design reflected the technocratic biases of the business and scientific elite of the period, and the imprint of its earliest personality can certainly be discerned today. It is also necessary to point out that this new field of biology had its origins in physics rather than the life sciences, which were predominantly concerned with holism at the turn of the century. In particular, physicists Neils Bohr (1933) and Erwin Schrödinger (1945) argued that the workings of living systems seemed to violate certain laws of physics, and thus should be studied to search for new laws of physics. It was hoped that genetics would remain incomprehensible within the framework of conventional physics (Markle and Robin 1985), thereby forcing a paradigm shift. Ultimately, then, molecular biology was not just born, it was bred. Historian Lily Kay (1993:3) writes:

[Molecular biology] did not just evolve by natural selection of randomly distributed disciplinary variants, nor did it ascend solely through the compelling power of its ideas and leaders. Rather, the rise of the new biology was an expression of the systematic cooperative efforts of America’s scientific establishment—scientists and their patrons—to direct the study of animate phenomena along selected paths toward a shared vision of science and society.

24 New laws of physics were not discovered as a result of these efforts (Markle and Robin 1985).
According to Kay, then, the birth of molecular biology—and its mechanistic epistemology—is best situated within the Rockefeller Foundation’s cultural breeding program known as the “Science of Man” – essentially a technocratic agenda aiming to restructure human relations to march in step with the requirements of industrial capitalism. In fact, the term “molecular biology” was coined in 1938 by Warren Weaver, the director of the Rockefeller Foundation’s natural science division (Kay 1993:4; Weaver 1970:591-2).

The goal of this new biology was to explain and eventually control the fundamental mechanisms of human behavior, not to mention life in general. As such, its heritage in the popular and scientific eugenics movements of the time cannot be denied. As analysts such as Gottweis (1998:45) have suggested, the crucial difference between molecular biology and eugenics is one of scale. Whereas eugenics focused on the gene pool as a site of intervention, molecular biology narrowed the focus to individual genes. In effect, the field of biology was distanced from concerns such as emergent properties and interactive processes such as symbiosis and directed instead toward a physicochemical understanding of life and its processes, aiming toward greater social control. Speaking of mechanism at a general level, Longino (1990:97) states, “the reason (or a major reason) for the eventual triumph of mechanism is that…the overall philosophy of nature that guided research was compatible with the needs of the socioeconomic climate in which it developed.”

It is important to recognize that Kay’s (1993:10) arguments are “not Machiavellian attributions or pronouncements of academic subversion and co-optation.” Rather, she
explains the emergence of molecular biology within the Gramscian analytic framework of cultural hegemony (Hoare and Smith 1971; Lears 1985). From this point of view, the maintenance of hegemony does not require the conscious and active commitment by social actors to legitimate elite rule. Consensus is achieved by formal and informal systems of power-sharing and incentives rather than by top-down social control and coercion. Complicity is only half-conscious, and hegemony is the interactive result of different social groups seeking power in a mutually-reinforcing manner.

To use the present example, the social goals of the private sector interacted with the research goals of reductionist-oriented life scientists to form a “hegemonic bloc” (Kay 1993:10). While not denying agency, conscious motivations are largely determined by self-interest. What is of primary importance is that by offering their expertise, scientists “supplied an instrumental rationality that not only legitimated their own enterprise but also validated the cultural goals of their patrons” (Kay 1993:11). In other words, the goals of the Rockefeller Foundation were as dependent on the legitimate authority of molecular biologists as the latter were on the power and resources of their patrons for the funding and expansion of their research.

The observational crux of her historical analysis is that the “molecular vision of life” (Kay 1993:16) is just that – a vision, a perspective, one of many possible representations of life including but not limited to the ecological, the evolutionary, and the organismic. As Longino (1990:99, emphasis added) describes it, “[the] object of inquiry is...nature under some description...Certain descriptions make certain kinds of questions meaningful and appropriate that would not be so in the context of another overall
characterization.” The molecular vision of life was privileged by private sponsors such as the Rockefeller Foundation precisely because of the type of knowledge that it produced. Encouraging the development of a molecular biology resonated with the Baconian scientific ideology of “knowledge is power” (as opposed to the Platonic scientific ideology of “knowledge is union”). The power spoken of here is the power to manipulate and control nature for the utility of humans, or more precisely, for the utility of industrial capitalism. Witness the remarks of Jacques Loeb, widely regarded as one of the patriarchs of molecular biology: “The idea is now hovering over me that man himself can act as a creator even in living nature, forming it eventually according to his will” (quoted in Pauly 1987:51).

Narrowing the focus to agriculture, the nature of this technological thrust toward control became evident during the past few decades as industry increasingly commodified the food supply. The dynamics of this process will be discussed in detail further below. For now, it is important to recognize that controlling life has long been a hobby of civilization. Neolithic plant and animal domestication demonstrate this clearly, and traditional plant breeding is hardly more innocent in this regard. However, for human history up until the late nineteenth century, “the limits on biological manipulation were more notable than the achievements” (Pauly 1987:4). Among plant scientists, they were able to “[rearrange] a given genetic vocabulary, but they have not been able to create new words or novel syntactical structures” (Kloppenburg 1988:2). The Scientific Revolution, however, moved this equation in the other direction. Indeed, Francis Bacon’s vision was “to establish dominion over Nature and effect all things possible”
This "engineering ideal" (Pauly 1987) created a version of biology explicitly concerned with manipulating, controlling, and transforming nature, and to the extent that this approach was favored, other concerns of biology were devalued.

This Kuhnian (1962) approach to understanding the emergence of molecular biology is just as relevant to understanding the emergence agricultural biotechnology. In most official accounts (see e.g., Frederickson 1982, cited in Wright 1994:7), scientists, government representatives, and corporate executives are cast as being perfectly objective and without personal and/or financial interest in the development and deployment of these new technologies. Furthermore, they are the champions of truth, reason, and rationality struggling against an irrational and alarmist public (Wright 1994:7-8). This projected image of stalwart decision-making based purely on technical grounds is deceptive. The term "transcientific field" (Knorr-Cetina 1981)—in which nonscientists as well as scientists are interested and involved in the conception, operationalization, and outcome of research—perhaps best captures the truth of the situation.

As an academic discipline, molecular biology pursued theoretical questions "largely without commercial intent or interest" (Markle and Robin 1985:71) until the 1970s. Beginning in 1972, when molecular biologists developed the techniques of genetic recombination, commercial interests began to have a greater and greater influence in the field. The controversies this engendered, as well as fears over the potential abuses of the technology, culminated in the late 1970s. Susan Wright's (1994) history of the political economy surrounding the development, regulation, and promotion of recombinant DNA
technology suggests that the production of consensus within the scientific community in the late 1970s was more representative of an effort to contain the spread of controversy than it was evidence that all technical problems had been solved. A political discourse premised on the notion that scientific development, political stability, and economic growth were intrinsically intertwined (Gottweis 1998:52) created a socioeconomic context interested, if not yet heavily invested, in the growth of this technology. McNally and Wheale (1994, 1998) use the term bio-industrial complex, "[the] world-wide complex of scientific expertise, technological capability, and transnational capital accumulation" (1998:304), to describe the set of institutions committed to the success of genetic engineering. If biotechnological innovation is seen as crucial to economic growth, and if economic growth is seen as necessary for political stability, then it is not surprising that policy was crafted as if uncertainties widely expressed by those in the field only two or three years previous had been entirely vanquished, when in fact the uncertainties about the nature of genetic engineering were expanding. Summarizing the prevailing atmosphere at one pivotal conference, Wright states, "[these] discussions had a siegelike feeling, a shared sense of threat, of polarization, of scientists versus society" (230-1).25

The official legacy of these conferences was the creation of a consensus among scientists regarding the appropriate use of the technologies, and hence a vaccination against public debate. In fact, this "consensus" represented the viewpoints of those scientists at the forefront of molecular biology research, and thus revolved mostly around

25 Notably, this is a theme in the interviews I conducted with proponents. See Chapter 5.
regulatory and technical issues. The broader debates surrounding the socio-economic, political, ethical, and safety aspects of genetic engineering received scant attention (Gottweis 1998:87).

Furthermore, shortly after the U.S. Office of Technology Policy concluded that the risks of genetic engineering had been mitigated, President Reagan's Chemical Warfare Review Commission concluded that "biological weapons...could be designed to spread disease and kill indiscriminately" (quoted in Wright 1994:443). Thus, while military agencies were urging preparation for emerging hazards associated with the new technology, civilian agencies insisted that there was really nothing at all to be worried about. This contradiction between military paranoia and civilian tranquility "[rests] on the slender logic of the assertion that what might happen by design could never happen by accident..." (Wright 1994:443). The unpredictability of complex ecosystems as described by ecology runs counter to this line of thinking, but this was never confronted. For the most part, and due to the requirements of scientific, industrial, and national competitiveness, genetic engineering lost much of its stigma during the 1980s. This "stabilization of meaning" (Gottweis 1998:78) contributed to a hegemonic social construction of biotechnology as the cutting-edge technology of the future, and political concerns shifted from how to control it to how to promote it.
C. The Social Context of Agricultural Biotechnology Research

Essentially, those arguing in favor of agricultural biotechnology have "[claimed] a monopoly on the expertise that really matters" (Purdue 1996:540), that is, technical knowledge. Government and industry experts possess the "legitimate knowledge" (Giddens 1990) concerning the issue of plant biotechnology, at least as long as they hold the trust of the lay public (Beck 1992). As ostensibly omniscient experts, it necessarily follows that only they are in a competent position to assess risk and benefit, and public intervention is thus deemed inappropriate and irrational. According to this line of reasoning, experts are only pursuing objective truth, for which there can be "no legitimate epistemological rationale for the public to be frightened of, or opposed to" (Kleinman and Kloppenburg 1991:433).

Assuming these social actors are acting in the larger public interest, and not on the basis of corporate profitability, the matter would seem to be as straightforward as educating the ignorant public about the safety and desirability of a biotechnological future (Purdue 1996). In the words of a former chairman of the Monsanto Corporation26 (the industry leader), Louis Fernandez:

The only thing that will stand in the way of achieving the full potential of our next golden era is that we will be thwarted by a public that doesn’t understand science or technology and that doesn’t trust us to use science wisely and with appropriate regard for the concerns of the public we serve...We must double, redouble, and redouble again the amount of time

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26 Monsanto has recently merged with Pharmacia and Upjohn to form a new company called Pharmacia. It has 60,000 employees, $17 billion estimated annual sales, and a $50 billion market capitalization. An autonomous agricultural subsidiary headquartered in St. Louis retains the Monsanto name (King 2001), and is the second largest seed corporation in the world (after DuPont/Pioneer), with 1999 sales of $1.7 billion (RAFI 2000).
and money we devote to educating the public (quoted in Richardson 1985:44).

From the industry's standpoint, then, the controversy is a communication and education problem rather than a dialogue between social actors regarding the evolution of society. The assumptions underlying this perspective reflect the rhetorics of scientific expertise and technological determinism, i.e., the belief in technology as an independent force of social change (Bak 1997).

But according to those opposed to the current development of this technology, public concerns over genetically-modified foods (GMFs) are not only warranted, they are a necessary part of technological development if it is to reflect anything more than maximum profitability (Richardson 1985). As Kloppenburg (1988:278) concludes in his history of plant biotechnology, "the public has a right to demand...a voice in determining the goals and purposes to which science and technology are directed."

Corporations, however, are loathe to entertain and legitimate public skepticism and so respond with efforts to suppress public concerns. A frequent tactic is to abuse scientific skepticism27 to steamroll and deride public apprehensions over the use of their products (Cohen 1997; Bak 1997). This is especially so in the case of biotechnology. Indeed, one panelist at a 1993 conference on biotechnology lamented that the industry was repeatedly confronting "ethics and other irrational considerations" (Athanasiou 1996:11). In the context of an arrogant and impatient debate, the "fate of our science and our society devolves into a contest of power and will. While some may embrace this turn

27 A typical tactic is to commit the informal fallacy of arguing from ignorance, i.e., "you have not proven that this technology is not safe," when the burden of demonstrating safety most probably lies with those who are developing the technology in the first place.
of events, it seems deeply inconsistent with the spirit of scientific inquiry to do so” (Thompson 1997a:8).

Thompson goes on to argue that one need not necessarily agree with the concerns of opponents of biotechnology to conclude that a lack of trust in science and technology hardly constitutes an idiotic attitude. Indeed, given recent human history, this may represent a healthy skepticism, and is in any case a reasonable point of view.

[In] a world that has given us disasters like Bhopal and Love Canal, where the safety of chemical and then nuclear technologies was badly oversold and where scientists performed experiments on humans without informed consent, not only in Nazi death camps but also in Tuskegee, Alabama, is it really so surprising that some people are a little reluctant to accept scientific assurances about the safety of biotechnology? (Thompson 1997a:74).

At the forefront of such public relations campaigns masquerading as science is the Monsanto Corporation. Monsanto has been a leader in defining the realm of meanings surrounding biotechnology for two decades. As a result of lobbying and testimony at congressional hearings, Monsanto holds considerable influence over how agents of the government understand this new technology (Kleinman and Kloppenburg 1991). The following statement made by U.S. Secretary of Agriculture Dan Glickman is instructive. It is an impressive reiteration of the cultural frame with which the biotechnology industry wishes to define the issue, as well as an apt use of the OTA’s official definition of biotechnology referred to above.

Biotechnology’s been around almost since the beginning of time. It's cavemen saving seeds of a high-yielding plant. It's Gregor Mendel, the father of genetics, cross-pollinating his garden peas. It's a diabetic’s
insulin, and the enzymes in your yogurt....Without exception, the biotech products on our shelves have proven safe (Glickman 1997).  

As Kleinman and Kloppenburg (1991) illustrate, Monsanto does not limit its public relations activities to the sphere of political discourse. Along with sponsoring science museum exhibits and lectures by company scientists, their mass market, issue-oriented advertisements serve to create "structures of meaning" (Williamson 1978:12) around biotechnology and its products, thereby contributing to the sphere of public discourse as well. Furthermore, as Hornig and Talbert (1993) have shown, newspaper reporting on biotechnology is heavily dominated by a reliance on industrial and university sources of information, who, as Kenney (1986) demonstrates, forward a unified agenda. Consequently, benefits and economic considerations are promoted to the exclusion of social, ethical, and environmental concerns.

The goal of the biotechnology industry, because they are heavily invested in the products of their technology, is to achieve a hegemony of meaning (Kleinman and Kloppenburg 1991). In order for their technology to be accepted, the industry must define a worldview in which their ideology is commonsensical (Miliband 1969; Mouffe 1979). To accomplish this, they need create nothing new, but only to draw upon existing

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28 Tangentially, it is worth mentioning that this line of reasoning is a demonstration of the naturalistic fallacy, that is, concluding that something is good merely from the fact that it exists in nature (Thompson 1997a), here defined as "not everything which happens, but only what takes place without the agency, or without the voluntary and intentional agency, of man" (Mill 1885:8). In other words, ethics cannot be derived by comparing intentional actions by humans to acts of nature, for "[in] sober truth, nearly all the things which men are hanged or imprisoned for doing to one another are nature’s everyday performances" (Mill 1885:28). Among proponents of biotechnology, this fallacy takes at least two forms. First, genetic modification is just like what occurs in natural mutation, thus it is an acceptable risk. And second, as the above quote exemplifies, genetic modification is just an extension of plant and animal breeding (for which society has neither undertaken a debate regarding the acceptability of its risks), thus it is acceptable (Thompson 1997a).
habits of thinking about science, technology, economy, and nature (Kleinman and Kloppenburg 1991).

Additionally, Longino (1990) points out that most contemporary science is dependent on corporate and/or government funding. The questions that science pursues, as well as the answers which science provides, are “at least partly a function of the values of its supporting context” (Longino 1990:5). Furthermore, the logical relationship of current research to prior research only cements its socio-historical determination, and peer review ensures the research that gets funded, published, and accepted as knowledge reflects the scientific community’s values.

To offer a scenario of the mechanisms of such influence, an agricultural biotechnology premised on efficiency, productivity, and profit seems destined to offer up solutions to, e.g., crop pests, that fail to address the monocultural farming practices that perhaps made the crop vulnerable to disease in the first place. A knowledge trajectory contrary to these premises would be unlikely to be treated seriously by gatekeepers. Not only would such a project not be in the interests of funding sources, it would also threaten the carefully-constructed worldview that gives purpose to this community of scientists, not to mention the personal integrity—and hence identity—of individual scientists. For these reasons, individual-level biases are rarely the focus of critique. Community-level biases are simply much more liable to succeed in passing themselves off as objective.

As Longino (1990) indicates in her examination of the social world of science, to claim that science is objective is to say that it is above the social forces that rule our everyday lives and create our society. This is an exalted status which bears a remarkable
resemblance to the institution of religion (Noble 1997), and indeed, science has replaced religion as the chief legitimating force in society (Habermas 1976). "Science claims a method that is objective and nonpolitical, true for all time" (Lewontin 1991:7). Its embeddedness in the social world, including its own community-level biases, and particularly its dependence on and/or integration with political and economic institutions, is consequently overlooked. Hence, science and the development of technologies come to be seen as inevitable footsteps on a straightforward path to objective truth rather than a directed program of research fundamentally and inescapably determined by dominant political, social, and economic forces. Perhaps it goes without saying that this occurs at the expense of less immediately profitable alternatives (Lewontin 1991). The example of hybrid corn below demonstrates this dynamic.

D. The Commodification of Seed Germplasm

According to Lewontin (1991), himself a geneticist, and consistent with Noble's (1977) and Kloppenburg's (1988) assertions that capitalist interests shape technological systems, the invention of hybrid corn (and the subsequent expansion of the technique to other crops) was a deliberate use of genetics to create a copy-protected product. Simply stated, it is difficult to capitalize on something which can reproduce itself. A seed contains immense productive potential, but has little value as a commodity unless its (re)productive capacity can be controlled and/or owned. A profitable seed industry must

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29 Perhaps this fulfills, in a rather disappointing manner, Auguste Comte's (1851/1957) vision of a positivist religion. To claim objectivity is to claim divine right, for both presume to stand aside from human consciousness and the subjectivity and cultural embeddedness it invariably implies.
not only reduce or eliminate competition from other seed companies and public breeders, but from the farmers themselves, who may save their own seed to be planted the next season (Buttel and Belsky 1987).

Due to these “natural barriers” (Buttel and Belsky 1987:32), very little private capital was devoted to improving agricultural crops prior to the development of hybrid corn in 1935 (Kloppenburg 1988). As Busch et al. (1991:96) observed, “[only] after control became not just a goal but a reality, did private direct investment in either plant breeding or plant molecular genetics for the purpose of product development appear desirable.” Capital has since managed to impose the requirements of its own dynamics on the recalcitrant biological reality of the seed along three avenues: technical, political, and legal/juridical (Buttel and Belsky 1987; Kloppenburg 1988).

Hybridization technology provided the initial technical means of coercing seed germplasm into a profitable commodity. Hybrids are produced by crossing two inbred, genetically-uniform varieties and planting the seeds from that cross. The inbred, homogeneous varieties themselves give poor yields, while the hybrid, via the biological phenomenon of heterosis (hybrid vigor), gives superior yields. It is not worthwhile, however, to save the seeds produced from a hybrid because these will be a wide mixture of genetically dissimilar plants resulting in a dramatic decrease in yield (15-40%). Additionally, because the parent lines of the hybrid are trade secrets, the farmer must return to buy new seed each year. Hybridization thus provided a technological means of attaining proprietary control over seeds, essentially creating a more viable commodity by creating a less viable seed. Although it was debatable at the time of the hybrid
technique's introduction in 1926, biologists have known for four decades that simple
direct selection and propagation of high-yielding plants could produce varieties that yield
as much as hybrid varieties. This does not occur because it would create high-yielding,
self-propagating seeds, thus undermining proprietary control over the product. The
hybrid method has since been expanded into nearly every agricultural sector, and is
hailed as a triumph of science rather than market manipulation.  

Seeds can also be rendered commodities by manipulating the political environment.
From the mid-nineteenth century to the early twentieth, the U.S. Department of
Agriculture (USDA) freely distributed improved varieties of seeds to farmers. Clearly,
this was a significant obstacle to capitalizing on seeds. The industry's political solution
to this problem was to pressure public sector agricultural research and development not to
release improved seeds to farmers if these could be potentially profitable by seed
companies. In 1923-4, the American Seed Trade Association persuaded Congress to end
free federal distribution of seeds. Public sector agricultural research has since taken on
more of complementary function, focusing on basic research, and ceasing to compete
with applied private sector research (Buttel and Belsky 1987).

Finally, the legal approach to solving the dilemmas presented by the natural
processes of plant reproduction revolved around the gradual extension of proprietary
rights over the seed germplasm. After years of intensive lobbying by the seed industry,

30 It is reasonable to suppose that this same market logic was behind the ill-fated but not entirely abandoned
"terminator" technology, i.e., genetically modifying a plant to produce only sterile seed, as well as the
approach taken with regard to agricultural biotechnological development in general. Indeed, the USDA
recently licensed the terminator technology—for which it co-owns three patents—to Delta and Pine Land
Company for commercialization to begin 1 January 2003 (RAFI 3 August 2001).
the Plant Patent Act of 1930 gave proprietary protection to breeders of novel varieties of asexually-reproducing plants such as fruit species and ornamentals. In 1970, legal control was partially extended to sexually-reproducing plants as well with the Plant Variety Protection Act (Busch et al. 1991). This—along with a confluence of other factors—resulted in nearly every American seed company of any significance being acquired by transnational petrochemical and pharmaceutical firms with substantial agrichemical interests and financial commitments to the commercialization of biotechnology (Buttel and Belsky 1987; Kloppenburg 1988).

As well, the industry achieved complete General Patent Law protection for genetically-modified plants in 1980 with the landmark U.S. Supreme Court (1980) decision *Diamond v. Chakrabarty*. Ananda Chakrabarty, while working for the General Electric Company, developed a bacterium that degraded crude oil. The U.S. Patent and Trademark Office initially rejected his patent application on the organism itself, although they accepted his patent applications for the process of making the microbe and the method of dispersal. The case was eventually appealed to the Supreme Court, which in a 5-4 ruling held that patentable material includes “anything under the sun that is made by man” (quoted in Krimsky 1991:47-8). This was reaffirmed in the 1985 ruling by the U.S. Board of Patent Appeals and Interferences, *Ex parte Hibberd*, which first granted utility patents for novel plants, protectable under Section 101 of the U.S. Code. As Figure 3.1 shows, agricultural biotechnology patents have since been nothing less than explosive.
What is more, the industry has been vigilant in enforcing its newfound proprietary rights. To illustrate, in a recent case in Canada, Monsanto sued third-generation Saskatchewan farmer Percy Schmeiser for patent infringement on their Roundup-Ready canola. Roundup-Ready crops are engineered to withstand spraying of Monsanto’s trademarked herbicide, Roundup (glyphosate). Inspectors from Monsanto routinely test seed samples from farmers to ensure compliance with intellectual property law. Schmeiser claims he did not illegally obtain Roundup-Ready canola seed, as
demonstrated by the fact that he did not use the Roundup herbicide on his crop, which is
the entire purpose of planting Roundup-Ready seeds in the first place. If he had, in fact,
it would have killed the majority of his crop, which was not Roundup-Ready canola.
What is likely is that pollen from a neighbor's Roundup-Ready canola drifted into his
fields, with the proprietary trait subsequently showing up in some of the seeds he saved
and replanted. Nonetheless, the courts ruled that Schmeiser must pay Monsanto $10,000
in licensing fees and up to $75,000 in profits from his 1998 crop. The case is currently
under appeal (RAFI 1 April 2001), and Schmeiser has filed a $10 million countersuit
(Clark 1999).

Agricultural biotechnology has accelerated a profoundly ahistorical shift, begun in
1923, of varietal breeding from the civic domain to the corporate domain, from the public
to the private sector (see Figure 1.1, page 5). In 1923, USDA distribution of free seeds to
farmers ceased, replacing this practice with the dissemination of new varieties to seed
companies who would multiply them and then sell them to farmers (Busch et al.
1991:192). Thus began the process of the commodification of seeds, and one which
cannot be seen as an entirely innocuous development. "Agricultural plant sciences have
over time become increasingly subordinated to capital...[This] ongoing process has
shaped both the content of research and, necessarily, the character of its products"
(Kloppenburg 1988:8).

An excellent example of this dynamic is the fact that many of the private companies
that invested heavily in biotechnology at an early stage had nitrogen-fixation research
programs. By the mid-1980s, most of these programs had been abandoned, perhaps
because it's technically complex and expensive (as is all biotechnology), or perhaps because it conflicts with the fertilizer product lines of agrichemical investors, who absorbed and concentrated nearly all seed companies during the 1970s (Buttel and Belsky 1987).

The intuitive findings of Shetty (1979) demonstrate that the top three most-cited corporate goals are profitability, growth, and market share. Thus, the treatment of seeds—and by inevitable extension our food supply—as a means of capital accretion for corporate institutions with goals definitionally different from the best interests of society as a whole warrants serious consideration of possible consequences.

Busch et al. (1991) explored a number of potential and already extant circumstances created by the commodification of seeds. First, a number of minor crops could be abandoned by the interests of capital in charge of our food supply if the market is not big enough or the profitability not attractive enough (see also Buttel and Belsky 1987). This is already taking place. Seminis,31 the world's largest fruit and vegetable seed company,32 announced on 28 June 2000 that it would eliminate 2,000 varieties—25% of its entire product line—as part of a global restructuring and optimization plan (RAFI 17 July 2000). Critics contend that these are likely their non-hybrid varieties (Guidetti 2000), and the logic of the foregoing analysis would support such suspicions.

Additionally, the private sector may also pressure the public sector researchers to focus on major crops as well, through grants, contracts, consulting, and legislative

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31 Seminis is a subsidiary of the Savia Corporation, and controls 40% of the U.S. vegetable seed market, and nearly 25% of the worldwide fruit and vegetable seed market (RAFI 17 July 2000).

32 This does not include grains.
pressure. Similarly, the long-term research emphasized for the public sector may increasingly be replaced by research with more immediate profitability (Buttel and Belsky 1987; cf. Heisey et al. 2001). For instance, Monsanto's patent on glyphosate, the world's bestselling herbicide, expired in 2000. Despite the patent expiration, Monsanto managed to effectively perpetuate its monopoly through exclusivity contracts with farmers buying Roundup-Ready seeds, i.e., forbidding farmers who purchased Roundup-Ready seeds from using any other brand of glyphosate (McNally and Wheale 1998).

Third, an increased concentration of scientific talent at a select group of public and private institutions is likely. A comprehensive plant biotechnology program is much more expensive than a conventional plant breeding program, and consequently the particular needs of some regions will no longer receive the attention of the latest technology and trends.

Fourth, and as Kenney (1986) explored in depth, the complete commodification of seeds, concurrent with declining federal support of research, increases the ties between universities and industry. In the past, grants were comparatively small, to individual scientists, and had few if any strings attached. Today, however, companies offer grants to entire departments or institutions, contingent on contractual acceptance of an agreement that any knowledge gained is proprietary and that any patents generated are shared with the patron. The "transcientific" (Knorr-Cetina 1981) nature of these arrangements is apparent, and creates a situation in which the work of science is harnessed to the needs of industry. Proprietary knowledge is unshared, thus inhibiting the free flow of vital information. Furthermore, even publicly-funded scientists under no
such legal obligation may refrain from talking about their research for fear that their ideas will be co-opted, and patented, by industry.

As well, commercialization potential may take precedence over scientific importance in the choice and organization of research projects. As Auerbach (1983:566) notes, “The existence of a protective patent system has the effect of encouraging scientists to proceed with inventions for which they can claim exclusive rights.” Additionally, scientists who do not agree with the patenting of life must nonetheless patent the products of their research if they wish to exercise any control over its future. As reported in Chapter 2, as far back as fifteen years ago, Blumenthal et al. (1986a, 1986b) demonstrated that 25% of faculty engaged in biotechnological research with industrial ties were prohibited from publishing the findings without the prior consent of their patrons, who in fact owned the research. Another 40% reported that their ties resulted in unreasonable delays in publishing. It can reasonably be assumed that this dynamic has only increased, and it is an examination of the impacts of the corporate colonization of science that this dissertation explores.

In conclusion, the logical extension of current patterns of technical, political, and legal manipulations of the seed lead society to a future of something resembling franchise farms, where farmers are little more than unskilled laborers on their own land, and where the traits of crops are determined by profitability and market control. Witness the vision of Monsanto’s Howard Schneiderman (NOVA 1985, quoted in Kloppenburg 1988:283): “The farmer would provide his labor and his land and Monsanto could provide him with the system which would be seeds, chemicals, and perhaps microorganisms.”

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E. Summary

This chapter has shown that the development of molecular biology—and consequently biotechnology as well—has been driven from its inception by capital interests. This process intersected with the historical thrust in agriculture toward proprietary control over seed germplasm. The attainment of proprietary protection over the seed is the only way in which reasonable profit can be derived from something which would otherwise reproduce itself. The new agricultural biotechnologies, because they involve patentable products and procedures, enhance proprietary protection over seeds in the same manner as the earlier hybridization technology. Hence, the development of these technologies has been significantly driven by commodification concerns. Consequently, the involvement of industry in those scientific disciplines contributing to the development of agricultural biotechnology cannot easily be seen as neutral and without consequence.
CHAPTER 4

METHODOLOGY:

VOICES FROM THE CULTURE OF OBJECTIVITY

[Human] social life is ours to study naturalistically, sub specie aeternitatis. From the perspective of the physical and biological sciences, human social life is only a small irregular scab on the face of nature, not particularly amenable to deep systematic analysis. And so it is. But it's ours.

—Erving Goffman (1983:16-17)

This dissertation provides an in-depth examination of the impacts of the transformation of the scientific ethos on the subject and practice of academic science. This research is located within the growing literature on the transformation of the normative structure of science (e.g., Etzkowitz 1989), and extends it by analyzing how this normative transformation is perceived and experienced by the practitioners of those disciplines associated with agricultural biotechnology. Agricultural biotechnology provides an ideal instance for examining the impacts of normative transformation as scholars such as Faulkner et al. (1995), Krimsky et al. (1991), and Blumenthal et al.

33 Sub specie aeternitatis roughly translates as “eternally under the cloak.”
(1986a; 1986b) have shown that academic-industrial ties are notably high in those fields affiliated with the development of biotechnology.

To pursue these aims, I conducted 25 intensive, semi-structured interviews with scientists actively engaged in the popular and scientific debate over these technologies. My purposive snowball sample comprises a spectrum of proponents and opponents of the current development of agricultural biotechnology.

A. The Qualitative Approach

A qualitative approach to the research is warranted because of the nature of the research question and the state of the extant literature on the topic. In studying the impacts of a normative transformation, it is necessary for the researcher to be closer to the individual's perspective and lived experiences (Denzin and Lincoln 2000; Ragin 1994) in order to perceive the normative nuances. Qualitative researchers try to understand social phenomena in context, i.e., understanding "the meanings of social events for those who are involved in them" (Esterberg 2002:2-3; emphasis original). Furthermore, the qualitative approach "[seeks] answers to questions that stress how social experience is created and given meaning" (Denzin & Lincoln 2000:8; emphasis original). Intensive interviews enabled me to attain a sense of what it is to practice genetic science under this new normative milieu.

Additionally, empirical research into the impacts of increased industrial involvement in academic science (which is recognized as the cause of the normative transformation) is rather lacking. What research there is (e.g., Blumenthal et al. 1986a; 1986b; Krimsky et
al. 1991) is fast becoming outdated due to manner in which university-industry research relationships have expanded since the time of these original studies. The social context has dramatically changed, and the conclusions and implications of these early surveys in many cases may no longer apply. Thus, this research both updates these previous studies and enhances their findings by grounding them more solidly in the social world (Ragin 1994).

Rubin and Rubin (2002:76) have noted that “[one] of the key differences between qualitative interviewing and survey interviewing is that the surveyors are trying to generalize relatively simple information whereas the qualitative interviewers are trying to learn about complex phenomena.” Hence, by drawing upon the situated knowledge (Smith 1987; 1990; Haraway 1988) of scientific social actors, this study is able to paint a picture of the situation that makes up in detail what it may lack in breadth. Whereas earlier studies provided early analyses of the width of the situation, this study provides a later examination of the depth. Furthermore, exploring the social terrain in this manner lays excellent groundwork for future scholars to construct a contemporary quantitative survey of the impacts of this normative transformation.

B. Data

1. Sampling

Rubin and Rubin (1995:66) state that research informants should satisfy three criteria: “They should be knowledgeable about the cultural arena or the situation or
experience being studied; they should be willing to talk; and when people in the arena have different perspectives, the interviewees should represent the range of points of view.” My sample satisfies these requirements.

Primarily, data for this study was derived from 25 semi-structured, intensive interviews. Informants were chosen for the specific perspectives and situated knowledge (Smith 1987; 1990; Haraway 1988) they could bring to the study. A spectrum of informants was sought who could give me the greatest possible insight into the topic (Esterberg 2002). Because there is substantial disagreement among scientists as to the ethics, safety, and desirability of the current development of agricultural biotechnology, I made certain to interview informants from across the spectrum of perspectives. Ultimately, I divided all informants into a heuristic dichotomy: 12 opponents of the current development of agricultural biotechnology and 12 proponents of the current development of agricultural biotechnology.

This “purposive strategy” (Esterberg 2002:93) was supplemented by a snowball sampling technique (Biernacki and Waldorf 1981). Initial informants were identified via articles in mass media periodicals as well as topical Web sites. I asked for further referrals (as well as source citations) from this first level, specifying that I was looking for both opponents and proponents of the current development of agricultural biotechnology. Most were happy to comply, although a few proponents denied the existence of any opponents.

\[34\] One tape (a proponent) was damaged and unusable, and thus the final number of interviews was 24.
This overall strategy allowed me to secure data saturation (Glaser and Strauss 1967) as well as ensure both a similarity and dissimilarity of informants (Rubin and Rubin 1995). Saturation became apparent as previous data was confirmed and information was repeated (Morse 1994). Although some have warned that snowball sampling may yield respondents who are too similar to one another (e.g., Esterberg 2002), the purposive strategy utilized here ensured a broad spectrum of informants.

2. Interviews

To understand what the impacts of the transformation of the normative structure of science have been, I employed a semi-structured interview format. This allows respondents the freedom to express and elaborate their points of view in their own words (Esterberg 2002), and thus communicate their perspective more fully. This approach is particularly well-suited for exploring a topic in detail (Esterberg 2002).

All informants were academic scientists actively engaged in the popular and scientific debates surrounding agricultural biotechnology. All were affiliated with a university, excepting one who retired and one who, after earning a law degree in addition to a doctorate, accepted a position in a civic organization. Of those affiliated with a university, 17 were full professors, two were associate, and one was an assistant professor. Additionally, one respondent was a postdoctoral fellow, and one worked in a university-funded technology outreach program. Thirteen of the respondents were from
public, doctoral/research universities—extensive,\textsuperscript{35} one respondent was from a public, doctoral/research universities—intensive,\textsuperscript{36} two respondents were from private, non-profit master's colleges and universities \textsuperscript{1},\textsuperscript{37} one was employed in a civic organization, one was retired, and six respondents were from universities abroad not included in the Carnegie Commission's 2000 classification scheme.\textsuperscript{38} There were no discernable correlations along any of these axes.

Approximately 25\% were female, and ages ranged from the 30s to the 60s. There was no discernable correlation between gender and their perspective on this issue. In general, older informants seemed somewhat more likely than the younger to be opponents of the current development of this technology, although there were exceptions to this pattern in both directions. Importantly, none of my informants were against the development of agricultural biotechnology \textit{per se}. Rather, opponents were against the \textit{current} development of the technology.

Respondents self-identified (and these are not discrete categories) as biologists, microbial ecologists, geneticists, molecular biologists, physiologists, evolutionary

\textsuperscript{35} As defined by the 2000 Carnegie Classification, these institutions typically offer a wide range of baccalaureate programs, and they are committed to graduate education through the doctorate. During the period studied, they awarded 50 or more doctoral degrees per year across at least 15 disciplines.

\textsuperscript{36} As defined by the 2000 Carnegie Classification, these institutions typically offer a wide range of baccalaureate programs, and they are committed to graduate education through the doctorate. During the period studied, they awarded at least 10 doctoral degrees per year across three or more disciplines, or at least 20 doctoral degrees per year overall.

\textsuperscript{37} As defined by the 2000 Carnegie Classification, these institutions typically offer a wide range of baccalaureate programs, and they are committed to graduate education through the master's. During the period studied, they awarded 40 or more master's degrees per year across three or more disciplines.

\textsuperscript{38} The 2000 Carnegie Classification database is available at: http://www.carnegiefoundation.org/classification/.
biologists, biochemists, theoretical physicists, plant pathologists, plant geneticists, plant physiologists, forest biologists, and botanists. Regardless of discipline, what links them together is their participation in the popular and scientific debate over the development of this technology.

Notably, those arguing against the current development of plant biotechnology tended to be more disinclined to consent to an interview and less immediately forthcoming during the interview (although they often had much more to say once they became comfortable). This taciturnity also existed among proponents to a lesser extent, and is perhaps illustrative of the political nature of this controversy.

Interviews lasted between 60 to 100 minutes. Questions were taken from an interview guide (see below) developed to guide the discussion around the intended content areas. Each interview varied as individual informants revealed information that shifted the focus of the discussion. Interviews were conducted over the telephone and arranged via email. With the permission of the informants, all interviews were recorded on audiotape. Informants were informed that all identifying information would be kept confidential and that they were free to decline to answer any question—as well as to end the interview—at any time.

I transcribed all recordings of interviews myself, in their entirety and verbatim excepting "um's, ah's, you know's," and other verbal pauses.

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39 Theoretical physics was his academic training. He wrote on the physics of life processes.
a. Participation solicitation

Participation was solicited using the following script:

Hello. My name is Anthony Vigorito. I am a doctoral student at Ohio State University working under the direction of Timothy Curry, Professor of Sociology. I am currently researching the debate over biotechnology in general and genetically-modified food in particular. I understand that you have considerable expertise in this area. I would like to talk with you about this with a view to me learning how this issue developed and why it sparks such divergent beliefs about what is appropriate science and appropriate behavior towards the environment. I would also appreciate your telling me what you think I should know about this issue to be knowledgeable about it. Could I please meet with you for about one hour at your convenience to go over this material?

If the response was "No," I responded: "I thank you very much for your consideration of my request. Are there other people you could recommend that I should talk to about this?"

If the response was "Yes," then I proceeded to arrange a time for the interview.

b. Interview guide

Interviews were introduced using the following script:

At the outset, I would like to say again that this is a confidential interview. Nothing you say will be attributed to you, nor will your participation be divulged. You are free to decline to answer any question.

Is it OK if I tape record our conversation for my personal notes? If so, the tape will be kept locked in my office until I can review it or transcribe it. After that, it will be erased. If you would like a copy of either the tape or the transcription for your files, I will be glad to make one and get it to you.

As is the case in open-ended interviews of informants, the course of the interview often takes unanticipated turns (Blee and Taylor 2000). Nonetheless, the main questions I sought answers for are below. It is important to emphasize, however, that this is
properly understood as an interview guide, rather than a script, as a guide “helps the interviewer focus the interview” (Esterberg 2002:94).

The interview is also best understood as a combined topical and cultural interview (Rubin and Rubin 1995). In topical interviews, the researcher seeks out informants who have experienced a particular phenomenon (such as normative transformation) in order to gain an understanding of what has happened and how it is understood. The researcher is generally looking for factual information and explanations of events. In cultural interviews, by contrast, “the factual truth is less important than how well it illustrates the premises and norms” (Rubin and Rubin 1995:29). Hence my interviews sought not only situated knowledge (topical information), but also lived experience (cultural information).

The following questions comprised my interview guide, grouped according to broad topic areas. These are not intended as discrete questions. Invariably, answers to many questions were provided by respondents in the course of discussing another question that I initially posed. Thus, this guide should be understood as the minimum information that I wished to be certain to gather from each interview, and not as a script. Due to the boundaries of this report, many topics addressed in the interviews are not explored in this report. These undeveloped issues will form the basis of my future research.

—Professor Timothy J. Curry was my acting advisor when I first began this project.
3. Other data sources

The 25 semi-structured, intensive interviews were supplemented with descriptive quantitative data procured from the Economic Research Service of the USDA. This data describes the growth of private sector funding of agricultural research as well as the growth of intellectual property rights in agriculture. Additionally, books oriented toward
a popular market (e.g., Fagan 1995; Ho 2000; 1998; McHughen 2000; Shiva 2000; Shiva and Moser 1995) arguing either for or against agricultural biotechnology were used to gain a preliminary sense of the distribution of perspectives.

4. Analysis

My approach to my data collection and analysis was iterative at all stages (Charmaz 1983), permitting me to refine ideas and develop interpretations from my informants rather than imposing a preexisting theoretical model upon them. Topic areas which focus the presentation of findings in Chapter 5 emerged as factors from the interviews themselves. I ceased conducting interviews when I was confident that my existing data was adequate due to saturation and confirmation of previously collected data (Esterberg 2002).

After transcribing all 24 interviews, I coded them into multi-layered topic areas using NUD*IST qualitative analysis software (version 4.0). Initially, I sorted the data into broad categories as a method of processual analysis (Charmaz 1983), with each progressive layer being more detailed and specific. This method allowed for maximum flexibility in cross-referencing themes and factors. The first layer of categories was generally based on broad question areas. Further layers accounted for overlap and captured themes which were additionally relevant to other topic areas.

I made certain in presenting my findings to represent the perspectives of all informants. To ensure confidentiality, I do not identify them by name nor offer any information that might disclose their identity. While this may result in the omission of
certain passages, it is necessary to protect research subjects and required by human subjects review panels (see below).

C. Ethical Considerations

Because this is a potentially political topic, I assured confidentiality to all of my respondents. Notably, many of them did not mind whether I attributed their words to them or not. Nevertheless, this research proceeded according to guidelines set forth by The Ohio State University Behavioral and Social Sciences Institutional Review Board, Office of Research Risks Protection. This dissertation is based on research proposed in Research Protocol 00B0032.

D. Summary

Drawing primarily on 24 semi-structured, intensive interviews, divided into a heuristic dichotomy of proponents and opponents, I have gained a window into the lived experience of practicing genetic science under a normative milieu that has been increasingly influenced by transnational corporate capital. Additionally, by drawing on the situated knowledge of my informants, I have been able to get a sense of how the structures of reward and punishment within academic science have shifted to accommodate the presence of industry.
CHAPTER 5

FROM CAUTIOUS OPTIMISM TO RECKLESS PESSIMISM:

SCIENTISTS' ASSESSMENT OF INDUSTRIAL INVOLVEMENT IN ACADEMIC SCIENCE

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I agree with my cautiously pessimistic adversaries that reckless optimists are far more dangerous than reckless pessimists.

—Paul B. Thompson (1997a:11)

Stimulated by the earliest controversies surrounding biotechnology in the university, a closed conference was held in Pajaro Dunes, California in March 1982 to assess the situation. Conferees issued the following prescient statement:

These problems center on the preservation of the independence and integrity of the university and its faculty...[Research] agreements and other arrangements [should] be so constructed as not to promote a secrecy that will harm the progress of science..., diminish the role of the university as a credible and impartial resource, interfere with the choice by faculty members of the scientific questions they pursue, or divert the energies of faculty members and the resources of the university from its primary educational and research missions (MIT 1982, quoted in Ashford 1983:17).

Thus, it is evident that from the very beginnings of university-industry research relationships in biotechnology, there was a significant degree of awareness of potential
problems. Nonetheless, as early examinations such as Blumenthal’s et al. (1986a; 1986b) and Krimsky’s et al. (1991) have shown, these trepidations and cautions did not necessarily translate into prudence in the formation of university-industry research relationships, even as research confirmed the emergence of some of the aforementioned problems. On the contrary, as Figure 1.1 (page 5) shows, the extent of industrial investment in university-based agricultural research has only continued to increase up to the present, having first surpassed public funds in 1980.

As a consequence of industry’s increasing investments in academic research, Etzkowitz (1989) has argued that Merton’s (1942; 1973) normative structure of science involving universalism, organized skepticism, disinterestedness, and communalism,\footnote{These were discussed in greater detail in Chapter 2.} has been undergoing a transformation. Very little research, however, has explored the impacts of this transformation of the scientific ethos on the subject and practice of academic science. By drawing on the situated knowledge (Smith 1987; 1990; Haraway 1988) and lived experiences of scientists at the forefront of the scientific and popular debates in this area, this chapter provides an in-depth exploration of how industrial involvement has impacted the practice of academic science in agricultural biotechnology. In other words, this chapter will explore how Etzkowitz’s (1989) normative transformation is lived, experienced, and understood by scientific social actors.

This examination of the impact of industrial hegemony on agricultural biotechnology reveals that all respondents, whether proponent or opponent,\footnote{I will use the terms “proponent” and “opponent” as a shorthand means of referring to those supportive and those opposed to the current development of plant biotechnology.} recognize that the science
is in many ways marketplace-driven. There is general agreement that the realm of scientific inquiry in these fields is either directed or limited by the needs of industry. However, while scientists on both sides of the debate acknowledge that industry is having an impact on the institutions of science, they differ significantly in the focus of their concerns, the extent of their concern, and their interpretations of the larger situation.

In order to communicate the range of perspectives on these issues and to facilitate a relative ease of comparison, comments by proponents and opponents are organized within the same general outline. In the course of questioning respondents about their impressions of the impact of industry on science, six major topics emerged, which organize this chapter: (A) ambivalence regarding industrial capital and resources; (B) frustrations regarding the marketing and promotion of the products of agricultural biotechnology; (C) the degree to which profit and commercial concerns are driving the science; (D) problems associated with the proprietary nature of the science and technology; (E) structural mechanisms of *de facto* censorship; and (F) problems associated with the emerging “academic-industrial complex.” In discussing each factor, the viewpoints of proponents will be presented first, followed by the viewpoints of opponents. In general, proponents were more apt to discuss the earlier factors, and opponents were more apt to discuss the later factors. A summary of the major overlaps and differences between their perspectives will be reserved for a discussion in Chapter 6.
A. A Double-Edged Sword: Costs/Benefits of Industrial Capital and Resources

According to Etzkowitz (1989), Merton's (1942) description of the traditional scientific ethos has been transforming as a consequence of shifts in federal funding patterns and policy changes regarding intellectual property. Rising costs and sagging sources of federal research funding led universities to seek alternative sources of funding in the form of contractual partnerships with industry. At the same time, pivotal court rulings on the intellectual property protections afforded to the products of genetic recombination and other biotechnologies led industry to become interested in harvesting the biotechnological expertise of academic scientists as a strategy of renewal and growth (Goldhor and Lund 1983; Gerson 1987). The effectiveness of this strategy has been confirmed by Blumenthal et al. (1986a), who found that corporate investment in university research generated 4.2 times as many patent applications, per dollar invested, than company-based research over a five-year period. In short, university-industry research relationships exist precisely because they offer mutual financial benefit to both parties.

What follows is a brief introductory examination of the general perceptions of costs and benefits scientists working under this new milieu. Many of the themes touched upon here will be expanded in later sections.
1. Costs/Benefits: Proponents of GMF’s

Most proponents expressed a surprising degree of ambivalence about the role of industry. That is, while they were enthused about the growth of their field and/or their own research, they were also quite aware of the commercial concerns of their benefactors. Their struggle to come to terms with the relationship between science and industry is evident in the following remarks.

It’s tough. I’m double-minded. As someone who’s doing academic research, I’ve been able to get a lot of the tools, to use the tools for research purposes, and that’s good. I have relationships with many of the companies, good working relationships with many of them, and at the same time, right now it’s an oligopoly, and that’s probably not the healthy situation. As someone said, Monsanto’s motto is, if you can’t beat ’em, eat ‘em. I’m not sure that that’s terribly healthy.

It’s a double-edged sword. On the one hand, only industry has the necessary resources to develop the technology. And a lot of the materials that industry developed have filtered out to the university and public institution level, to where it’s been applied for a lot of other sources. If industry had not been there, we still would be far, far behind from where we are now.

[It] is a hard thing, but we would not have come as far as we have today without companies investing large amounts of money in developing these technologies. Of course, they didn’t do it on their own.

Such conflicting sentiments were frequent throughout proponents’ interviews, often serving to qualify or disclaim their remarks, and can be seen as demonstrating their own sense of normative conflict. Thus, while they support the current development of the technology, most could not deny that there were very real problems associated with the role of industry in science.

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43 I will use the abbreviation “GMF’s” as a shorthand means of referring to genetically-modified foods.

44 Unless otherwise noted, multiple excerpts are from different respondents.
2. Costs/Benefits: Opponents of GMF's

Opponents shared proponents' ambivalence regarding industry's participation in the development of agricultural biotechnology. However—and as might be expected—their concerns tended to be somewhat more passionate and developed. That is, whereas proponents merely expressed uneasiness with industry's influence, opponents were likely to offer a detailed critique.

Industrial involvement has definitely been a mixed blessing...Of course, we need industry. We need the resources of industry to take an idea through to a product that will be of value. But on the other hand, I do know, from experience and from other people, that industry does put undue pressure on academic scientists as to the kind of, it becomes very goal-oriented work. Basic science is often ignored, and things come up which compromise a certain development. They tend to brush these things aside...See, the agenda of industry is very different to the agenda of academia. They have to make discoveries, make products, have patents, and make their profits. In academia, we're motivated by curiosity, basic science investigations, we have to publish, we have to get more grants to survive. So at times we can be pulling in opposite directions...

This rather moderate critique of situation is based on the same sorts of problems expressed by those opponents with stronger viewpoints. In general, the perspective of opponents seems to be more closely aligned with an idealized view of science as described by Merton (1942), while proponents take a more pragmatic view of the situation.

Since there is considerable overlap between opponents' remarks on this topic and some of the more specific topical sections to follow, the majority of opponents' remarks on the impact of industry will be reserved for the more detailed discussions to come. For
now, the following excerpt prefigures what emerged as a major theme among opponents: structural mechanisms of de facto censorship. These sorts of issues, significantly, are rarely mentioned among proponents

I think it has had a very negative impact, in general. The way I look at it is very much the way I think, let’s say, the Manhattan Project impacted physics, in that the promotion, the very deep political promotion of one specific way of understanding physics and doing physics and what is a legitimate experiment and what is not and what is a legitimate question and what is not because of the nuclear imperative [sic]. It’s being played out again in biology. I think there is a very pervasive perception that only certain experiments are allowed, only certain types of questions are allowed within science, and I think that’s very harmful in general.

B. Frustrations Regarding the Marketing and Promotion of Products

Merton (1973) argued that the normative structure of science patrols the borders of scientific autonomy and provides the conditions necessary for the pursuit of truth. Universalism, organized skepticism, disinterestedness, and communalism are necessary to maintain the objectivity of science, because “[the] authority [of science] can be and is appropriated for interested purposes” (Merton 1973:277).

Of the biotechnology firms studied by Blumenthal et al. (1986a), 52% reported that sponsoring university research enhanced their firm’s public image. In the language of Merton, then, by drawing on the authority granted to science—or relying on an increasingly outdated and inaccurate definition—their interested purposes become less evident, and they can claim their activities are “just science.” As Kleinman and Kloppenburg (1991:433) point out, this leaves “no legitimate epistemological rationale

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for the public to be frightened of, or opposed to.” Recall the words of former Monsanto chairman Louis Fernandez from Chapter 3:

The only thing that will stand in the way of achieving the full potential of our next golden era is that we will be thwarted by a public that doesn’t understand science or technology and that doesn’t trust us to use science wisely and with appropriate regard for the concerns of the public we serve…(quoted in Richardson 1985:44; emphasis added).

To the extent that industry conducts its business in the name of science, scientists seem to distance themselves from the consequences of these activities. Once again, these frustrations can be understood as expressions of normative tension.

1. Frustrations Regarding Marketing: Proponents of GMF’s

a. Rushing products to market

There was consensus among all respondents that industry is exacerbating their own public relations problems by rushing products to market, thereby increasing the likelihood of undesirable outcomes. It seems very clear from this that when scientific research becomes confused with financial investment, haste and waste are sure to follow. This also demonstrates the notion that industry has colonized science. The industrial definition of the situation has overwhelmed the scientific, and industrial concerns are preempting scientific concerns.

Notably, while many proponents recognize the irresponsibility of rushing products to market, they are nevertheless quick to normalize the practice or dismiss any food safety

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45 This topic will be explored in greater detail in Section F below.
issues. Hence, while proponents have well-considered concerns about the current
development and deployment of these technologies, their critique often includes an
apology for the demands of industry. Such apologies constitute a key difference between
themselves and opponents.

I deal with companies a lot..., I don’t see them doing things that are
grossly unethical, or even unethical at all. I see them...moving to market
fast because they want to get market share, and maybe they could’ve done
a little more science, that would’ve been nice, but I don’t see it being
gale problems [sic]. Of course, I get some money from companies. I’ve
got a conflict of interest there. But I can tell you, I wouldn’t take money if
I thought they were really doing something that offended my sense of
ecological decency... My feeling as an insider here is that it’s business.
It’d be nice if it was a little softer, but it’s working pretty well.

Monsanto is so far ahead of all the rest of them, and I think that’s partly
why Aventis pushed so hard to keep some market share in the corn market
by getting a product out that was only cleared for industrial or livestock
feed use and not human food. I think it’s just a natural procedure.

The second quote above is referring to Starlink™ corn,\(^{46}\) a genetically-modified
variety approved for animal but not human consumption which nonetheless found its way
into the human food supply. The following respondent, in discussing the same incident,
acknowledges that the product was rushed onto the market while at the same time
denying that this could have possibly been a food safety problem. Again, the proponent’s
critique falls short of a substantive critique of industry determining the pace of science.

\(^{46}\) It is worth noting the mass media context during this period. A variety of genetically-modified corn
(Starlink, developed by Aventis, the company formed by the 1999 merger of the German companies
Hoechst and Rhone Poulenc [RAFI 2000]) that was only approved for animal consumption and not yet
approved for humans had been detected in taco shells, corn chips, and other corn products intended for
human consumption. This was receiving significant media attention, and is referred to in many of the
interviews.
And I know the Taco Bell issue has brought a lot of people out saying, oh my God, they don't know what they're doing. But that wasn't a question of food safety. That was a question of compliance. And to me, it was very dumb to have approved something for animal feed and not human feed, because how were you going to police that...? It's an impossibility. They should not have approved it until they had approved it across the board...

On the other hand, there were some proponents who were quite frank about the requirements of industry. Both of the following excerpts paint a relatively unapologetic portrait of industry's position, and also allude to the financial liabilities which make such haste inevitable. The following remarks indicate not only that companies are competing with one another for market share, but that they are also desperate to recoup some portion of their immense investments in the technologies.

I've had some dealings with Pioneer and Micogen and Monsanto, and I think that they don't want to make any huge mistakes. They want to produce a product that they can sell for a long period of time that's not going to cause any big disasters. But they want to do the minimum that they have to do to get the government to sign off and say, yes, these things are safe. Go ahead and sell them and start making money on it. And they're rushing because they've invested so much money and they have to get a product out soon. So rather than wait for more data, or a better way of doing it..., rather than being curious or slowing down, it's a very competitive market, and it's driving things to move really, really quickly...

Essentially, then, proponents find industry culpable for the mismanagement of the products of their research. The last sentence of the excerpt above highlights the separate and even opposite agendas of science and industry, and illustrates that the frustrations of proponents often stem from the interestedness of industry.

There's been a rush to market way ahead of time, especially here in the South with the cotton...All of a sudden, here they are, and half the South's planted in cotton, and it's coming down in virus diseases. Again, it's just a combination of shoddy breeding with rush to market...I think it has to do
with the way financing is done in the United States in this day and age. They have spent. The investments have been really, really heavy, you know, upwards of a billion dollars. And if you want to keep your stock price going, you’ve got to have some recovery on that.47

b. Corporate arrogance and market manipulation

This debt-driven approach to science seems to create an atmosphere of desperation in the promotion of the products of agricultural biotechnology. This is evident in the ways those corporations heavily invested in the technology approached the marketing of their products. This was a very common frustration expressed by proponents. In attempting to manipulate the public, political, and commercial environment, these proponents feel that industry has only succeeded in helping to discredit the technology. This is again reflective of the gulf between the scientific and the industrial approach to the field of agricultural biotechnology. That is, scientists are enthused that their disciplines have been the recipient of corporate largess, but frustrated by actions taken by industry in the name of the scientific disciplines they sponsor. Consequently, proponents frequently condemn the more egregious actions of industry in the interest of salvaging the scientific foundations of the technology.

I think the biotechnology industry, I have mixed emotions about it, mixed feelings. I think industry has done an excellent job in advancing the cause of science. Some of these big corporations have spent a lot of money

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47 This point deserves some elaboration. Consider the following remark made by an opponent:

One of the interesting things about this is that a lot of their power comes from the size of their debt. Did you ever think about that? It’s amazing. The big banks around the world have invested so much in this, and stockholders and institutions and university officials have bought stock in it, so many people have so much riding on this that they back it even when it isn’t showing profits. It’s very interesting how much power can come from debt.
trying to push the frontier of this technology in terms of developing new tools and more enabling methods, technologies, and in a way that scientists really would not have advanced this rapidly without that very huge involvement from industry. My problem with industry comes in that they could have gone in a little bit more responsible manner in the introduction of the products, trying to bring in more awareness, especially in Europe. This became very contentious. They clearly misread the public perception issue.

Corporate disregard for the subjectivity of the consumer market seems evident in these remarks. The general approach appears to have been one of manipulation and deceit rather than, in the spirit of Adam Smith, offering a superior product at a competitive price. It is important to keep in mind that proponents' frustrations stem from being associated with the mismanaged introduction of these technologies by industry. These frustrations can be understood as expressions of normative tension, and express a sense of the loss of control over the utilization and public presentation of their research.

My criticism is that once people found out and once it hit the newspapers and the whatever, it is my impression that Monsanto in particular, perhaps there were other companies that did the same, didn’t take it seriously. They thought, oh well, we can just do this ad campaign and everything will be fine..., it'll be business as usual, and we just need to take care of these few little things. And because they didn’t take this whole thing seriously, I think it blew up even bigger than it would’ve been anyway.

I think the biotechnology companies failed to recognize the opposition that might occur and really didn’t deal very well with the issue of keeping the public at large or consumers well-informed. They developed kind of an arrogant attitude that got them in quite a lot of difficulty...I think they were a bit myopic. They were focused on their piece of the business. They didn’t do a very good business risk assessment...It could have been managed much better.

Significantly, one prominent proponent acknowledged the role of scientists themselves in alienating the public. This sort of scientific arrogance and even contempt
for the lay public has been well-documented by Wright (1994), Gottweis (1998), Noble (1997), and other historians of the field.

Yes, not only the biotech industry, but I think those of us who work in this field must share some of the blame because the attitude which most of took in this area of research and also talking to people and all that was that, oh, this is good science, we know that, and we don't want to bother and try to go and explain to people. And so the public was not really well-served in that sense and not kept informed, and so that's why some of these groups which oppose biotechnology, they were able to exploit that situation.

Thus, many proponents expressed strong reservations concerning the manipulation of markets and the bulldozing of any public uneasiness regarding the products of agricultural biotechnology. The following excerpts communicate the same frustrations—albeit without admitting actual risk—embodied by Zimmerman's (1995) more radical assessment: "Many complex technologies pose substantial hazards and risks...To impose such risks on people without even their tacit consent is undeniably an act of tyranny."

Monsanto ended up cramming the stuff down the throats of the European people, when they need to have an international relations department or something to help them get sensitized. Instead of that, they were doing the cowboy thing.

I think that there had been years of investment and here was now a chance to get a return on that investment...And then I think Monsanto took way too heavy-handed an approach in trying to drive their products into the marketplace in Europe, and it just ticked the Europeans off, including very thoughtful people, people that I know from my own profession that said, you can't believe how they treated us. I think Monsanto has to take full responsibility for that.

[Industry] has not played this well. There's been an incredible arrogance on some of the biotech companies [sic]...I would say they have to share the lion's share of the blame, in particular a couple of those companies. Strong-arm techniques...There was just this sort of sheer arrogance pushing it.
Given such remarks, it almost seems unlikely that these scientists would nonetheless identify themselves as proponents. This may be interpreted as a means of balancing the contradictory agendas of science and industry. In other words, a major criticism that has emerged from proponents is that although agricultural biotechnology is based on "good science," the involvement of industry has resulted in a reckless and bullying approach to the introduction of the technology. My impression—intended as analysis and not dismissal—is that proponents wish to maintain both the industry-driven pace of their field as well as the respect traditionally accorded to scientists, and so they distance themselves from the interested and hasty activities of industry.

In the absence of the pressures created by competition and the shareholder imperative, it is unlikely that agricultural biotechnology would have been perceived by the European public as having been force-fed. In other words, if agricultural biotechnology had emerged only from publicly-funded scientific institutions, its introduction, however much slower, would not have been premised on such market-driven urgency. In the current context, proponents are offering accounts and engaging in role distancing, and this can be seen as evidence of their own normative conflict.

There is a second consideration regarding industry's approach to marketing that is worth noting. While most criticisms of industry's marketing strategy focus on corporate arrogance at the level of the consumer, some proponents point out that companies view their market in terms of farmers rather than consumers. While this may be the case, one respondent also noted the manner in which companies were treating their immediate
market, the growers themselves. This is representative of an effort to enforce their newfound proprietary rights over seed germplasm, and demonstrative of the legal peculiarities which result when attempting to treat science, and seeds, as intellectual property. Other such ramifications will be explored below.

Some of the tactics used, like when farmers were stealing seed, announcing their names over the radio, you know, you knew that was going to backfire. In Canada, that was one of the things that really got some of the foundations going. You’re not allowed to save your own seed. Nevertheless, they’re charging so much for it that it’s very tempting to keep your own seed anyway. So they have been going around and they have been testing and if they find a farmer who has Roundup Ready canola in his field, of course they would start a lawsuit. But at one point they were literally publishing the people’s names over the radio as a deterrent. And of course this backfired big time.

2. Frustrations Regarding Marketing: Opponents of GMF’s

In considering the impact of industry on science, proponents were quick to point out its failures in terms of the introduction of the products of agricultural biotechnology to the public. This, along with their frustrations about proprietary science (Section D), constituted the main themes of proponents’ critiques of industrial involvement in agricultural biotechnology. While opponents certainly shared these concerns as well, they had much less to say in this regard specifically and were much more likely to voice dissatisfaction over the actual corruption of the scientific ethos in the form of structural censorship (Section E) and the domination of science by industry (Section F).

48 Also recall the case of Percy Schmeiser discussed in Chapter 3, wherein a Canadian farmer was sued by Monsanto when they found traces of their proprietary Roundup-Ready canola in his fields, which he claims drifted there via pollen from neighboring fields (RAFI 1 April 2001).
Nonetheless, opponents did articulate frustrations with industry’s hasty approach to the release of GMF’s.

It is possible that agricultural biotech could just collapse. I think that’s possible...because they have really screwed up...It’s not just Monsanto, but they’re an easy scapegoat for a range of companies that have been very aggressive in terms of pushing projects through too fast, paying off regulators, the revolving door sort of thing, and heavy-duty political lobbying...

The major difference is that opponents offered no serious apology for the commercial demands of industry. Proponents perceived the issue in terms of a rash and clumsy approach to public relations by an industry increasingly desperate to recoup their investments. Opponents, on the other hand, were more apt to view the situation as the result of cold calculation by an industry intent on controlling the intellectual property underlying the world’s food supply. Indeed, the portrait of industry offered by the following opponents is exceptionally disturbing.

Industry’s gambit is clearly, or was, I don’t know whether it still is, to actually have the whole thing sewn up, on the market, no choice, and that’s the way it’s going to be guys, and that’s a bit tough but sorry. I think Monsanto, if you sort of sent some trainee advertising agent to go and design an appalling campaign, the worst you can possibly think of, they’d’ve done well to match that.

I think that this week’s *Nature* had a good, interesting article about the development of biotechnology, in particular crop biotechnology. They pointed out, and I think this is not just the European view but I think it’s widely accepted, the practice in the field has been dangerously careless...This is, in part, in reality, a strategy by some quite ruthless bureaucrats, agricultural and scientific bureaucrats, but mainly agricultural, who feel that they can get this genetically-modified material widespread under the table...To me, I think it’s not an accident. We’ll ultimately show that it was probably a conscious effort to get the material spread across the boundaries under the table.
In sum, proponents are likely to contextualize their concerns within the requirements of industry, and they thereby engage in considerable accounting and distancing. Opponents, on the other hand, were likely to condemn the involvement of industry in science altogether. Perhaps because they were not trying to reconcile contradictory normative structures, they had less to say in this regard. In either event, it is quite clear that regardless of a respondent's point-of-view, all recognized that industrial involvement in the development of agricultural biotechnology has come with certain costs to the practice of science.

C. Market-driven Science

1. Market-driven Science: Proponents of GMF's

This analysis seeks to examine the nature of the relationship between science and industry. It is apparent that this is not a relationship between equals. Instead, industry has considerably greater influence over science. This is recognized by most proponents, and their concerns can be grouped into two general categories: the emerging oligopoly possessed by companies pursuing agricultural biotechnology, and the consequent inevitability of "orphan crops," i.e., important and useful crops that are abandoned because they do not promise sufficient profitability.
a. Proponents: Oligopoly

At one side of the spectrum of proponents, there are those who fully recognize the emerging and concentrating oligopoly but dismiss it as not worth any attention or cause for concern. This is a minority viewpoint, and is not typical among proponents.

Now of course, food and agricultural production is already highly centralized and concentrating prior to biotechnology. But it’s another step, right? It’s one more step in that direction. So is that a social concern? If there’s five major seed companies in the United States rather than ten, is that a big issue? That’s kind of what we’re looking at, right, with biotechnology. It’s not just Monsanto, there’s several of them. Personally, I don’t think it’s a gigantic issue.

Much more common among proponents was a viewpoint that not only recognized the situation but also expressed discomfort with the increasing domination of the technology by private companies.

I think there’s six companies that almost completely dominate this technology, and I don’t think it’s healthy for any industry to be so dominated by six companies...I don’t have a problem with the involvement of industry. I have a problem with the complete domination by the private companies. I think an industry’s healthiest when there is strong representation of both the big companies as well as smaller companies, and also the public sector, government and university people as well. But that isn’t the case with biotech at the moment.

As well, some proponents are aware that the oligopolization of the industry has happened concurrently with the decreasing proportion of research funds made available by the federal government (see Figure 1.1, Page 5).

Even before industry invested in this technology, they invested in plant breeding. The proportion of plant breeders, public to private, has flip-flopped in the last thirty years, maybe twenty I think...They poured money into it. The public sector has not put as much money into agriculture and agriculture research.
A likely explanation for the massive increase in private research is the patentability of genetically-modified crops. As discussed in Chapter 3, the U.S. Supreme Court (1980) decision *Diamond v. Chakrabarty* had the effect of opening up the microscopic territory of the seed germplasm for ownership, investment, and capital accumulation. Specific problems associated with the proprietary nature of agricultural biotechnology will be explored in Section D below.

I think that the patenting of genes and the profits that, you know, the reason why all these companies are pursuing these technologies, is what's definitely driving. I mean, we never had agriculture be so affected by private industry and companies to such an extent as it is now. So it's got to be, you know, profits have a huge role there, and it's just really weird that plant breeding has shifted from schools like Ohio State to chemical companies and big huge seed companies now.

As discussed earlier, it was sometimes rather bewildering to listen to the critiques and condemnations made by respondents who nevertheless identified themselves as proponents. For instance, the following respondent recognizes that the more that agricultural biotechnology is controlled by industry, the more that research will ultimately be about profitability rather than "the public good." He is not comfortable with the situation, he is aware of its consequences, and yet he supports the technology.

I think that there is a fear that the private sector will have a bigger control over our declining number of farmers. I personally have a fear for this continued concentration, this vertical integration, as it's called. But what is not fully appreciated by those that are nervous over this (and I have seen what's driving this concentration), believe it or not, it is the need to merge the R&D parts of the companies... Well, we've driven them to that because we've been cutting out public sector R&D and saying the private sector will take over, and the private sector, in order to get the job done and maintain some sense of return on that investment, because their investment is driven by an opportunity for profit [sic]. It's marketplace-driven, and they're not going to just do things (they will to some extent)
for the public good, but for the most part they’re accountable to shareholders. And it’s not been working, it’s just not been working.

b. Proponents: Orphan Crops

In exploring the potential consequences created by the commodification of seeds, Buttel and Belsky (1987) and Busch et al. (1991) cautioned that a research agenda determined primarily by the interests of private capital risks leaving many locally useful crops and potentially serious agricultural problems uninvestigated (cf. Heisey et al. 2001). As well, because agricultural biotechnology corporations have also systematically bought most seed companies around the world, certain crops could simply be—and are simply being—abandoned (RAFI 17 July 2000). The following respondent speaks of this problem on a general level:

There’s been a sheer arrogance of preventing their technology—this reflects all the biotech companies—from going to help. You know, there’s certain crops that they’re never going to make a profit on. The market’s not big enough, the crop’s not important enough, the trait’s not important enough, so that these companies are never going to touch these particular crops. Nevertheless, these are crops that would be very useful to local communities or farmers on the regional level. And yet, they refuse to allow their technology to be used for these traits, the so-called orphan crops. So that has contributed to a lot of bad blood.

Markle and Robin (1985) argued that commercial application could become the primary or sole criterion of problem selection in genetic science, thus altering the agenda and practice of science and “reconstructing” genetic science on the basis of commercial requirements. “[The] business of biotechnology will promote, and probably co-opt, and

49 In 2000, the top ten seed companies controlled approximately 31% of the worldwide commercial seed market (RAFI 2000). Limited to vegetable seeds only, just five companies control 75% of the global market (RAFI 17 July 2000).
thus alter the *science* of molecular biology (Markle and Robin 1985:77; emphasis original). Thus, while corporations and the academic scientists they are funding “go to great lengths to stress the intellectually driven nature of the projects being funded” (Etzkowitz and Webster 1998:61), this ignores the fact that this research trajectory is proceeding at the expense of other less-profitable directions.

Proponents tend to suggest that these “orphan crops” should be the proper focus of public sector research (Heisey et al. 2001). On the surface, this seems like a reasonable solution to the situation, and yet as we will see in the next section, companies can patent the *techniques* of agricultural biotechnology as well as the products, driving up the cost at best and preventing their utilization at worst. For now, these serve as useful examples of what types of agricultural problems are being ignored by industry.

[The] public sector needs to come in and fill voids that are still being left by the private sector. One of them, for example, is the threat to the California wine and grape industry of this Pierce’s disease, which is a bacterium that plugs up the plumbing of the plant, and it’s carried by this glassy-wing sharpshooter insect. It’s been around for a long time, and traditional technologies have not been able to bring it under control. They’re looking at the new biotechnologies, including genomics, to understand the entire genome of the plant, the insect vector, and the bacterium...Now the private sector is not going to invest big time in the control of this disease, and yet it’s clearly in the public interest to protect that wine industry in California...

As well, the following respondent summarizes the publicly-funded research in which her organization is currently engaged.

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50 Alternatively, Battel & Belsky (1987) suggest that the private sector will pressure public sector researchers to focus on major crops through grants, contracts, consulting, and legislative pressure. It is not uncommon in this industry for public funds to indirectly pay for private research.
We just got a million dollar grant to study cow peas and genomics in Africa. It’s very, very important in Africa, and there is zero payback to industry...The objection to biotech is more than a question of the, if you like, fear of harm from either a food safety or an environmental point of view. Really, that big perception there, that it’s owned...by large multinational corporations...So this one, the cow pea, would be of zero interest to industry, because it’s primarily, it’s a major crop in Africa. 17-19 countries there completely depend on this for both animal food and human food, but there’s very little done on it because literally there really isn’t any money to be made out of it.

2. Market-driven Science: Opponents of GMF’s

In this particular theme as well, opponents had less to say than proponents. Once again, the perception among most opponents I interviewed is that industry is having a negative impact on the institutions and ideals of science. They were less likely than proponents to discuss the specific problems that emerge from the involvement of industry as issues to be dealt with than they were to discuss them as evidence that industry is corrupting the goals of science and mishandling the technology as a means of market manipulation.

And the thing is, at the minute, the pace is being pushed by financial arguments. All the big companies are saying, and the government over here, you’ve got to be in here. This is the big industry of the next century. And if you’re not up front, we’re going to lose out. That’s the driving force...I mean, I know what the benefits of gene technology are, and I realize it’s a very important technology. I just don’t feel yet that the time is right to be rushing out and planting millions and millions of hectares of things of unproven safety. With the Roundup-Ready canola that’s resistant to Roundup, the seeds can overwinter, which means that in the spring they grow, and if the farmers use crop rotation, wheat the next year, then they’ve got Roundup-resistant canola in their wheat fields, and it’s very expensive and difficult to get rid of that weed, which is something

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Cow peas are also known as black-eyed peas.
they should have thought about ahead of time. Maybe they did, and someone said, well, the company wants to sell other herbicides.

It is unreasonable to expect corporations to act in any other way than the way in which they are organized. A corporation is an institution organized for the purpose of delivering profit to its shareholders. Any claims by corporate representatives that their company is engaged in anything other than this (or any expectations by critics that corporations do anything other than this), can be dispensed with immediately. Given such structural limitations, some opponents recognize the socioeconomic difficulties that are emerging as the science of manipulating the seed germplasm becomes a tool of corporate profit and competition.

[If] GM crops ever became dominant, then it places the entire food supply in the hands of a few multinational companies, who openly admit that their prime objective is to make as much profit as they can. Now, that means they don’t really care, basically…Monsanto, I believe..., has developed a canola with a gene from the bay laurel such that it has a lauric acid content. So in other words, the oil composition, the fat composition of canola oil has been altered, which makes it look more like palm oil. So where you used to use palm oil, you can now use this canola oil...[At] the moment, of course, palm oil is imported into the United States from the Far East in the palm plantations in Indonesia, Malaysia, and that sort of part of the world. And those farmers, their whole livelihood is dependent upon the export of the palm oil to North America and Europe. Now if this canola really gets off the ground, and it means that you can displace the palm oil with this canola oil, it means that those people now end up having their total [livelihood] destroyed, and they now end up in poverty. Does Monsanto care about that? They clearly don’t, otherwise they wouldn’t be producing this product in the first place...

With this marriage of science and industry, decisions about marketing and profitability are having to be made concurrent with decisions about safety, reliability, and the public good. If it is the case that industry has hegemony over science, then these decisions are more and more likely to reflect the industrial definition of the situation
rather than the scientific or the civic. The disinterested, objective stance of science is simply being used as the public face for corporate profiteering.

What is more, the following respondent describes how governing institutions, who might have functioned to balance the contradictory impulses of science and industry, may have ceded its role to the requirements of capital as well.

[Whether] I like it or not, or whether I’m skeptical or not, whether I’m against it or not, I just say very simply that this is an unproven technology and its effects have not been proven either...Shapiro said a couple of years ago that in ten years time everything will be genetically-modified. If you add all that up on a case-by-case basis of looking at [risk assessment], that’s a lot of dollars. That would certainly cut into the profits of this industry. And they are not very willing because most of the governments, including our own here in Britain, have invested heavily (our pension funds and all that) into biotech shares, therefore it is not in their interest either to cast any doubts on it. But I just still have to say that I’m a scientist, I look at the facts and make up my own mind. Like or dislike doesn’t come into it, I’m afraid.

This financial path dependency limits the practical options that a scientific or government institution actually has. To the extent that economic well-being is dependent on the success of these technologies, the likelihood of discouraging the dissenting voice increases, and this constitutes a major theme among opponents. For those involved and invested in the technology, as the following opponent recognizes, this approach frames their understanding of the situation, and can be understood to account for the gulf in the debate.

Probably for them, the quote responsibility of taking care of the investors’ money, of the responsibility of being the best possible steward for the investors’ money, is the overall justification. And maybe that’s really their deeply held belief and feeling about things. And on one level, that is to be respected, but if you don’t incorporate other dimensions, then I don’t think it serves, it certainly doesn’t serve, the larger purpose.
D. Proprietary Science

While the ideals of science as described by Merton (1942) are certainly limited by professional competition, personal ambition, epistemological cliques, and other human characteristics, they nonetheless serve to protect against practices such as the restriction of information flow as a general practice, thereby maintaining "innovative vigor" (Grobstein 1985:56). The business worldview, on the other hand, encourages the restriction of information, using trade secrets, or the restriction of its use, with patents, as strategies for protecting investments.

The norm of corporate secrecy is overwhelming the norm of scientific cooperation. Nelkin (1984) reported on instances at scientific conferences wherein scientists refused to give details of their techniques due to proprietary concerns. Additionally, Blumenthal et al. (1986b) found that 41% of the biotechnological firms reported that their funding of university research had resulted in at least one trade secret. At the same time, industrially-sponsored researchers were four times as likely as their non-industrially-sponsored colleagues to report that their research had resulted in trade secrets. Furthermore, 44% of industrially-sponsored researchers reported that university-industry research relationships risked undermining intellectual exchange and cooperation, while 68% of non-industrially-sponsored colleagues agreed.

A technology is fundamentally a technique devised by humans for understanding and/or manipulating the natural environment. As discussed in Chapter 3, intellectual property law seeks to motivate innovation in technique by guaranteeing rewards. With
agricultural biotechnology, however, the notion of "private knowledge" undermines the practical utility of the technology, not to mention a core component of the scientific ethos. We have seen how a proprietary technology directed only by commercial concerns can leave many areas of potentially important research entirely unexplored. In this section, we will see how such a proprietary science can in many ways act as an ironic hindrance to the pace of scientific innovation.

1. Proprietary Science: Proponents of GMF's

The proprietary nature of the technology was the most common frustration cited by proponents. The following proponent, however, sees no alternative. As will be shown shortly, this is a major point of difference in the nature of concerns cited by opponents. They perceive alternatives, which are generally perceived as quixotic by proponents.

[If] a company isn't in the position of being able to reap the returns on the massive, and it is massive, investment that they make in the science, then it's never going to be done, so it's never going to get out there. So to me, to the question is really what is the cost of not doing this, or what is the cost of making it such that nobody will do this type of research? It would be wonderful, gosh, it would be wonderful if it could all be free and available, but the reality of the market economy is that for these industries to survive, they are going to have to be able to pay their researchers and pay their investors.

It is clear from examining the above excerpt that at least for this respondent, Etzkowitz's (1989) normative transformation is entirely complete – proprietary science is taken for granted. Nelkin (1984:11) warned almost twenty years ago that "the commercialization of molecular biology may be eroding the pattern of open
communication and exchange of information essential in this field.” This prediction has been realized. Proprietary science has become the norm.

Seeing no alternative to the given, the content of proponents’ criticisms often becomes little more than highbrow complaining. Echoing an earlier theme, they are enthused that their disciplines have become so well funded, yet they find the unsharing of scientific information to be a considerable obstacle to technological advancement. The following respondents discuss the proprietary problems associated with the production and release of “Golden Rice,” a variety of rice genetically-modified to contain Vitamin A, and marketed as the solution to childhood blindness in the Third World.

'It's] very, very frustrating for someone like me to try to study the risks when it’s all confidential business information, and these companies don’t, they’re not very open. It’s difficult to see what kind of information they’re submitting to USDA when they try to get their crops approved and things like that. And then from the point of view of Third World countries, a lot of these very useful genes are tied up in patents, all these multiple patents that have to be approved. Just to get the Golden Rice out to be used by anybody who’s growing rice for subsistence level use, there’s so many patents that have to be cleared.

[What] we did to ourselves was create a nightmare of patents and patents on patents. You might have heard that the technology used to produce Golden Rice has infringed on something in the neighborhood of scores of different patents that would have to negotiated for license agreement…, and that’s a nightmare.

But on the other hand, I mean, for me as a scientist it’s still very difficult to understand why you should be able to patent a gene. And I’ve been involved a bit about all these problems they’ve had with the Golden Rice because of these patents, and that really makes it for me very difficult to be able to work for something that would actually go out into the field eventually if you have to take care of all these patents. So I think that’s not only something that bothers activists but also scientists because it just makes it so complicated and we’re not used to dealing with that. But on the other hand I also see that it’s important for small companies to be able
to patent their things and to make a profit from it, because that’s what they do, so I think, yes, that is something very difficult.

Thus it seems clear that proprietary technology hinders the utilization of the technology. Additionally, the financial dynamics described above spurred the largest companies involved to simply buy out smaller companies in order to consolidate and control the intellectual property. It becomes apparent, then, that oligopolization and its consequent problems were all but inevitable as soon as it was decided that genes and biotechnological techniques could be patented in the first place.

[Because] there was such proliferation of patents and claims of ownership on genes, when you actually started to make a new variety, you would owe this company something on that gene and that company something on this gene and another company something on a promoter of the gene. Some of these companies were small, they were innovative, and they had intellectual property ownership, and so the big companies went and bought them out so they would own the technology and get it all put into one place. It was just simpler than to negotiate fifty different license agreements to buy fifty different companies and just own them.

Because the “enabling technologies” are proprietary as well, it threatens to increase the gap between private and public sector research. In explaining the approach taken to research by the biotech industry (which is not necessarily typical of all industries), the following respondent describes how this greatly increases the obstacles to effective public sector research. This respondent also proposes a reasonable alternative to the current situation.

You develop technologies, you use those technologies, you think what you want to do, you create something, but every one of those steps along the way is protected. It makes it almost impossible for anybody in the public sector to start from A and go all the way to Z and create a product. And so, what I would like to see is I would like to see enabling technologies all put in a basket in the middle of the room, and when you need one of those to create your new plant or new food or whatever, you go to the basket and
you pick out what you need and you go back to the lab and you do what you do, and when you get your product, then you protect it. You don’t protect all the things in the basket. That’s what I would like to see as the way we move forward…[T]hat would be my wonderful paradigm for the future.

2. Proprietary Science: Opponents of GMF’s

At the most straightforward level, opponents simply expressed discomfort with the premise behind an agricultural biotechnology that is more or less owned and directed by industrial concerns. In contrast to proponents, they are unable to convince themselves that they are still working for people rather than for profits.

I guess about thirty years ago, a good part of the funding in my area came from governments, and it was research done for the common good. I guess in Canada a good example could be the development of the crop canola, which was developed for prairie farmers so they’d have an alternative crop to wheat, so that if wheat went bust they’d still have an income. And we spent about thirty years to develop canola, to get rid of some of the poisons which are in rape, which is the wild relative…Monsanto took our crop and put in a gene so that the canola is resistant to Roundup…So we now have Roundup-Ready canola, which the farmers have to pay to use the patent, and have to make promises about not saving the seed and planting but going back to the company and buying it every year. So instead of something for the common good, it’s something for the profit of the company.

On the other hand, opponents shared an awareness with most proponents that proprietary science hinders the utilization and advancement of these technologies. The primary point of difference here is that whereas proponents see this as cause for frustration, most opponents see this as cause for resistance. It also seems that the perceived mechanism of hindrance for proponents is mainly the problems associated with
intellectual property law, whereas for opponents it is mainly the damming of the flow of
scientific information and the consequent stagnation of knowledge.

Forget about genetic engineering and just look at what’s going on in
medicine and the increasing ties of industry with medicine. There’s some
scientists who are being sued because they were testing a product for some
company and they found that it was ineffective and they published that
and the company is suing them. That sort of thing is happening…Medical
ethics traditionally have been that if you’re doing experimentation on
human subjects and there are any adverse effects, you have to share this
with the medical community so that knowledge is part of the system of
science. It would help save lives for people to be alert to the fact that
there have been side effects. Also, it’s in the spirit of the free exchange of
information in science. Anyway, the corporations were lobbying that this
information was proprietary. Even failed experiments would tell too much
about what’s going on. They’ve really been pushing for industrial
confidentiality, whether it’s non-genetically-engineered pharmaceuticals
or whether it’s genetic engineering.

Opponents are becoming alarmed, in other words, because those norms which
characterize the scientific approach are being undermined by their close associations with
industry. Without a free exchange of information, individual scientists are prevented
from acting from a point which encompasses the available knowledge about a given
object of inquiry. The consequences of this run deep, for as Longino (1990:90-1) notes,
“[such] privatization of knowledge cannot help but influence the development of
knowledge if only by insulating mainstream investigation from discoveries in classified
and ‘privately held’ inquiry.” Intellectual property, proprietary knowledge, private
science, these are terms that run contrary to what these respondents had hitherto
recognized as science.

I think in general it’s had a negative impact, a profoundly negative impact
on the speed and accomplishment in this field because, in general,
information has become so much more proprietary. At the time I was a
student and throughout most of my professional career, why, we
exchanged strains of molecules and information freely, and it was just expected...Beginning when the possibilities of patents became acceptable, then this whole process stopped. Publication became much more proprietary both within the university and within the companies that it cropped up...The emphasis of research became much more attuned to what was commercially viable in the short run. From a technical point of view, that did, I think, stymie information flow a great deal. It did really stymie both information flow and the development of ideas...

The following respondent describes a personal experience with private science at a conference on the human health impacts of agricultural biotechnology.

[For] the first two days of the meeting, we weren’t allowed to ask any questions. We had to sit and listen, and then at the end of the two days, there was a half a day, and we were allowed five minutes each to present our briefs or ask our questions. And I asked three questions, and that so upset them that they hired three consultants, all who were in business with biotechnology companies, with huge salaries to answer my questions. They would answer them within three months, and two years later they still hadn’t answered them and finally they said they’d answered them but we won’t let you see what their answers are. That’s proprietary.

The industrial approach views knowledge in terms of profitability. To the extent that the scientific approach does not threaten this directive, there is no contradiction. However, in pursuing truth, science requires all the information available, and so is inherently contradictory. As well, due to the immensity of industrial investment, financial pressures have been created which encourage the creation and marketing of products of agricultural biotechnology as soon as technically feasible. As already discussed, proponents and opponents recognize this.

Significantly, none of the opponents interviewed were necessarily against the technology itself. Rather, they were against the manner in which the technology was being handled. In this new-fashioned system of proprietary knowledge, opponents argue that the technology has stagnated at a very early level of development. That is, while its...
rapid development thus far may be attributed to the involvement of industry, so may its relative lack of development. The implications of this dynamic are difficult to overstate. As Blumenthal et al. (1986a) found in their survey of biotechnology firms, the primary reason companies invest in university-based research is to keep current with significant new research. However, the irony of increased industrial involvement is that the undirected, basic research that companies wish to keep abreast of suffocates in the presence of immense industrial investment. This is congruent with McNally and Wheale's (1998) arguments that patenting and the consequent monopolization of particular fields of biotechnological invention ultimately creates disincentives to further R&D investment. Innovation thus slows, and the technology stagnates. The following respondent discusses this dynamic:

[We] have got a very imprecise and extremely unpredictable technology whose effects and health effects and environmental effects we cannot actually predict. And this technology...has inhibited scientific inquiry into other more precise methods of genetic modification...We have an imprecise technology, and because it was relatively successful, and because it's been patented, therefore it does inhibit the development of further, more precise genetic modification methods...and there are other methods of trying to do it, but there has been no money forthcoming for it...So, this is the main point. I'm not on religious ground or any other ground. What I do hate is poor science, and this is poor science. I resent that everybody tells me that I'm a Luddite because I ask for more science and not less. I am not in the pay of those companies who are likely to benefit from this, or who are already benefiting from this business. They should have done a proper job. They have not done it. In their huge rush towards who will be the first to patent and get it out on the market, they just cut corners everywhere.

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E. Structural Censorship

Industry has not been embracing the ideals of the now-antiquated scientific ethos. Rather, industry has been the force antiquating ideals such as disinterestedness and communalism. Thus far, we have seen how the relationship between science and industry appears to be one of co-optation rather than cooperation, of colonization rather than reciprocal exchange. This section, as well as the next, will explore those mechanisms of information control that more or less prevent scientists from pursuing research or even asking questions that might threaten the investments made by industry. Very significantly, the comments both in this section and the next are composed almost entirely of opponents. Perhaps predictably, these are themes which did not tend to emerge during interviews with proponents.

1. Structural Censorship: Proponents of GMF’s

Among proponents, there was a near-complete lack of recognition that there might be any sort of structural censorship occurring to stifle the opposition. As will become shortly apparent, this is utterly contradictory to the perspectives and experiences of opponents.

I haven’t encountered anyone saying that they thought their grant was in jeopardy if they came out with, well, let me careful here. I certainly support any scientist who has a criticism of the technology if they have research evidence indicating that there is a hazard that had not been previously reported or was underreported. The whole purpose of most of these grants is to find out just what are the hazards. I haven’t heard any

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52 Of course, reciprocity does exist at the level of exchanging resources for expertise, but at the level of culture and meaning, the relationship is almost entirely unidirectional.
scientist, in my experience anyway, say that they were afraid to release negative findings.

On the other hand, there was one proponent who was impressively frank throughout the interview. What follows is an exception to the general pattern, and is much more typical of the perspective of opponents.

I'll give you a little historical perspective on what it's been like as a scientist, which is that starting around 1993, when I got my first grant to study these issues, people who raised any questions about the safety of GM crops were not welcome at meetings and were not given very much funding and we kind of felt suppressed and unappreciated. I got a grant, but it was only because the USDA was forced to give 1% of the funds they have for biotech research to risk assessment, and that was something that they were forced to do by law.

2. Structural Censorship: Opponents of GMF's

As Ashford (1983:20) insightfully pointed out, the health of academic freedom may be indicated by “the extent to which a university permits a meaningful diversity of viewpoints,” rather than by measuring the influences on some mythology of neutrality.53 Thus, when scientists report that their viewpoint is not only unwelcome, but also worthy of punishment, then academic freedom can be understood to be fundamentally threatened, if not destroyed.

The issue of structural mechanisms of censorship was discussed in considerable detail in nearly all interviews with opponents. They exhibited a surprising degree of awareness of the sociological dynamics surrounding science. Consistent with Longino’s (1990) and other analysts’ perspectives on the scientific enterprise, opponents perceived
the evitability of the directions in which their disciplines were moving, and that those directions were either directly or indirectly determined by industrial interests.

I think the funding, the mechanism of funding. They have an idea what industry wants to have funded, so they write their grant applications to answer questions that industry wants answered. So industry in a way is directing their research.

This is consistent with Blumenthal’s et al. (1986b) findings in which 30% of industrially-sponsored biotechnology researchers reported that the direction of their research was influenced by the likelihood of its commercial application. Additionally, 70% of industrially-sponsored biotechnology researchers were concerned that commercial involvement would shift attention toward applied research, and 78% of their non-industrially-supported colleagues agreed. The following respondent discusses these concerns:

I think, yes, to a degree, scientific integrity has been jeopardized by the overt commercialization of the discipline and the close associations of academia with industry. It’s not right out there in the open, but anecdotal incidences clearly indicate that. And in fact, in a newspaper article, there was a survey conducted in the U.K. last year, which was reported in one of the main daily newspapers here in England, where they surveyed somewhere between 1,000 and 2,000 scientists, and 30% of those scientists said that they were asked by their sponsor, mostly industrial sponsors, to present their work in such a way that it did not put a bad light on the project, so it didn’t compromise the project and its potential commercial value.

The situated knowledge communicated by the foregoing respondent is supported by Webster and Packer (1996), who have shown that commercial interests shape the speculations made in the concluding section of papers related to biotechnology. Thus,

Longino (1990:80) has also commented in this regard: “[The] greater the number of different points of view included in a given community, the more likely that its scientific practice will be objective.”
industry is indirectly driving biotechnological research due to an awareness of what sorts of research questions are likely to be funded. It also appears that industry wields some direct influence over how those research results are presented. The consequences for resisting this kind of direction will be explored shortly. For now, it is important to examine those elements of the structure of academia itself which make it difficult for scientists to ask certain questions or to argue against certain assumptions.

I know there are other critics out there. I know they all don't think it's great. But it's just the positive people who seem to be speaking up... Maybe grants. If you criticize it, you mightn't get grants, or your department chairman might not like you if you criticize it... These things happen in science too.

[Fine]-scale censorship... really pervades the whole establishment. Funding, publication standards, and peer pressure and review, all conjure up to produce a very tense environment for anyone who decides to look into questions of risk, look into alternatives to industrial, biotech-based agriculture or medicine or whatever. So yes, I think it has had that very strong negative impact... The funding, publication, the peer-review process, and allocation of space, description of jobs, and so on. It's a very complex, very subtle mechanism.

Hence, the same structures which make innovative research possible and which are supposed to ensure validity and reliability can also function as mechanisms of social control (Longino 1990). As well, the shifting structure of academia itself, wherein tenure becomes more rare and short-term contracts become more common, has the effect of discouraging dissent. Krimsky (1984) has cautioned that increased industrial involvement may cause junior faculty without commercial involvements to be reluctant to speak their mind on issues which may displease senior faculty, who may have financial interests. The following respondent reflects on this dynamic:
I went to a meeting in Berlin a couple of years ago on the safety of novel cultivars, and there were 300 people there, and there were about four of us asking questions for the whole three days...And these other people said nothing. I found that absolutely astounding, but instructive. There are a number of reasons, aren't there, I think it's happening in the States as well, but most young people in academe now are on short-term contracts. The degree of people who have tenure who can feel reasonably safe in speaking out what they think is reducing, and the number of people who are in academe who are strapped into a tight confidentiality agreement and things like that is also increasing.

If these descriptions are accurate, they provide a compelling reason why I found it more difficult to secure interviews with opponents than with proponents. This may also explain the relative scarcity of scientists willing to offer a dissenting voice.54

Well certainly, when it comes to things that are, especially that are politically sensitive..., then many scientists are, do keep their heads down, because they know that if they say something which embarrasses their institute or could compromise their position, several government grant-funding agencies, then they will tend to keep their heads down...This is why you'll find...most scientists who speak in public are those that are for biotech developments. Very few are raising a cautionary view. But I can reassure you that I come across scientists regularly who in private will admit to you that they're very worried, but they just feel that they're not in a position, for one reason or another, to say anything in public.

This foregoing description demonstrates Krimsky's (1984) observation that because university-industry research relationships typically involve influential faculty, they can potentially bias the collective judgement of an entire field of research. As the following

54 As of 7 March 2002, 3330 scientists had signed a “Declaration of Scientists in Support of Agricultural Biotechnology” (http://www.agbioworId.org/PHP/index.phtmI) while another 457 scientists had signed the opposing “Open Letter from World Scientists to All Governments Concerning Genetically Modified Organisms” (http://www.i-sis.org/list.shtml) as of 1 September 2001. Since the institution of science does not generally operate according to democratic principles, the only thing these decidedly unscientific tallies demonstrate is that there is significant scientific disagreement over the current development and deployment of genetically-modified organisms.
respondent explains, such *interestedness* in the success of these technologies creates undeniable conflicts of interest:

They’ve done so much to influence things like the National Academy of Science and you know, there’s fear now in the community of science. There’s fear to be critical of it. People are afraid they’ll lose their grants. They’re afraid the president of the university will ostracize them. There’s an awful lot of power being thrown around right now and it’s creating a very unhealthy climate in science. I’m against that; that doesn’t mean I’m against the technology itself, what goes into the test tubes.

In describing their view of the debate, some respondents drew parallels to historical events that cast the current controversy in a disturbing light. One respondent compared the situation to Lysenkoism\(^5\) in the former Soviet Union.

It been a lot like Lysenkoism in the Soviet Union. There’s sort of a party line...There was a fellow in Stalinist Russia named Lysenko..., and he had an enormous effect on the development of science in Russia. People were afraid to take points of view and to do research in areas with an underlying philosophy that was not Lysenkoism. There was fear in the scientific community. Basically there was kind of an orthodoxy in their science...and I think we’re sort of getting something like that in this country, in the West...You have to believe certain things or else you run political risks on your campus.\(^6\)

Combined with the near-complete dismissal of critics by proponents of these technologies, considerably enhanced by the force of their scientific expertise, it was sometimes difficult to hear descriptions such as this and not get the impression that this is all conspiratorial paranoia. Indeed, critics themselves are not unaware of this dynamic. As one opponent commented, “part of the way of maintaining unity in the ranks was to say that if you didn’t go along with the leadership of science that you were a kook.”

\(^5\) Lysenko claimed that traditional Western genetics was not good Marxism and instead asserted Lamarkism, i.e., that acquired characteristics are inheritable.

\(^6\) Cf. Miller 1996 for an interesting use of the Lysenko allegory in the opposite direction.
Those with less extreme viewpoints did not draw such dark parallels as Lysenkoism, but their critique was nonetheless similar in content.

Every time you raise these objections they say that the critics are Communists or that they're anti-science. But these are legitimate scientific questions. It's getting to the point where you can't even ask legitimate scientific questions without having your integrity questioned.

Well, in Canada it's been the government strategy, and certainly in the U.S., anyone who speaks out would have gotten into deep doo-doo. They really would have little chance of achieving a career. And so they don't speak out.

Most proponents tended to dismiss opponents as being motivated by some political agenda and/or simply uninformed. In my interviews, however, opponents typically provided compelling examples either from personal experience or from the experiences of a colleague that supported the claims they were making. The following respondent discusses the incident with which I began this dissertation, the case of Arpad Pusztai, in illustrating the forces of intellectual conformity. Although some proponents claim that his research is invalid, it is nonetheless a rather severe reaction to methodological problems in a peer-reviewed study.

I think we have enough high-profile case, like the Pusztai case in Scotland. In that case, a researcher in a government-run agriculture research institution does experiments with transgenic potatoes. He feeds them to rats, and the rats show apparently quite nasty histological and then eventually physiological and medical veterinary problems. And he is dismissed the moment he publishes this. He chooses to send a publication, but he's also called in to a television program, and on this TV program he says something about the results, and then the next day he's dismissed, he's fired...That's just an example of how I, as a biologist, I see that happening, and I say what? Who calls me to look into problems when if I find a problem I'm going to be chastised like that? So that is just one type of I think internalized censorship.

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Opponents were not against agricultural biotechnology from the outset. Indeed, as mentioned earlier, none of the opponents interviewed were necessarily against the technology itself. Rather, the typical social psychological dynamic described was to have been forced into such a position as a result of attempting to participate in the scientific dialogue and then being sanctioned for their point of view. The following respondent describes the process of their estrangement within the scientific community:

I started out working with the National Science Foundation and the EPA and with friends of the National Academy of Science to lay out the risks and to figure out what the scientific community should be doing to deal with this. I was getting encouraged by President Reagan’s biotech czar, David Kingsberry, to do this, and by the people at the National Science Foundation, and so on and so forth. This is a service to the nation. But the molecular biologists got furious, and they started saying I was like Jeremy Rifkin, that I was an enemy of genetic engineering. Well, after ten or sixteen years of that, you wonder if you are or if you aren’t, you know what I mean...? So it becomes a self-fulfilling prophecy. I think a lot of people have been through that process. When you speak out, they call you an enemy.

Later, this same respondent describes a colleague’s experiences who, notably, declined to be interviewed:

[A colleague’s company], they were working with the EPA, and when they ran these tests and found out that [a genetically-modified bacterial organism] killed the plants, everybody got mad at them. Her university administrator came down on her, and the people at the university were mad at her, and they said, what are you trying to do? What are your motives? Nothing, this is science. It was kind of like you should conceal this for the good of the club.

What is emerging is a portrait of a scientific community that is committed to a certain path of technological development, and that is impatient with any research that might hinder or slow down their progress in any way. This is certainly not generally
recognized as the scientific approach to knowledge. It seems probable that the industrial
approach to knowledge is what created this dichotomy of scientists as being for or against
the technology in the first place. Left to their own devices, scientific culture may engage
in considerable squabbling and even intellectual conformity, but such extreme
enforcement of the realm of meanings surrounding agricultural biotechnology seems
likely to be driven by the requirements of capital.

What they’re ending up doing is polarizing people. One of my colleagues
started out genetically-engineering fish with two molecular biologists.
The three of them were actually making genetically-engineered fish.
When she started, she said, I want to be on this team because I want to set
an example for everybody and show them how to do it safely. She was an
ecologist, and she said, we’re going to do it ecologically sound,
scientifically, etc, and she found that her colleagues didn’t care about the
safety. They just cared about getting the product out. Now I think I’d say
that she’s dead-set against genetic engineering. She’s on a campaign,
virtually, because she’s been so frustrated trying to do this safely. She
didn’t start out with any political agenda, but she got polarized, she got
forced into a position. If people won’t listen, you talk louder. And if
people still won’t listen, you talk louder, and then you talk louder.

Finally, one respondent’s experiences as a result of dissenting went so far as a
lawsuit against him, which was eventually dropped after a number of years.

[Certainly] if you speak out, you don’t get anywhere. I mean, my
promotion in this institution has been opposed by the head of the School
of Biological sciences, the University...refused to have any input from me
in its submission to the Royal Commission on Genetic Modification here
because they just wanted to present only those topics which were
ultimately of financial consideration...So yeah, I’m quite sure there’s
structural intimidation. I mean, I’ve been intimidated structurally by being
sued for four million bloody dollars. But let’s not make that an excuse for
ourselves, that’s my point of view. Take on the structural intimidation
because that’s the thing that you have to fight in the end. That’s what I
say to that...
F. The Academic-Industrial Complex: Corporate Hegemony in Science

This analysis has demonstrated a broad awareness among scientists of industry’s impact on science from a variety of perspectives, ranging from moderate to radical. It is appropriate, then, to conclude this inquiry with a theme that is the most unsettling from the point of view which sees science as the autonomous arbiter of truth in society.

Discussions of industry’s hegemony over science, its colonization of the scientific worldview, and its manipulation of science for public relations purposes—in short, discussions of the “academic-industrial complex” (Culliton 1982)—were limited almost entirely to opponents.

1. Corporate Hegemony: Proponents of GMF’s

One notable exception to this was the following proponent, who was unusually frank throughout the interview. The theme of industry using science as public relations, or as a smokescreen to conceal the industrial agenda, is explored in greater detail by opponents below.

They’ll say they’re concerned, and I think, I’m very cynical. I’ve talked to people at Monsanto who’ll go around to meetings giving talks about how they’re interested in stewardship and they want to, they have this ecological technology center, and they’re doing all this research that’s to check and make sure this is safe for the environment. And at one of these meetings, I asked this person, who I know pretty well, but I said, are you doing anything that’s not required by the regulatory agencies? And he couldn’t give an example of anything that wasn’t required, but he was promoting it as if it was this extra caution that they were taking. But all it was was the normal regulations. So that made me really cynical about, what are they doing? I don’t know, I’m pretty down on the companies. But that’s the way business is supposed to work. That’s capitalism.
2. Corporate Hegemony: Opponents of GMF’s

a. Opponents: Science as an entrepreneurial activity

To be sure, any discipline is going to have its orthodoxy and its heterodoxy. Indeed, this is part of the process of science and scientific revolutions (Kuhn 1962). However, the particularly vehement suppression of dissent described above is likely accounted for by the massive involvement and investment by industry in the fields developing these technologies. Consequently, and consistent with other analysts’ findings (Kenney 1986; Wright 1994, 1998), many individuals are not only occupying the role of scientist, but also that of entrepreneur.

First of all, I want to say that I think there is a lot of dishonesty in some when you have a conflict of interest, you have stocks in this company or the other. That has been creeping and very rapidly growing into the field, so that cannot be dismissed off the cuff.

In addition to such role conflict at the level of the individual, it was also pointed out that the academic institutions themselves have conflicts of interest, casting serious doubts on the trustworthiness of their endorsements.

There are very few in the academic scientific community who are willing to take a stand other than you would expect them to take as people who are going to benefit from it. It is in the interest of the scientific community to promote the technology because that will hopefully give people reasons to invest in their universities and they will make more money if that happens. To that extent, they’re just like companies. They have a short-term interest in making money off of the technology and so they’re going to promote it at every turn and they’re going to try to turn away people that, for whatever reason, are not enthusiastic. They’re going to dismiss them.
In order for scientists to pursue research, they require grants, funding, and other resources. Because the public sector has not been able and/or willing to match the funds made available by the private sector, industry has achieved a great deal of influence over the direction and the content of scientific research in these fields. The first casualty of this shotgun wedding between science and industry appears to have been academic freedom. If scientists lose the ability to pursue fact and truth without fear of consequences, then industry is undeniably dominating science.

I would like to see the thing go more slowly, I think, in a more measured way. I can understand what the commercial pressures are on the companies, they've invested a lot of money. I would like to see the preservation of academic freedom. I think that's probably our main hope of managing the thing properly. If everybody's tied into contracts with the businesses that are actually about promulgating this technology, then I think that's, again, a bad move.

These comments reflect Blumenthal’s et al. (1986a) earlier findings that most university-industry research relationships were likely to have a focus on applied research. Additionally, they found that firms directly support the training of students, and that one-third of these arrangements define the project that the student must work on. The practice of science is harnessed to the needs of industry.

I think we're seeing an erosion of academic freedom, there's no question about that. There was this drive which was started a decade or so ago to get academe and industry to collaborate much more together, and in the field of biotechnology, as in no other development I've seen ever before, the level of contractual obligation of people working in the field with commercial sponsors is extreme.

If these descriptions are accurate, then they provide compelling evidence that industry and science are not just closely associated. There is nothing startling in that revelation. Rather, science is being colonized by industry, and the industrial definition of
the situation is overwhelming the scientific. Etzkowitz and Webster (1998) discuss the trans-institutional relations between science and industry that have resulted in something resembling an academic culture emerging within industry. Corporate research facilities are dubbed campuses, for example. However, they devote little attention to the emergence of corporate culture within academia, noting only that departments are under increasing pressure to generate profitable income. I submit that, at the level of normative culture and meanings, there is no institutional interaction, only institutional domination. This is apparent in the following respondent’s appraisal of how his colleagues view environmentalists, and provides an interesting extension of Jackall’s (1988) ethnographic findings that there is a mentality in the business community that views environmentalists as anti-business.

I’ve heard molecular biologists for years now saying, we’ve got to fight the environmentalists. I wonder, where do they get this? I think a lot of it’s from their corporate contacts. It’s become indistinguishable. They’re dealing so much with the business community that they are part of the business community.

From the perspective of these respondents, industry is achieving an overwhelming hegemony of meaning within certain fields of science. To the pragmatic, it is an unfortunate but perhaps inevitable circumstance. To the idealistic, it is horrifying.

I’ve been hearing once or twice that this is the greatest crisis in the history of science. I’ve been mulling that over. I don’t really know if I believe that or not, but if science gets so taken over by corporate interests and self-interest, then maybe we’ve lost it historically, or maybe we’re losing it historically. That’s something people ought to realize.
b. Opponents: Science as public-relations

This apparent co-optation of science has far-reaching ramifications. An industrial program of research presenting itself as a purely scientific endeavor improperly assumes the mantle of objectivity traditionally granted to science. This ultimately undermines the legitimacy of scientific institutions as autonomous arbiters of truth and transforms them into something resembling a public relations department for industry.

I think that the involvement of industry in the scientific community and its co-optation of science has meant that scientists have not remained independent. Rather than being critical and giving a skeptical point of view on what industry is trying to achieve, they’ve ended up becoming the servants of industry, the apologists for industry, when they should be the ones that you can rely on to give some sort of critique...And the supposed autonomy of science is being used as a kind of smokescreen by industry to carry on and pursue its own interests.

This point of view cannot be dismissed as the mere grumblings of disgruntled scientists. Over a decade ago, Krimsky et al. (1991) showed that 49% of scientists on the National Science Foundation’s peer-review list of potential reviewers in the biomedical sciences were affiliated with industry, while 37% of biologists or biomedical scientists in the National Academy of Sciences had formal ties to companies. Scientists working in this institutional milieu are not unaware of this.

Science has lost its autonomy to a very great degree without admitting it. And so the involvement of industry has been basically to co-opt most of science into its service...If you look at the U.S. National Academy of Sciences, what you see is that there’s this incredible conflict of interest with the panel that they set up to look at genetically-engineered foods. A lot of the people involved had some association with the biotech industry or were even in their pay. And so the involvement of industry has been in fact to co-opt science in the name of neutrality and autonomy into its own interests.
In promoting the technology into which it has invested so much time and money, industry faces the challenge of public mistrust and the quite correct perception that their interests are fundamentally financial. From the perspective of opponents, industry has attempted to avoid this critique by using scientific institutions as their public face.

I guess I'm critical of the biotech industry rather than of biotechnology. But they want to equate the two. They don't make a distinction between themselves and the science that's on paper.

Industry has little to lose here in terms of institutional self-presentation, for the worst outcome would be that the public would view industry for what it already is—an institution seeking maximum profit for its shareholders. Science, on the other hand, has much to lose in terms of institutional self-presentation. As the following respondent points out, this lopsided relationship ultimately threatens the legitimacy of science.

Whenever you have quote unquote scientific advisory panels..., you can't make up a whole panel of people who have no interest in the technology. I mean, it's nearly impossible...There is no place to go to get scientists who bring only scientific credentials and only the scientific culture to these decisions. Many people now wear one, two, three hats that they are taking on and off as they try to make these decisions. But that's going to have a big impact, every time they hear the National Academy of Science, they're thinking, is that the National Academy of Science or is that the National Academy of Science and Industry?

From the perspective of these opponents, then, science (at least in those disciplines related to biotechnological development) has lost its public voice. In order to maintain and compete for the massive amounts of corporate funding available, it has become a public relations servant.

[Meeting] commercial objectives has become paramount, and as a result, the applications of technology have become severed from their basic science roots. Basic science continues, and can highlight more and more concerns, but for some reason these tend to be ignored. And it's really
quite bizarre, because if you read the basic science papers..., they're quite happy to in fact highlight the unpredictability and difficulty of generating what they want, because they're not in control...But when those very same people then present to governments or to the public, they give the impression that there's something that they're in fact totally in control of, and that everything is safe, and that we...can predict it all. And that I find unacceptable, clearly. You're saying one thing in one sector and totally the opposite in another context. And so, I just feel that this must stem from the pressures that are there within certain sectors of science to meet commercial ends.

Another respondent argued that if the fundamentally profit-driven requirements of industry corrupt the ideals of science to such an extent that the legitimacy of its highest institutions begins to be questioned, then science itself, as some opponents indicated, may indeed be an endangered dream.

Industry and science are becoming so co-mingled that I think you can question whether anything like what used to be called pure science, I don’t even think people talk about it anymore...I don’t think anybody thinks of science anymore as a place to go to just push back the envelope of knowledge. Everyone now has at least one eye, at least that’s my impression, one eye cocked on how much money you’re going to make, as I said, either directly or indirectly. I think major institutions are inviting and allowing, whatever the word is, big corporations to come and play a major part in financing them. And of course, he who pays the piper sings the tune, and so yeah, I think corporations have a huge amount to do with how the scientific enterprise is organized, how it presents itself to the public, who succeeds within it, and that in the long run, it’s become a farm team for industry.

G. Conclusion

Drawing on 24 intensive semi-structured interviews with a spectrum of academic scientists actively involved in the popular and scientific debate regarding agricultural biotechnology, this analysis demonstrates that science is not operating as a social force independent of the requirements and the culture of industry. Even a conservative reading
of the data, admitting only the perspective of proponents, makes it undeniable that industry is driving some, if not most, of the research in agricultural biotechnology. It is unreasonable to suppose that industry, in seeking to protect and acting to guarantee its investments, would not pursue every available option toward this end, including requiring proprietary research contracts with departments and confidentiality agreements with researchers.

Equally important are the processes of intellectual conformity occurring within academia, dynamics which were largely discussed only by opponents. According to them, corporations are wielding considerable influence over the questions that are asked and the manner in which findings are presented. Gramsci’s concept of *hegemonic bloc* (Mouffe 1979; Kay 1993), wherein compliance is achieved primarily via resource allocation, accounts for this dynamic. Researchers are understandably enthused about their access to such funding, both for reasons of research expenses and identity advantages. Even without any financial investments or entrepreneurial endeavors in agricultural biotechnology (and these seem to be common as well), they are likely to resist any individual that threatens their corporate stipend. This ostracization is easily achieved via mechanisms of funding, peer-review, contract renewal, and tenure. Ironically, these are the very structures which were originally intended to ensure academic freedom.

Among proponents, there was general agreement that industry was playing a large role in the direction of their field and the development of these technologies. In contrast

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57 Kay (1993) applied this concept to university-industry relationships.
to the opponents, however, their concerns tended toward the manner in which industry was driving, rather than the fact that industry was driving at all. The overriding themes which emerged from interviews with proponents were problems associated with the proprietary nature of the technology and frustrations regarding industry’s mismanagement of the technology. Predictably, all concerns and frustrations cited by proponents were covered by opponents as well, although not necessarily to the same extent. Opponents’ concerns primarily revolved around the threats that industrial involvement poses for the traditional scientific ethos.
CHAPTER 6

ON THE MERGING OF SCIENCE AND INDUSTRY:
IMPLICATIONS OF THE SALE OF SCIENCE TO CORPORATE INTERESTS

_Science...is the body of assertions and theories about the world made by people who call themselves scientists._


That powerful economic forces are behind the apparent embrace of agricultural biotechnology by society is seemingly undeniable. And yet for some scientists, such an assertion is heretical to the spirit of scientific inquiry. After all, it is a “constitutive value” (Longino 1990) of science to represent the objective—and thus supra-contextual—stance. To suggest that the path of scientific progress has been colonized by industry and is thereby something other than the straightforward march of a value-free, disinterested science violates this laudable ideal.

Yet, this is precisely what this dissertation demonstrates. Data was primarily drawn from the lived experiences and situated knowledge (Smith 1987; 1990; Haraway 1988) of 24 scientists (a spectrum of opponents and proponents) actively engaged in the popular and scientific debates surrounding the technology. This analysis has demonstrated that
industrial interests—interests which are by definition profit-driven—are having a 
significant impact not only on the directions of genetic science, but also on the content of 
its debates, the pace of its research, and the continued credibility of its scientists.

This chapter will proceed first with a summary of the major findings, followed by a 
theoretical discussion and concluding remarks.

A. Summary of Major Findings

Every social structure has a system of norms. The lived experiences of those who 
adhere to or are subject to a given structure are thereby constrained by their respective 
normative milieu. According to Etzkowitz (1989), Merton's (1942) codification of the 
normative structure of science as involving universalism, organized skepticism, 
disinterestedness, and communalism has been undergoing a transformation as a result of 
increasing industrial involvement and investment in academic science. Krimsky et al. 
(1991) and Blumenthal et al. (1986a; 1986b) have shown that such academic-industrial

ties are notably high in agricultural biotechnology, and so this dissertation provides an in-
depth examination of the impacts of massive industrial funding on academic science, as 
exemplified in those disciplines related to the development of agricultural biotechnology.

In exploring the impacts of Etzkowitz's (1989) normative transformation on the 
subject and practice of science in agricultural biotechnology, this dissertation has shown 
that industrial involvement in those disciplines related to the development of these 
technologies has radically transformed the normative milieu of these knowledge-
producing activities. The practice of science as described in Chapter 5 would not be
recognized as science by sociologists from Veblen (1918) to Merton (1942; 1973). At issue is the impacts of the erosion of two components of Merton’s (1942) normative structure of science: disinterestedness and communalism.

1. Disinterestedness

The perceived credibility of scientists and their institutions is closely linked to their impartiality, or disinterestedness. Without a normative structure encouraging this, the legitimacy of scientific assertions is increasingly questionable. Most respondents saw industrial involvement as a “double-edged sword,” and the attitude of most toward industry was ambivalent at best. That is, while recognizing the clear advantages of industrial funding of research, they were nonetheless frustrated by the normative structure of industry. Significantly, elements of the normative structure of industry can be seen as replacing disinterestedness as one element of the normative structure of science.

Proponents cited many examples of industry rushing products to market. Their frustrations stem from an industrial definition of the situation overwhelming the scientific, i.e., from industrial concerns preempting scientific concerns. Proponents clearly enjoy their research, and are confident in the health and environmental safety of GMF’s, and yet they recognize the irresponsibility of industry’s approach to the release of these products. This frustration stems directly from the interestedness of industry. Industrial investments have been incredibly immense, and the imperatives of competition and profit create industry’s normative system.
What is more, many proponents expressed astonishment at industry's arrogance toward both the consumer and grower market. This too stems from a frustration with the normative structure of industry (or a frustration with being associated with such an approach). The agricultural biotechnology industry, after all, frequently presents itself as "just science" rather than "just desperate profiteering." Scientists, meanwhile, have lost control over the utilization and the public presentation of the products of their research. Consequently, such industrial colonization of science risks undermining the perceived legitimacy of scientists themselves. Commercial interests have thus not only manipulated the realm of markets, but the realm of meanings as well. In other words, industry has occupied the cultural space of science and the disinterestedness it implies, thereby destroying the credibility of that space while simultaneously using it as a tool of marketing and public relations.

Opponents share these critiques of industrial involvement, but their concerns run deeper still. They discussed examples both of individual scientists who have financial investments in the success of these technologies as well as entire departments that have research contracts with private firms. From their point of view, the practice of science in these disciplines has been harnessed to the needs and requirements of industry. Moreover, the financial stakes in the success of these technologies—not only by industry but increasingly by scientists themselves—has placed limits on questions asked and conclusions advanced.

Paralleling existing studies (e.g., Krimsky 1991), opponents discussed disturbing conflicts of interest at the highest levels of scientific institutions. With prominent
scientists having financial stakes in the success of these technologies, it creates a rather
tense environment for untenured junior faculty to raise certain questions or concerns.
Indeed, opponents discussed instances wherein scientists became polarized as being
against the current development of these technologies precisely because of their
treatment upon asking questions or releasing findings that in any way threatened the
success of these technologies. In addition to such direct mechanisms of intellectual
conformity, there are also subtler, more indirect mechanisms. The manner in which
results are presented is frequently influenced by the requirements of industrial sponsors,
and the questions that are posed in grant applications are shaped by an awareness of the
needs of industry and what is hence likely to get funded. Thus, ostracization and
alienation of dissident scientists is easily achieved via existing structures of funding,
peer-review, contract renewal, tenure, etc.

Science, as traditionally defined, exists as a social institution independent of external
social forces, or at least striving to be so. Proponents as well as opponents discussed their
discomfort with and the consequences of commercial considerations stimulating the
development of these technologies. Both the pace and the direction of agricultural
biotechnological development are significantly influenced by financial arguments. In
other words, research trajectories are proceeding at the expense of less profitable
alternatives. For example, relatively unprofitable “orphan crops” have been or are being
abandoned because there is little or no research funding. Hence, decisions about
marketing and/or commercialization potential are taking precedence over decisions
regarding health safety, environmental safety, and whether the technology and its
products even serves the larger public need and/or good. The oligopolization of the industry exacerbates these problems, as both the financial and intellectual property resources are increasingly controlled by fewer and fewer corporations.

Opponents also discussed the irony of corporate involvement in the development of these technologies. Whereas commercial interests are rushing the early products of agricultural biotechnology to market in their attempts to keep and/or control market shares, investment in more precise, refined methods of genetic modification have not been forthcoming. Thus, while the development of the technology thus far could not have occurred without industrial involvement, it now appears that industry is merely relying on the investments that it has made and the intellectual property that it controls. According to opponents, the technology is at risk of stagnating at a relatively early level of development. This dynamic underlines the normative contradictions between science and industry. The interests of industry are financial. The interests of industry are not, as one respondent stated, in “pushing back the envelope of knowledge.”

2. Communalism

The norms of industry demand proprietary rights over knowledge, and thus there is an inherent variance with the norms of science. Thus, the second of Merton’s (1942) norms of science undergoing transformation (Etzkowitz 1989) is communalism, the uninhibited sharing of information between scientists. Increasingly, proprietary concerns are overriding communalism in those disciplines related to the development of agricultural biotechnology.
The norm of communalism serves the purpose of maintaining "innovative vigor" (Grobstein 1985:56) in a given field of study. On the other hand, intellectual property law attempts to motivate innovation by guaranteeing rewards to the innovator. Accordingly, there is an immediate contradiction between these two approaches to innovation. According to most proponents, applying the intellectual property model to agricultural biotechnology has resulted in an undermining of the practical utilization of the technology by tying up products as well as techniques in multiple layers of patent law. Opponents see also that it undermines a core component of the traditional scientific ethos, and that in many ways intellectual property acts as an ironic hindrance to the pace of scientific innovation in these fields.

Specifically, without the free exchange of information, communalism is undermined and researchers are unable to access either all available knowledge on a given research question, or unable to access patented biotechnological techniques—"enabling technologies"—necessary for performing certain procedures. Proponents see this as a hindrance to the utilization of the technology and a cause for considerable frustration. Notably, however, they dismiss any possibility of alternatives. This demonstrates that norms of communalism are already obsolete in their minds, and that the transformation of the normative structure of science is all but complete. Opponents primarily see intellectual property as a hindrance to innovation in the technology, and are uncomfortable practicing science for proprietary purposes rather than the common good. Both recognize that this dynamic threatens to increase the gap between public and private sector research.
Very significantly, all opponents emphasized that they were not against the technology itself. Rather, they were against the commercial premises of research, the commerce-begotten secrecy, haste, market-manipulation, and stagnation. Even a conservative reading of this data grounded only in the perspective of proponents demonstrates that science is not operating as a social force independent of the requirements and the culture of industry. These findings, along with existing research (see e.g., Etzkowitz 1983; 1989; 1996; Blumenthal et. al. 1986a; 1986b; Krimsky 1984; 1988; 1991; Krimsky et. al. 1991; Webster and Packer 1996), make it undeniable that industry is driving some—if not most—of the research in agricultural biotechnology. However, and despite the near-complete dismissal of opponents by proponents, there is no reason not to admit the perspective of opponents as having situated knowledge which speaks very well to the question at hand. Indeed, opponents’ perspectives more closely reflects the findings of existing sociological research on normative transformation within science.

B. Suggestions for Future Research

These findings demand further inquiry into a number of additional areas of research. These include studies of the constructivist processes of boundary work between proponents and opponents, comprehensive surveys designed to examine the generalizability and reliability of these findings, and analyses of the net impact of intellectual property law on the pace of scientific innovation.
1. **Boundary work**

Perhaps ironically, proponents were dismissive of opponents for being unscientific. Proponents defined opponents as being outside the boundaries of science due to alleged interestedness, such as an environmental or religious agenda. However, if Krimsky’s (1991) and Blumenthal’s et al. (1986a; 1986b) findings are to be accepted, such an assertion is made from an equally (financially) interested position on the part of proponents. In other words, proponents are relying on demarcation criteria—norms—that have been transformed, which is to say, they are defending a cultural space they themselves do not occupy.

As this dissertation has shown, disinterestedness can no longer be a tacit, taken-for-granted aspect of the scientific ethos in those fields related to the development of agricultural biotechnology. Gieryn (1983; 1995) has written on the processes of boundary work among scientists, and the changing contexts of scientific practice in these fields leads to a curious situation of double-edged boundary work: a constructivist process of demarcation relying on essentialist criteria, criteria which in fact no longer exist. The data on which this dissertation was based can be applied to an exploration of these dynamics.

2. **Survey-level analyses**

This dissertation is intended as an *in-depth* examination of the changing context of genetic science as perceived and experienced by its practitioners. As such, it is limited in its ability to answer the question of how widespread these issues are. Survey-level
analyses are best suited for examinations of the width of the problem. The last major survey conducted in this area was based on 1984 data (Blumenthal et. al. 1986a; 1986b). Given that industrial funding of agricultural science has vastly increased since that time (see Figure 1.1, page 5), it seems clear that the situation requires a fresh analysis.

Hence, research should further document the impacts of industrial involvement on the practice of science. Blumenthal et al. (1986a; 1986b) and Krimsky (1991) provided relatively early quantitative examinations of this topic, but a contemporary survey, informed by dynamics uncovered in qualitative analyses such as this, is presently necessary.

3. Intellectual property law and scientific innovation

Many respondents in this analysis discussed the consequences of proprietary knowledge in science, with criticisms revolving around the hindrances that it poses for both technological utilization and scientific innovation. These are strong arguments against proprietary science, and seem to underline the importance of Merton’s (1942) inclusion of communalism in the normative structure of science.

However, it is important to maintain a balanced view of the situation. As Blumenthal et al. (1986b:1365), conclude in their analysis, “[any] losses to science or to university values that result from marginal increases in the level of secrecy in universities may be more than offset by net additions to knowledge that result from the infusion of industry funds into the labs of talented faculty.” This point is well-taken, and future research should examine if the net benefits of industrial involvement do indeed outweigh
the net costs. The goal of science, after all, is the extension of certified knowledge, and industrial involvement may well be helping science along, or it may be hindering it. Isolated examples can be drawn for either scenario, and so a net analysis seems necessary to evaluate these assertions. This could be done using a data set forthcoming from the Economic Research Service of the USDA,\(^{58}\) which will enable researchers to examine whether patents in agricultural biotechnology are acting as motivations or hindrances to technological innovation and scientific research.

C. Discussion

At the most general level, this dissertation is about the social context of science – an institution which is frequently granted the assumption of value-freedom and objectivity. Merton (1942) recognized that the extension of certified knowledge—the stated goal of science—requires a social structure which encouraged the norms of universalism, organized skepticism, communalism, and disinterestedness. Absent these practices, science increasingly loses its autonomy and its presumably objective assertions come to be harnessed by interested social forces.

This discussion will focus on two related themes, both of which are intended to enhance the relevance of these findings. First, the findings of this dissertation will be linked with Commoner’s (2002) recent arguments that genetic science is relying on obsolete theoretical models because these are more closely aligned with the commercial requirements of industry. Second, the findings of this dissertation will be linked with

\(^{58}\) See http://www.ers.usda.gov/ or contact Cassandra Klotz-Ingram at cklotz@ers.usda.gov.

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existing critiques of value-freedom in science, concluding with suggestions for how sociologists should approach the study of science as a human social activity.

1. The Triumph of Obsolescence

Genetic science itself currently provides an ideal sociological arena for examining how industrial involvement interacts (or interferes) with the normal processes of scientific revolutions as described by Thomas Kuhn (1962). Barry Commoner, Director of the Critical Genetics Project at the Center for Biology of Natural Systems at Queen's College – City University of New York, has recently argued that the scientific foundation of current techniques of genetic engineering is highly questionable. As can be seen in the following explication, the paradigmatic consensus of biology—particularly the mechanisms of genetic inheritance—has not been shifting to accommodate new data and findings which undermine the current paradigm (Commoner 2002). It appears that paradigmatic stasis and stagnation become increasingly likely when billions of dollars have been invested in the assumptions of the current paradigm.

Modern genetic science proceeds from the premise that the DNA molecule is the sole mechanism of inheritance in all living things. Known as the “central dogma,” this premise assumes that DNA will fully account for an organism’s inherited traits. Findings released in February 2001, however, drastically refute this assumption. These findings came from no less a source than the highly-publicized Human Genome Project, a $3 billion, 11-year scientific undertaking. In short, theory predicted far more genes than
were actually found, leaving scientists with a severe dearth of genes to account not only for the complexity of a human’s inherited traits, but also for the immense differences between organisms. In pure science, such data demands a revision of existing theory. In modern genetic science, however, such data destroys the foundations of the biotechnology industry. In particular, claims characterizing methods of genetic modification as specific, precise, and predictable (and therefore safe) are entirely unfounded. As Commoner (2002:47) argues, “the biotechnology industry is...conveniently devoid of more recent results,” and by operating from an outdated foundation, industry manages to claim rationality while dismissing any critics as irrational.

The estimated number of human proteins led researchers to predict approximately 100,000 genes. Ultimately, the gene count was about 30,000 – only twice as many as a fruit fly or primitive worm. Ironically, these results contradict the very premise which guided the Human Genome Project and upon which the biotechnology industry relies – that a single gene codes for a single protein. What now appears to be the case is that many genes are “alternatively spliced,” wherein “the gene’s original nucleotide sequence is split into fragments that are then recombined in different ways to encode a multiplicity of proteins” (Commoner 2002). This dramatically alters the gene/protein ratio. For example, a single gene originally thought to encode for a single protein in the inner ear actually generates 576 different protein molecules. Indeed, the current record is held by

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59 This is a particularly apt example of the philosophical principle of dialectical interaction, i.e., the complete elaboration of a technique leads to its transcendence or overthrow.
the fruit fly, which possesses a single gene that gives rise to 38,016 variant proteins via alternative splicing.

Merton (1942) argued that the normative structure of science was necessary for the extension of certified knowledge. Norms such as disinterestedness exist precisely to ensure that no political or economic considerations compromise the conditions he argues to be necessary for the pursuit of truth. In the situation described above, the “central dogma” of molecular biology is becoming increasingly obsolete in the face of new experimental data, and yet the fundamental clash with the governing theory is rarely noted. As Commoner (2002:47) reflects:

Why, then, has the central dogma continued to stand? To some degree the theory has been protected from criticism by a device more common to religion than science; dissent, or merely the discovery of a discordant fact, is a punishable offense, a heresy that might easily lead to professional ostracism.

Very clearly, this resonates deeply with the perspectives expressed by some of my respondents. Adding Commoner’s (2002) arguments to my own analysis, it becomes evident not only that the pace, path, and products of genetic science are being increasingly determined by industrial involvement, but also the very paradigmatic assumptions which themselves guide the scientific research and consequent technological development. To offer an analogy, a similar situation might exist within chemistry if the guiding paradigm refused to admit the process of covalent chemical bonding because this
would undermine the investments of an industry built upon the assumptions of ionic chemical bonding. 60

The foregoing discussion demonstrates that the cognitive premises with which scientists approach a problem are deeply influenced by culture. As Lewontin (1991:3) states, "[the] problems that science deals with, the ideas that it uses in investigating those problems, even the so-called scientific results that come out of scientific investigation, are all deeply influenced by predispositions that derive from the society in which we live." As the culture of science is increasingly determined by the culture of industry, we can expect barriers to innovation to emerge wherever it may threaten financial investments.

2. The Culture of Objectivity

The foregoing discussion argues that the pace, path, products, and paradigms of genetic science are being increasingly determined by the commercial requirements of industry. This section will link this to a body of theorizing which dismisses the notion of value-freedom in science altogether, at least insofar as it exists as a given rather than a asymptotic goal.


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60 An ionic bond is one in which two ions are bonded via the transfer of one or more electrons. A covalent bond is one in which the bond is formed by the sharing of a pair of electrons by two atoms. Covalent chemical bonds (1960-65) were a considerable innovation on the older model of ionic chemical bonding (1935-40).
Keller 1985; Longino 1990; Rose 1986, 1994; Rose and Rose 1976) have since demonstrated that science is contingent on its social and cultural context, and thus is ultimately just "as much a product of its social environment as an account of natural phenomena" (Wright 1994:4). Accordingly, science is as much a textual as a material practice (Gottweis 1998), and so must be viewed as a social activity and a cultural product.

Longino's (1990) conception of science "admits political considerations as relevant constraints on reasoning" (Longino 1990:193), which is to say that scientific objectivity is approached to the extent that the social context of knowledge claims are recognized. Essentially then, the primary premise behind these critiques is that science cannot—honestly or possibly—claim value neutrality or value freedom, and least of all objectivity.

It is important to recognize here that when speaking of values in science, one must draw a distinction between what Longino (1990) has termed "constitutive" and "contextual" values. Constitutive values are those ideals and norms which define science as a realm of human activity—accuracy, predictability, parsimony, etc., as well as the scientific ethos as described by Merton (1942). Contextual values are the background assumptions, personal biases, and sociocultural values in which science is done, and it is to this set of values which these critics wish to draw our attention, especially insofar as sociocultural autonomy is a constitutive value of science. In other words, the "integrity thesis" (Longino 1990:6) of science, the notion that science proceeds and is propelled by
its own internally generated questions and answers, uninfluenced by its sociocultural context, is rejected.

Defining the authoritative source of knowledge in this way is “deeply subversive” (Rose 1994:238), and indeed, many of these writers are unabashedly radical. All challenge the notion that science is autonomous from human affairs and sociocultural life, for according to them, it is precisely this acultural ideology of science that enables this social institution to be so easily misused by those social forces seeking to transcend all possible opposition by claiming objectivity and neutrality (McCarthy 1996).

According to these critics, rather than the steadfast pursuit of objective truth, objectivity is granted by role position. As such, science becomes a cultural space which can be occupied by various political, economic, or cultural interests, as this dissertation has shown. In its classical formulation, science must strive to rise above preconceptions and prejudices. This, however, cannot be assumed. Indeed, value-freedom is probably an unrealistic expectation to place upon scientific inquiry (Longino 1990). Where objectivity lies implicit and unexamined, science becomes the pursuit of an unadmittedly ersatz truth, and supposedly one which cannot be disputed. Furthermore, technology becomes synonymous with science, and technological progress (being but one possible path of technological elaboration and sophistication) is assumed to be inevitable and determined (Kleinman and Kloppenburg 1991; Bak 1997). This amounts to “ideological deceit” (McCarthy 1996:95), and results in a nonfalsifiable (Popper 1959) epistemology.

Applying this point of view to the findings of this dissertation, these are the assumptions which underlie defenses of the current state of agricultural biotechnology as
"just science." Science, in other words, becomes a "justificatory strategy" (Harding 1990:87) of the powerful, rationalizing and further entrenching the "dominant social paradigm" (Dunlap and VanLiere 1978, 1984; Drengson 1980; Bowen 1988).

While the ideals of science are probably not as entirely corrupted by social forces as the "externally determined views" (Busch et al. 1991:39) of science (see also Mannheim 1936; Brannigan 1981) might lead one to believe, such a perspective is a necessary—albeit nagging—caveat to any assertion cloaked by the cassock of science. Indeed, as Longino (1990) has indicated, it may well be the case that scientific neutrality and autonomy are approached precisely to the extent that the influence of political, social, and economic conditions are given proper recognition. In other words, no scientific assertion should be made without footnoting the social context, perhaps even highlighting it.61

It is clear that in order to preserve the authenticity of science, science itself must recognize its own embeddedness in the social world. It is its failure to do so that has left science open to colonization by interested social forces in the first place. Assumed notions of value-freedom and objectivity create a cultural space as powerful as religion once was (and often still is) in its ability to dictate reality (Noble 1997). Merton (1943) recognized the normative structure necessary for the extension of certified knowledge. That this structure has been shifting (Etzkowitz 1989) is indisputable. However, this need not be the end of the story. Science can coexist with transnational industries, fascist regimes, fundamentalist religions, or any other social institution, but the true aspirations

61 Notably, this point of view may be gaining acceptance. As noted in Chapter 2, a dozen of the world's most prominent medical journals recently announced that they would reject manuscripts submitted by authors who did not have control of either the data they used in their studies or the decision to publish the results (NEA Higher Education Advocate 2001).
of science will persist only to the extent that it recognizes the influences of its own surrounding social context.

D. Conclusions

This dissertation has shown that genetic science is not operating as a social force independent of the culture of industry. It is clear that a great deal of research in agricultural biotechnology is premised on commercial considerations. Even among those respondents who supported the current development of these technologies, there was general agreement that industry was playing a large role in the direction of their field and the development of these technologies. This was seen as a frustrating but inevitable state of affairs. Among those respondents who did not support the current development of these technologies, concerns primarily revolved around the threats that industrial involvement poses for the traditional scientific ethos. Significantly, their point of view echoes much of the existing literature on university-industry research relationships and normative transformation within science, as well as the broader critiques of value-free science in general.

I agree with Kloppenburg (1988:279) when he states that "[we] must not allow our options to be foreclosed by ceding to capital the exclusive power to determine how biotechnology is developed and defined." However, government officials and university administrators can only act on the basis of information, and information on the dynamics unfolding between industry and science are rather lacking within the literature. This
research offers an in-depth understanding of scientific-industrial conflicts of interest, consequent shifts in research direction, and the growing impediments to the free sharing of research findings. Moreover, and reiterating Blumenthal's et al. (1986b) suggestion, research in this area must continue to develop in order to provide the information necessary to effectively manage university-industry research relationships. The commodification of scientific knowledge should be prevented from undermining the central commitment of universities.

The ideal situation is for the university to be funded for what it is traditionally supposed to be doing, i.e., basic research (Rosenweig 1985). This, however, is an untenable arrangement from an industrial point of view, for their capital is less an eleemosynary contribution and more a financial investment. Thus, the question is not whether industry should be involved in the practice of science. That question, for better or for worse, has already been answered. The question for universities at this juncture is how best to manage their relationships to industry, i.e., what are the organizational innovations needed to accommodate industrial connections (Etzkowitz and Lois 1991)?

University administrations have already established committees to define rules of conduct in university-industry relationships in accordance with institutional objectives (Etzkowitz 1989). These committees should recognize the value of the university’s intellectual culture vis-à-vis industry, and act to minimize industry’s undue influence on the direction of science while maximizing the undeniable benefits. As Etzkowitz (1983:233) argues, “[as] knowledge created within the university is increasingly in
demand outside the university, academics have greater opportunities to set their own terms for its use.”

This perspective can also be seen as potentially valuable to corporate firms looking to invest in university research. After all, Blumenthal’s et al. (1986b) pioneering survey found that industry-supported university research generated 4.2 times as many patent applications, per dollar invested, than company-based research over a five-year period. They also found that the primary reason companies invest their research and development dollars in university-based research, and not merely company-based research, is that it helps them keep current with significant new research. Ironically then, the more that science is colonized by industry, i.e., the more that university-based science is driven by interestedness with proprietary and unshared research results, the less effective it will be in generating the cutting-edge research for industry to develop into products. This process of devitalizing academic science could be likened to gradually deflating the tires of the car upon which it relies to keep moving forward.

These new technologies were created in universities, and the university should not allow its own normative structure to be overwhelmed and colonized by the needs and requirements of industry. Absent such praxis, the increasing comingling of science with industry carries the potential to delegitimize science in the public view. Without the maintenance of reasonable boundaries between industry and science, the university may well be heading towards a transformation “so radical that the very identity of the
university and the justification for even using the term itself may be called into question" (Wasser 1990:122).\footnote{This point of view echoes a prediction made by Veblen in 1918, and with which this dissertation opened: "If these business principles were quite free to work out their logical consequences, untroubled by any disturbing factors of an unbusinesslike nature, the outcome should be to put the pursuit of knowledge}

In order that the institutions of science can be preserved, while at the same time encouraging their enhancement via industrial sources of funding, we must dispense with our illusions regarding the nature of science as a human activity. Longino (1990) advocates contextualist accounts of scientific inquiry, analyses "of science and values interaction that [deny] neither the genuineness and integrity of science nor its shaping by contextual interests" (Longino 1990:98). In other words, science is as much an expression of its culture as is a work of art, and is deserving of precisely the same respect and value. However, to pretend that science is value-free and objective only leaves it vulnerable to colonization for interested purposes. Merton (1942) recognized this dynamic in the Nazi science of his era, and we should recognize it in the corporate science of this era.

Every technology emerges from a particular school of scientific thought, which is itself influenced by the surrounding socio-historical moment. As with any other scientist, "the biotechnologist's hand...is indirectly guided by cultural information that has been deeply shaped by a set of socio-economic and historical forces" (Goonatilake 1992:244). However, when the social forces influencing molecular science are dominated by the concerns of industry, it is impossible not to question whether the pursuit of truth has become the pursuit of profit. In other words, is the development of these technologies...
responsive to “competitive imperatives [or] to basic human needs” (Wright 1994:100)?
The answer, regrettably, appears to be the former, and if industry and science present a
unified public front, then corporate arrogance becomes scientific arrogance, corporate
intelligentsia has the responsibility of comparing the constructed images of biotechnology
with empirical reality. If that role is relinquished..., [neither] the media, the general
public, nor much of science will be in a position to distinguish appearance from reality.”

Science is not autonomous from the affairs of society. Science is a human social
product, and the questions it asks and the answers it advances reflect the interests, biases,
and subjectivities of its practitioners. Something resembling objectivity can only be
achieved by admitting as diverse a variety of viewpoints as possible (Ashford 1983;
Longino 1990). When certain points of view are restricted and when the path of
innovation is being driven by financial considerations, objectivity recedes and is
increasingly replaced by incomplete and even obsolete knowledge which serves the
interests of industrial sponsors. We are then, as a culture and as a species, left with no
position from which we can hope to successfully navigate the ramifications of our own
ingenuity. In light of the present research, science and its institutions need to undertake
serious efforts to maintain an independence from industrial agendas. Science, after all, is
the pursuit of nothing so golden as truth, and truth is unsustainable amidst the mundane
demands of industry.

definitively in abeyance within the university, and to substitute for that objective something for which the
language hitherto lacks a designation” (Veblen 1918:170-1).
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