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Contradiction, convergence and the knowledge economy: the confluence of academic and commercial biotechnology

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Efforts to understand the structure of the emerging knowledge economy have paid particular attention to the shifting boundary between academic and commercial (for-profit) research, especially in life sciences. Yet, empirical studies have tended to adopt a segmented approach, focusing on either industry or the academy, thus obscuring the increasingly interwoven nature of these two domains. In this paper, we explore the changing organizational logics that govern both academic and corporate science, using interview data gathered from two important clusters of the biotechnology industry: Route 128 in Massachusetts and the San Francisco Bay area. These data, while provisional, lead us to suggest that cultural traffic between university and commercial science has increased, blurring the boundary between them and generating a new and often contradictory knowledge regime, the product of a growing confluence of organizational logics that had previously been distinct. The emergence of this regime, which conforms to Stark's (2001) notion of 'heterarchy', holds important implications for prevailing theories of university–industry relations and of organizational change as well.

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JEL classification: L0 industrial organization, L1 market structure, firm strategy, market performance

1. Introduction

In recent years, scholars have devoted a great deal of attention to the nature and functioning of the knowledge economy (Brint, 2001; Powell and Snellman, 2004). One particularly important aspect of this literature is centred on the changing relation between the university and the marketplace, which poses far-reaching

questions about the nature of knowledge production within the United States. In much of this discussion, life sciences have provided an especially significant terrain, not only because of scientific developments within medical and agricultural biotechnology but also due to sustained interest on the part of pharmaceutical firms, venture capitalists and entrepreneurial ventures promoted by prominent scientists themselves. Analysts have viewed these developments as posing novel challenges, in that they threaten to disrupt longstanding distinctions that scientists have drawn between basic and applied research, public and private knowledge and, at the most general level, between the university and the marketplace itself (Gieryn, 1983; Shapin, 1994).[1]

This blurring of the boundary between previously distinct institutional domains has given rise to much debate and uncertainty. Some analysts have sharply criticized the growth of university–industry relations, viewing the institutional logics of science and corporate research as fundamentally incompatible (Heller, 1998; Shenk, 1999; Slaughter and Leslie, 1997; Slaughter and Rhoades, 2004). The argument here, variously expressed, is that the profit imperative threatens to erode the freedom and autonomy of scientific inquiry, erect institutional constraints (through patenting and licensing conventions) to the flow of knowledge and information and allow pressures to engage in revenue generation to shape the questions that researchers are likely to pursue (AAUP, 1983; Kleinman and Kloppenburg, 1988; Hart, 1989; Louis and Anderson, 1998; Shenk, 1999; Hackett, 2001; Bok, 2003). By contrast, other scholars have argued that these concerns misconstrue newly emergent structures of knowledge production, whether the latter are viewed in terms of a new 'mode of knowledge production' (Gibbons *et al.*, 1994), a 'triple helix' linking government, the academy and industry (Etzkowitz and Webster, 1998) or collaborative networks that link firms, academic scientists, venture capitalists, medical institutions and government agencies (Powell *et al.*, 1996; Powell and Owen-Smith, 1998, 2002, Owen-Smith and Powell, 2001).

These debates have provoked a surge of interest in the commercialization of science, the changing relation between university and industry more generally and the consequences that ensue when universities adopt an entrepreneurial orientation towards scientific research (Slaughter and Rhoades, 1993, 2004; Slaughter and Leslie, 1997; Owen-Smith, 2003; Murray and Stern, 2006). Despite this outpouring of discussion and debate, understanding of the 'new

[1] Analysts commonly point to the passage of the 1980 Patent and Trademark Amendment Act (also known as the Bayh–Dole Act), which enabled universities to patent the results of federally funded research, changes in federal fiscal policy which often forced academic institutions to generate revenues on their own account, and commercially valuable developments within the life sciences themselves, which were successfully brought to market by the first generation biotechnology companies. For a fuller discussion, see Slaughter and Leslie (1997), Powell *et al.* (1996) and Owen-Smith and Powell (2001).

knowledge economy' has been hampered in several respects. First, much of the existing research has focused one-sidedly on questions involving intellectual property rights (patents, licensing conventions, participation in entrepreneurial start-ups, etc.). Important though such issues may be, studies in this vein have largely neglected the informal cultural codes and practices that underlie intellectual property conventions and that shape the nature of scientists' work situations.[2] Second, the bulk of the literature has adopted a segmented approach towards the university–industry relation, typically focusing on the conduct of science on either side of this boundary, but only rarely on both. This has made it difficult to grasp the *interactions* between academic and commercial entities, the cultural 'traffic' that has unfolded apace with the mobility of scientists, and the co-evolution that may well ensue. Finally, few of the existing studies have sought to understand the ways in which the shifting of institutional boundaries is experienced and conceivably shaped by scientists themselves (for exceptions, see Owen-Smith and Powell, 2001; Murray, 2006).

The present paper seeks to move beyond these limitations. It builds on previous theoretical work in which we speculated about some of the ways in which the normative codes and practices of industry and the academy have empirically combined, yielding structures of knowledge production that assume novel and contradictory forms (Kleinman and Vallas, 2001). Seeking to develop a theory of what we termed 'asymmetrical convergence', our previous efforts operated at a high level of abstraction, relying as they did on the limited body of knowledge that existed on the commingling of normative codes. In the present paper, we seek to ground our theoretical work empirically, using interview data on norms and practices found among a sample scientific personnel ($N = 95$) employed within two important clusters of biotechnology research: the Route 128/Cambridge area in Massachusetts and the San Francisco Bay area adjacent to Silicon Valley. It should be made clear that our aim is not to test a set of hypotheses, but rather to engage in the work of theory (re)construction, using qualitative data to develop a model of the changes currently impinging on the codes and practices that govern life science research within both academic and corporate contexts.[3]

We begin by sketching several competing understandings of the fate of knowledge work in both university and commercial establishments. We then develop a critique of existing distinctions between basic and applied research, academic and corporate science, and private and public science. Addressing the work situations

[2] Indeed, recent studies (Walsh *et al.*, 2003; Walsh *et al.*, 2005) report that few scientists are cognizant of patenting as an imperative and few experience patenting as a constraint on the nature of their work.

[3] Following Burawoy's 1998 'extended case' method, we use our data as a means of highlighting points of vulnerability within existing theory, a useful step in the formation of alternative conceptions of the institutional processes actually underway.

of university and commercial scientists, we focus on two aspects of laboratory life: the organizational structures that govern the production of scientific knowledge and the social relations that obtain among scientists themselves. Although our data are provisional, they begin to suggest that there has indeed been a confluence of normative constructs drawn from either side of the university–industry divide. The discovery-oriented logic traditionally found within the academy has increasingly been combined with entrepreneurial practices originating in the marketplace, even as the entrepreneurial, profit-driven logic of commercial laboratories has accommodated academic or collegial norms. We view the result as giving way to a single, increasingly interconnected scientific field—in Stark's (2001) terms, a 'heterarchy'—marked by multiple anomalies, tensions and ironies (Dubinskas, 1988; Hackett, 2005). These developments, we conclude, have significant bearing not only on current debates about the structure of knowledge production in the United States, but also on theoretical models of institutional change more broadly (Schneiberg and Clemens, 2006).

2. Understanding the new knowledge regimes

In the early 1980s, amid rising concern for US economic competitiveness, the public role of academic scientific research (initially shaped during the years immediately following World War II) began to shift in subtle, yet significant, ways. Once viewed as a relatively autonomous realm,[4] university research was increasingly construed as a source of economic and technological innovation. Universities, endowed with new-found powers of patenting and intellectual property, were encouraged to play a central role in the process of capital accumulation. Amid rising fiscal constraints on public spending, and with social entitlements placing limits on public support for higher education, university administrators looked to market-based sources for much-needed material support and legitimacy. The result, many suggested, involved a historically significant shift in the very logic that traditionally informed university research, especially as faculties engaged in the founding of biotechnology start-up firms and otherwise sought to profit from the knowledge they produced (Slaughter and Leslie, 1997; Powell and Owen-Smith, 1998; Owen-Smith and Powell, 2001; Slaughter and Rhoades, 2004).

Early research on university–industry relationships (UIRs) focused on the apparent erosion of traditional academic norms that accompanied the increase in formal relationships between academic scientists and biotechnology firms (e.g. Blumenthal *et al.*, 1986). Much of this literature voiced concern that

[4]While many science policymakers and scientists *believed* academic research to be substantially independent from the world of commerce and other pressures, the idea of an autonomous university was always more myth than reality (see Kleinman and Vallas, 2001; Kleinman, 2003).

faculty start-up firms, licensing arrangements and patent provisions posed a salient threat to the free flow of knowledge and the autonomy of scientific research (e.g. Shenk, 1999). Analysts often predicted that UIRs would distort scientific priorities, constrain scientists' selection of topics and methods for research, skew graduate education towards commercial concern, and erect barriers to the sort of cooperation, collaboration and sharing of information and resources on which science has historically relied (e.g. Hackett, 2001). This critical perspective was premised on the presumed incompatibility of the scientific logic of objective, discovery-oriented research, on the one hand, and the market-driven logic of financial pursuits, on the other.

In response to this approach, other less normatively critical perspectives emerged, which called for more complex accounts of the structural changes underway. Perhaps the most systematically developed version of this second approach has been advanced by Powell and his colleagues (see Powell, *et al.*, 1996; Powell and Owen-Smith, 1998, 2002; Owen-Smith and Powell, 2001), who have used network theory to understand the rise of new institutional structures that depart from previous organizational forms. In this view, the uncertainty and dynamism that characterize science-intensive industries have deterred firms from relying on in-house research and development staffs, given the risks and rigidities such a strategy entails. What has, therefore, developed is a new ecology of collaborative networks that link small start-up firms, venture capitalists, large corporations, university-based scientists and government agencies, which increasingly collaborate on particular initiatives, licensing agreements and partnerships of various sorts. Implied here is an argument that the logics of science and industry are by no means incompatible; to the contrary, 'academic and commercial life scientists are now members of a single technological community' (Powell and Owen-Smith, 2002, p. 107) whose organizing principles have grown more varied and dynamic than critics of commercialization have claimed (Powell *et al.*, 2005).

Empirical efforts to apply these conflicting images of academic and corporate science have grown rapidly during the last two decades (Dubinskas, 1988; Etzkowitz, 1998; Hackett, 2001, 2005; Owen-Smith, 2003; Stuart and Ding, 2006). Yet these efforts have been limited in several respects. First, reflecting the high degree of specialization that informs research on universities and corporations, analysts have often focused on either academic environments or corporate laboratories. Such research designs have approached these two domains in isolation from one another, rendering it difficult to capture the 'cultural traffic' that occurs when normative codes and practices begin to migrate across previously distinct institutional domains. The result has impeded our understanding of the *relationships* that unfold between academic and corporate science as these previously distinct domains increasingly co-evolve.

Theoretical assumptions have also taken their toll. Because much of the debate over the commercialization of science has emphasized the potentially negative effects that flow from intellectual property concerns, the ensuing literature has focused narrowly on contractual agreements, patenting constraints and formal linkages and partnerships between academic and commercial organizations (Sampat, 2005; Murray and Stern, 2006). Yet, arguably, the formal trappings of intellectual property regimes in fact constitute an expression of a deeper, cultural-ideological process that has increasingly engulfed life sciences. The conceptual tools of institutionalist theory are quite useful here. In effect, by emphasizing the pressures that flow from contracts, patenting and licensing provisions, researchers have focused solely on what DiMaggio and Powell (1983) and Powell (1991) have termed *coercive* isomorphism—influences that stem from legal and contractual controls. As a result, they have largely neglected the other forms of isomorphism that institutional theory detects, such as *normative* pressures (as when the mobility of scientific personnel fosters the diffusion of codes and practices across organizational lines) and mimetic ones (in which organizations engage in legitimacy-seeking behaviour by emulating high prestige arrangements). In other words, *underlying the direct, formal legal linkages that UIR theorists have stressed may well be found a deeper process, involving changes in normative codes and practices quite apart from formal, contractual ties*.

Yet, if institutionalist accounts can deepen our understanding of the changes impinging on academic and corporate organizations, they also contain important limitations of their own (Schneiberg and Clemens, 2006). Although institutional theorists have sought to move beyond the assumptions of stasis and conformity that characterized early statements (Jepperson, 1991; Davis *et al.*, 1994; Scott *et al.*, 2000), the tendency has been to view institutional change as a linear historical process in which a once-dominant logic comes under attack and is subject to critique ('de-institutionalized'), until an entirely new alternative arises in its place (Davis *et al.*, 1994; Scott *et al.*, 2000). Arguably, such an approach oversimplifies the process of institutional change, in that it fails to capture situations in which multiple organizational logics *coincide*, yielding tendencies towards hybridity and contradiction that generate ongoing tension, conflict and internal debate (Dubinskas, 1988; Vallas, 2003; Murray, 2006). Indeed, Stark (2001) has suggested that the innovation and creativity that new organizations need often rest on the coexistence of precisely such conflicting logics—a state that prompts him to speak of 'heterarchy' as a nascent organizational form.

With these considerations in mind, we introduced an outline of a theory of the new regimes emerging within science-intensive fields, viewing these regimes as the outcome of what we termed 'asymmetrical convergence' (Kleinman and Vallas, 2001). A central contention of our approach is that the boundary between previously distinct institutional domains has begun to collapse, with

normative codes and practices commingling in novel and often anomalous ways. To be sure, these developments are not entirely new: American universities have long been tied to practical purposes, and corporate laboratories (most notably, Bell Labs) have long made accommodations to scientists' expectations (Kleinman, 2003). Yet what is new is the emergence of a broad structural trend, partly induced by new state policies and partly by substantive developments within science itself, which has encouraged the confluence or co-evolution of previously separate organizational fields. The growth of small start-up firms that reflect the academic origins of their founders; the spread of novel alliances between corporations and university departments; the growth of collaborative publications linking scientists in distinct organizational settings; the increasing citation of work conducted in corporate laboratories; the growing mobility between academia and industry, with the latter recruiting young PhD's from the most prestigious universities—all of these are but a few of the signs that industry and academia have begun to co-evolve in new and distinctive ways.

As a result of these developments, we argue that a two-way cultural traffic is growing, in which market pressures and entrepreneurial practices increasingly pervade academia, even as university-like codes and practices are adopted by science-intensive firms. In speaking of a confluence of norms within corporate and academic contexts, we do not mean to suggest that as codes and practices move across the academic/industry divide, they are simply cut and pasted unaltered. Instead, they are often modified to comport with aspects of the established realm into which they move (Murray, 2006). Thus, academic scientists adopt entrepreneurial orientations where the currency at stake—academic as well as economic capital—often comports uneasily with traditional, discovery-oriented modes of inquiry. And on the commercial side, concern for collegiality and for contributions to 'basic' knowledge is increasingly valued, but largely as a means of attracting and motivating both scientists and investors, not as an end in itself. In private sector science, the free flow of ideas—a deeply held academic ideal—is promoted, but within constraints and always in the service of profit. The result is an increased blurring of relatively distinct institutional domains, where an inherently contradictory, tension-laden knowledge regime takes root, however unevenly, on both sides of the institutional divide. We describe this process as one of 'convergence' not because the two institutional spheres are increasingly indistinguishable, but because each realm begins to manifest parallel tensions and contradictions and because the two domains begin to function as part of a single knowledge regime. We characterize the process as 'asymmetrical' because, in the last instance, the values of neo-liberal capitalism have an overarching impact on how, why and where corporate and academic cultures are drawn on and mixed (Harvey, 2005). Academic norms are adopted in firms in the service of corporate profits, and universities adopt corporate practices most frequently in

the interest of improving the legitimacy they enjoy, whether in the public's mind or in the market for prestige within higher education.

3. Methods and data

Seeking to ground these theoretical formulations in the work situations of life scientists, we designed and conducted a qualitative study of the normative and organizational patterns that obtain among a sample of life scientists employed in both corporate and academic laboratories.

Undertaken between the fall of 2001 and the summer of 2002, the study relies on interview data with scientists, administrators and support personnel within both university and corporate contexts. Approximately half of our interviews were with academic respondents employed at six prominent research universities—three of which were located in the San Francisco Bay/Silicon Valley Area and three that were in the Route 128/Boston region. All of the university personnel we interviewed conduct broadly similar work in biotechnology-related life sciences, chiefly addressing medical as opposed to agricultural questions. The other half of our respondents came from 14 dedicated biotechnology firms evenly drawn from the same two geographic regions. Our selection of these two locales was largely guided by the fact that they have the highest concentrations of biotechnology firms in the United States.

On the industry side, we used both industry directories and snowball sampling methods to construct a size-stratified sample of biotech companies that included small start-up firms as well as large, highly prominent biotech corporations. We then used quota sampling methods to represent the full array of positions ordinarily found within both university settings and biotech firms. At the universities, we interviewed administrators, professors of all ranks, postdoctoral fellows, graduate students and technicians; at the corporations, interviews were conducted with research directors, managers, PhD scientists who led research groups, junior scientists, research associates and technicians. Interviews were semi-structured and ranged between 45 and 90 minutes in length. A second wave of interviews was conducted to follow up issues that arose during our initial wave of interviewing and to lend greater depth to our understanding of the institutions in our sample. Note that, although our interviews sought to retrospectively tap into processes of organizational change, our research rests on a cross-sectional research design and thus cannot directly capture the ongoing co-evolution of university and commercial science. Our research should therefore be read as part of a necessarily larger effort to grasp the growing interdependence or confluence of previously distinct institutional domains.

In the following analysis, we focus on two interrelated dimensions of knowledge production: the organizational structures that govern scientific research

and the social relations established among research personnel (the vertical and the horizontal division of labour). The questions we pose concern the ways in which normative codes and practices in university settings and commercial laboratories have changed over time, deviating from the models that have existed in the past.

4. Organizational structures and control of scientific research

4.1 Academic laboratories

The dominant conception of the workplace in academic science has been one in which individual scientists have sovereign control of their research agendas and daily practices. This view (a kind of interpellation of the individual scientist) is found in the mythmaking accounts of analysts such as Merton (1973) and Polanyi (1962). It is found in science textbooks (Rudolph, 2002), policy documents (Lederman, 1991) and hagiographic histories. Critics of UIRs often naively accept this portrait, claiming only that direct UIRs pose threats to its continued viability (Kleinman and Vallas, 2001).

When asked about the distinction between their own situations and those of corporate scientists, our academic respondents were at pains to affirm the traditional conception of their autonomous position as independent scientists. These scientists insisted that, in contrast to industry scientists, they retain near-complete control over the selection of research topics, the day-to-day operation of their laboratories and, for more junior scientists, their own work practices.[5] Yet, even as they voiced such beliefs, our respondents also reported evidence of normative and organizational influences that quite clearly tend to constrain, in subtle yet important ways, the choices that academic scientists would likely to make. Such influences often involved shifting reward structures, changing funding imperatives and normative pressures emerging among scientists themselves.

As is the case among university scientists more generally, our respondents did have experience with direct, formal ties with corporate, for-profit organizations, much as analysts of UIRs have stressed. Most common were joint ventures or exclusive licensing agreements between departments and companies—precisely, the sort of entanglements that have attracted so much debate. Yet such experiences seemed to hold limited significance, for reasons that were two-fold. First, rather than inducing universities to adopt corporate norms, such arrangements

[5]Typical statements included comments such as these: 'Well, I'm the person in charge of the lab and my intellectual interests are the overriding concern' and 'The general questions are completely up to me'.

often seemed to provoke or inflame conflict and resentment on both sides.[6] And second, as is the case among university scientists more generally, only a small minority of these academic scientists was actively engaged in start-ups, the pursuit of patents, consultant arrangements or other commercial endeavours. In recounting instances of such activities as direct partnerships with biotech firms, respondents often described episodes that stretched one or two decades backward in time.

In spite of the relative paucity of such formal, direct relations with industry, the academic departments in our study have quite clearly encountered increasing pressures to conform to organizational logics that have been traditionally associated with commercial enterprises. Said the dean of sciences at one prestigious Massachusetts university:

> *We are not given the privilege any longer of doing research just because we're curious about an answer*. . . Because nowadays I think it's absolutely critical that we justify the use of taxpayer money based upon the fact that it has some potential to have impact on people. I don't know whether or not the committees that are evaluating people for promotion and tenure are now beginning to understand that they must take into consideration numbers of patents, numbers of companies, the commercialization and the impact of that on the economy of the area. But I'm assuming that if we're going to encourage that, which I know we are, that that will start to become part of the equation, if it isn't already.

Another dean was even more forthright. Describing institutional changes at his university, he invoked an industrial metaphor to describe his conception of the role of the academy within the knowledge economy:

> Right now as a university we're going through a fairly [major] search and re-evaluation of who we are and what we do, and how well we're doing it in view of budget cuts, how we should react, and what I've tried to convince my colleagues is that it would be reasonable to think of a university *as a manufacturer of capital goods*. We manufacture minds, ideas, patents in some cases, and these are the capital goods that industries are built around.

[6]Thus at one Bay Area university, graduate students in molecular biology were materially supported by a biotech firm interested in commercializing the results of their research. When, on the eve of one student's dissertation defence, the firm suddenly insisted that faculty advisors sign broad non-disclosure agreements, a bitter conflict unfolded between the university and the firm, leading many faculty members to become highly critical of corporate partnerships for several years to come.

Other administrators sometimes spoke of beginning to 'focus on research areas for investing', much as venture capitalists might. Ironically, one administrator insisted that universities have remained sharply different from corporations, but the model he used—one that likened faculty to a board of directors overseeing university administrators—was itself drawn from the corporate world. These kinds of remarks indicate that academic institutions have indeed moved to adopt codes and practices that increasingly draw from a logic of commerce and capital accumulation.

Despite describing a work environment in which they were fundamentally autonomous, these scientists often acknowledged that they increasingly faced economic pressures, even if these were not directly related to the commercialization of academia. Said one academic scientist, shrugging his shoulders at our questions:

> Even if you have tenure, in order to keep your lab functional, you have to keep the publications and grants coming in, so it's never completely free. And to get the grants you have to work on stuff which is considered fundable.

Another academic scientist, wryly commenting on the pressures he encountered to conform to scientific fashions and trends, spoke of ensuring that his research proposals were sufficiently 'buzz-word compliant', the better to leverage their chances of success. Many of our respondents lamented the increased pressure and the sheer crush of time as they sought to accommodate the growing demand to engage in fundraising alongside their various other duties.

Such an escalation of pressure to engage in revenue generation was apparent to the graduate students in our sample and was also cited by many of our respondents as a major reason why they left academia in the first place. Many graduate students seemed highly reluctant to shoulder the entrepreneurial burdens their faculty mentors encountered and seemed prone to factor them into their career decisions. Thus, as one West Coast graduate student noted:

> I don't think I could lead a lab . . . I mean, if you're a P.I. and you can't get funding, then you can't pay your graduate students and you can't pay the people relying on you. I think maybe in industry I could hopefully get into a position where I wouldn't have to be in such authority.

Similar inclinations emerged among several of our industrial scientists, who had grown disenchanted with the pressure to generate revenue and elected to leave desirable academic positions in favour of commercial employment. These scientists felt compelled to work for corporations—ironically enough, precisely to escape the entrepreneurial pressures they encountered within the academy.

In these interviews, we begin to sense a ratcheting up of the organizational inducements faced by academic scientists, who are increasingly encouraged to select topics and methods that are attuned to funding imperatives. So intense are these pressures that scientists sometimes find it desirable to seek out research opportunities in industry, since organizational arrangements here make *collective* provisions for entrepreneurial activity that insulate scientists from the need to concern themselves directly with the generation of revenue.

4.2 Commercial science

The stereotypical view of scientific research in corporate settings has traditionally held that scientific projects in this domain are normally conceived, designed and conducted along lines envisioned by corporate managers (see Marcson, 1960; Kornhauser, 1962; Dubinskas, 1988). Several of our academic respondents invoked this stereotype, as when one senior scientist referred to biotechnology firms as mere 'data mills'. A scientist in a middle-sized firm in Boston was all too familiar with this view, which he characterized as: 'Turn the crank, let's, you know, make a molecule but not care about what we're understanding'.

There is an element of truth in this representation. Indeed, a few of the managers we interviewed had moved to focus their research activities more tightly on the discovery of saleable products than their predecessors had done. Yet, for the most part, with important cross-firm variation, the organizational culture and practices we unearthed drew freely from academic norms and conventions, suggesting that the character of scientific research and profit imperatives of corporate goals were much more loosely coupled than academics have presumed.

At some of the biotech firms we studied, for example, one would be hard-pressed to distinguish organizational routines from those found within academic laboratories. This was especially clear at one large commercial enterprise in the Bay Area. One scientist described the culture of research at this firm:

> We're more basic research focused, where we can either work on what is a drug candidate, a therapeutic problem [with obvious commercial value] or you can work on just about anything else provided it will be published in *Science* or *Nature*. . . . If you're doing that kind of glamorous, visibly recognized science, it doesn't matter what it is because something we also care about is our reputation within the scientific community for doing cutting edge research. And you're supported in doing that. So I feel the freedom to say, you know, this is really hot

> and we really need to study this. No it's not a drug, but it's something important . . .

In this case, the firm provides lavish support for basic research, despite the commercial goals the firm must achieve.

Not surprisingly, we did encounter firms in which academic norms were more fully subordinated to commercial imperatives and where scientists needed to gain formal authorization from managers and directors of science before embarking on a given avenue of research. Yet even within these settings, several considerations allowed scientists to preserve a substantial degree of autonomy. First, although the general direction of research was defined by management, concrete lines of research were typically proposed by bench scientists. This meant that in practice, PhD scientists often led projects which they themselves had proposed.

Second, at several firms, respondents reported having substantial freedom to pursue exploratory research of their own choosing, up until the point at which the research became expensive; only then would formal authorization be required. Such an arrangement preserved an important zone of autonomy for scientists employed at commercial laboratories.

Third, the managers we interviewed often seemed quite conscious of the need to accord such autonomy to their research scientists and, for this reason, applied the firm's policies in a flexible manner that allowed for ample give and take. Often, the science directors at these firms played a role that was analogous to that of a senior faculty member leading a large laboratory or research institute. Reflecting this role, several respondents spoke of their efforts to maintain an ongoing dialogue between bench scientists and themselves as to which lines of research to pursue. At times, science directors spoke of forming common cause with bench scientists, seeking support from the company's executives for their jointly formed ideas. In such cases, explained the science director at a larger Boston firm, 'we try to convince [the CEO] of the validity of looking into a particular technology or a particular drug or something like that. We try to educate [the CEO] and everyone about what would be good, something good to look at'.

It is important to acknowledge that none of the commercial firms we studied closely conformed to the academic ideal of scientist autonomy and that there was significant variation in the control that firms allowed their scientists. Still, at many of our firms, managers had made a determined effort to accommodate academic traditions, in keeping with the expectations of their scientists. Indeed, our private sector scientists were often encouraged to maintain an occupational identity *as* professional scientists—a matter discussed further below.

Thus far, our analysis has begun to suggest a number of important points concerning the social organization of scientific work in university and commercial contexts. To begin with, the normative codes and practices in which academic

science takes place have apparently begun to acquire an increasingly overt entrepreneurial cast even in the absence of licensing or patenting conventions or other manifestations of commercial activity. At the same time, for their part, corporate laboratories have made significant accommodations to academic norms, thus appealing to university-based conventions in addition to their customary concern for profitability as such. Thus, despite long-standing conceptions of university and commercial science as institutionally distinct, our interview data begin to suggest an increasing blurring of the boundary between academia and industry, although in ways that are fraught with irony and contradiction. As a number of our respondents themselves observed, the traditional conception of 'separate worlds' seems to have less and less purchase on the ways in which biological science actually operates today.

5. Social relations among research personnel

A second aspect of great interest concerns the social relations established among research personnel themselves. This dimension commands particular attention, given the significance of occupationally rooted norms and practices for the flow of strategic knowledge, resources and techniques within organizations seeking to maintain a culture of innovation (e.g. Saxenian, 1994; Barley, 1996; Orr, 1996; Kleinman, 2003). Since universities have traditionally been regarded as the bearers of the collegial ideal, we ask: How do social relations among academic and corporate scientists compare? In what ways, if any, are the processes of asymmetrical convergence altering social relations in the university and industry? And how do social relations within these laboratories affect the distribution of knowledge among scientists themselves?

5.1 Collegial relations versus status competition in the academy

One of the key points of concern registered by scholars studying UIRs is that the increasing emphasis on the protection of intellectual property threatens to erect increasingly formidable barriers to the free flow of information and resources that are needed for cutting-edge research. Our data speak to these concerns, yet they suggest that analysts have at least partly mischaracterized the nature of such constraints: barriers to the flow of information and mutual support are plainly apparent among the academic scientists in our sample, yet such constraints seem only weakly related to any licensing or patenting arrangements or to the policies of technology transfer offices (Kleinman, 2003). Indeed, many of our respondents could not be bothered to patent their research findings, and only a minority was personally involved in direct commercial ventures of any sort. Rather, the major constraints on the sharing of information and materials that we observed

stem from more subtle, indirect changes in the normative context in which academic science is conceived and conducted.

In contrast to the traditional, idealized conception of academic collegiality, the university scientists we interviewed only rarely spoke of engaging in collaborative research on the basis of shared intellectual interests and concerns. Rather, they most often exhibited an instrumental orientation towards collegial interaction—a view in which collaboration was defined as a means by which to gain access to information, materials or technical expertise (Vallas *et al.*, 2003). Even more noteworthy were the repeated statements we heard in which respondents seemed increasingly wary of sharing information about their research, out of manifest fear that doing so might harm their competitive position.

Evidence of an instrumental view of collaborative work emerged at several points in our interviews. Noted one respondent, an assistant professor:

> If you're interested in some question and somebody has a reagent or a mouse model or animal model which might be very useful for you, and you have that, then you collaborate with them to get [the information or research material you need].

Again, an associate professor described collaborative work as largely lacking in intellectual content: 'we sort of exchange reagents and so forth . . . but it's not, there's not . . . a whole lot of research done in the lab that is sort of directly feeding the collaboration . . .'. Ironically, some of these scientists expressed frustration with such an instrumental approach towards collaborative work and saw the corporate laboratories as more conducive to genuine intellectual collaboration. Thus one scientist at a biotech firm told us that 'in a company, there's much more of a team spirit and excitement about getting something done. So you can put pieces together in ways to accomplish things that could never be done in an academic lab'.

A second point that emerged in our interviews centres on the increasing wariness or reluctance academic scientists displayed when it came to sharing their knowledge and resources with colleagues. To be sure, our interviews do provide evidence of scientists who remain deeply committed to the Mertonian norm of scientific communism. Yet, far more common were expressions of growing secrecy among academic scientists. One scientist who laments the growing secrecy he sees among his colleagues expressed a view that is again fairly close to our own:

> That's becoming an increasingly serious problem in science that, that people are really not sharing things the way they used to, and it's becoming more competitive . . . . A lot of people you know would claim that this has to do with closer interactions with companies and

> financial interests and everything and I don't believe that . . . . It's mostly self-protective and it doesn't have to do with financial interests. It has to do with credit, advancement, grants, prestige, all those things and that's why I think the simple answer is that the field has become highly competitive.

In the same vein, a senior scientist on the West Coast observed that

> The information flow is less free [now] in the sense that if I have four projects going on in the lab and I'm working with a particular collaborator on one of them, I'm not going to tell [him] about the other three. The reason for that is really just competition. . . I suppose that raises some issues about free flow of scientific information, but I don't really think it's an issue because that information gets recorded publicly anyway when you're ready.

These interviews repeatedly suggest that the infusion of an entrepreneurial ethos in academic science is, indeed, increasing the number of barriers that impede the flow of information, but in ways that involve broad, normative shifts in the culture of academic science that cannot be attributed to the formal trappings of intellectual property. Instead, it is *sharpening competition for professional distinction, combined with the entrepreneurial ethos driven by the scramble for scarce dollars, which has yielded increasingly potent barriers to the sharing of knowledge among scientists in the same or similar fields*.

In this respect, our results mirror findings reported in two recent studies of information sharing among life scientists (Marshall, 1997, p. 525; Campbell *et al.*, 2002). These studies, combined with the data reported here, begin to suggest that if the commercialization of science impedes the flow of information—and we believe it does—this effect is a mediated one that operates through subtle change in academic culture and is not directly the result of formal–legal constraints.

5.2 Collegial relations and information sharing in biotech firms

In contrast to the circumstances we found in academic biology, the biotech firms we studied ironically seemed to provide a buffer against sharp status competition, thereby managing to adhere more closely to the collegial, academic ideal than did universities themselves. Commonly, the companies we studied were able to engender a cooperative set of social relations among their research personnel that stressed the value of collaboration and the sharing of information and techniques across different ranks and departments within the firm. As noted above, work processes were generally cooperative and infused with a team ethos that enabled information and other resources to flow quite openly within the firm.

Workers in the commercial laboratories offered a variety of explanations for this culture of cooperation and information-sharing. Some pointed to a specific managerial effort, loosely based on the precepts of knowledge management and the need for a culture of enquiry generally (Kunda, 1992). In keeping with this view, one human resources director explained that the company sought to encourage communication by fostering an informal and relaxed setting:

> The open environment we provide is one that provides for collaboration. [In] the hallways and the bathrooms, wherever you are, [we] try to get people to engage in conversation, talk out ideas, and it's a very open environment that way. I mean our president definitely encourages that. It's a fairly informal environment. We don't wear ties, we don't get all dressed up or anything. It's because it is a working environment and so we try to really encourage comfortable conversation between people.

A manager at another company also spoke of fostering a culture of cooperation and interdependence, seeing shared intellectual efforts as important for the effective use of the firm's talent:

> Well, we do things to try to enhance [information sharing.]. . . We have monthly research meetings which are not to present data but to present plans for research, to organize research going forward . . . . Even in the new facility we have areas that we call collaborative areas which are just off the lab. People can go and sit down and talk about projects or . . . read, or discuss. It's important because everybody needs to know what is going on in other projects so that there's not redundancy.

So well established was this pattern of collaborative relations that, for many of our industry scientists, this feature of their work situations provided a marked contrast with what they had previously encountered in the university setting. Indeed, several scientists at biotech firms reported that their decisions to work in industry instead of academia stemmed precisely from this desire for teamwork and from their feelings of isolation in academia. For their part, human resource managers and science directors often indicated that such openness was not an end in itself, but reflected their recognition that permitting—even promoting—openness within firms not only enhanced the work experience of the scientists but also facilitated the realization of corporate goals (e.g. in the need to avoid 'redundancy').

In pointing to the differential forms that collegial relations take within academia and industry, we hasten to acknowledge that such comparisons are fraught with complexity, given the multiple levels to which comparisons must attend. Although we have emphasized rising levels of status competition among scientists

operating within the same or overlapping area of specialization, academic scientists do retain highly collegial relations with the members of their own research teams and to some extent with colleagues in their own departments. And obviously, biotech firms must, by their very nature, maintain sharply competitive relations with their commercial rivals. We suggest that social relations within the two domains contain elements of both competition and cooperation, yet in ways that have begun to shift. On the one hand, relations among scientists in the same or overlapping areas of specialization seem increasingly market-like, as competition for academic capital impedes informal intellectual exchange. On the other hand, the very appearance of biotech firms can be viewed as an effort to institutionalize the collegial norms that have long characterized the members of a laboratory team and to generalize those norms throughout a given firm. Although elements of incongruity remain, what seems to characterize both academic and commercial science is the increasing purchase of a proprietary relation towards knowledge, with academic scientists and biotech firms each adopting an entrepreneurial or competitive orientation towards colleagues in similar or overlapping fields.

5.3 Publications as currency

A key question that emerges here, of course, concerns the degree to which property considerations constrain commercial scientists from sharing their results with parties external to the firm. On this score, the long-held concern has been that commercial enterprises will be loath to allow publication of their results, for doing so would place privately owned knowledge in the public domain. To be sure, several of the firms in our study looked askance at such a prospect and saw little value in the publication of proprietary findings within peer-reviewed journals. Yet this orientation quite clearly applied to a minority of the firms in our sample. Far more commonly, firms actively embraced the academic tradition of journal publication, making ample provision for scientists to publish the results of company research. At times, our respondents pointed to the cognitive orientations scientists had imported from academia ('it's something they've developed and they bring with them'). At other times, our respondents pointed to the legitimacy-seeking behaviour of the firms ('when a company is new and trying to establish itself . . . , publications help the company establish credibility'). Either way, it seemed clear that publication was an important part of the expectations that these biotech firms embraced. Indeed, one science director went so far as to boast about the citation ratings of his firm, adopting a posture that might easily be taken by a dean or department head.

Our interviews at biotech firms made this point clearly and repeatedly. Said one scientist at a large Bay Area corporation:

> You know, we want to be successful scientists and we're, in many ways I would say, academics at heart and we know that. When you're excited about what you do, you want to tell people about it, and you want to get their ideas, and so you have to be open, and if you're not talking to people on the outside, you get kind of stuck in one way of thinking . . . . I mean it's just part of the whole scientific process . . . . *If you're not publishing, if you're not going to conferences, then of course you're not a real scientist.*

A scientist at a mid-sized firm on the West Coast explained that firms accommodate and even encourage publication, so long as their legal staff are consulted and can file patent applications prior to an article's submission:

> I mean, see, it's weird because there's sort of like this myth that permeated about 'oh when you're in industry, you can't publish.' I found that to be . . . total bull. When I actually got here, there was really no difference.

Yet another scientist, this one at a large Bay Area firm:

> I think it's sort of the dual nature of [this] company that they both want to produce drugs *and* want to be recognized as a first-rate research place. And again, I think in the company's mind those two aren't necessarily so separate . . . [Publishing] creates an outside view of the company that makes really good people want to come here and want to interact with us, and I've seen that a lot. When you say the name [of the firm], people go 'Oh, you know, I want to come there, I want to talk to you, I want to work with you. . .'

Although, on its face, pursuit of scholarly publication seems to run counter to the property interests of the firm, our data suggest that scholarly publications have in fact served as an important source of currency that can actually further a firm's material position. Making allowance for or indeed even encouraging publication productivity enables firms to recruit and retain the best talent, and in doing so foster connections with other scientists, universities and investors, and government agencies as well (Powell *et al.*, 2005).[7] Given these points, it is not difficult to understand why an increasing proportion of the most frequently cited articles in biotechnology are authored or co-authored by scientists employed by commercial enterprises (Stephan, 1996). Apparently, in this respect, the logics of

[7]This point is consistent with data suggesting that entrepreneurial scientists (those enmeshed in commercial ventures) are in fact more highly productive in terms of publication than are those who are more distant from commercial networks. (see Zucker and Darby, 1996; Stuart and Ding, 2006).

academic and industry are not so incommensurable as some theorists have previously held.

6. Conclusions

This study provides a number of findings that hold important implications along two different planes. First, they prompt a rethinking of previous efforts to understand the changing structure of scientific research. And, second, they provide an example of institutional change that takes a different form than that which the dominant theories have allowed. In these concluding remarks, we draw out both sets of implications and offer some suggestions for future research.

First, and with respect to the processes currently reshaping research in life sciences, our findings lend credence to our claim that the codes and practices from industry and academia have grown more intertwined, engendering structural and cultural shifts that previous studies have missed. Caution is needed here: despite our efforts to reconstruct normative shifts, our research has utilized a cross-sectional design that cannot directly capture temporal shifts. It thus cannot document the co-evolution of university and commercial research so much as provide a comparison of the organizational logics that characterize each. Mindful of these limitations (and of the paucity of such cross-domain comparisons in previous research), we suggest that the normative constructs found in both university and commercial laboratories have grown increasingly less distinct. The culture of university science seems clearly to have incorporated entrepreneurial pressures to a greater extent than before, even as commercial science has moved to adopt codes and conventions that had previously been specific to university laboratories. Indeed, commenting on the willingness of biotech firms to accommodate the norm of journal publication and intellectual exchange, and in the light of the abundant resources that companies can provide, many of our respondents had begun to conclude that *private industry better accommodates 'academic' norms than does the academy itself*.

Our findings further suggest that there is some basis to the fear, often voiced by critics of university–industry relations, that salient obstacles have begun to impede the sharing of information and other resources among academic scientists. Yet we find that such impediments do not hinge on such formal, institutional arrangements as patent rights, licensing constraints or direct ties to industry (predominant concerns in the literature). Indeed, such arrangements were only episodically reported among the academic scientists we studied. Rather, *it is the normative orientation that has taken root in many departments and disciplines, based in status competition, which impedes the sharing of knowledge and other resources among professional scientists*. In other words, proprietary concerns do obstruct cooperative and collegial relations, but these relations are

premised on status competition among scientists rather than on the formal–legal apparatuses that analysts have stressed.

Our findings suggest that *a nascent knowledge regime has begun to emerge, however unevenly, across previously distinct institutional domains*. This regime is, we believe, different from its predecessors in that it incorporates conflicting imperatives, lending it a hybrid character that is riddled with inconsistencies, ironies and anomalies. Thus, for example, university departments find themselves torn between their traditional focus on curiosity-driven research and their newer emphasis on research with commercial applications. This tension—viewed by administrators and faculty in disparate ways—lends the structure of academic research a more contentious nature than in the past, reflecting the normative duality that governs university research. Yet, much the same is true of private industry, which has likewise found its traditional commitment to profitable research overlaid by an ethos that supports academic norms and practices (Dubinskas, 1988). The results again infuse the structure of scientific research with a conflicted and contradictory character.

Although we cannot develop the point in the present context, we believe that these developments cut to the very heart of the knowledge economy. Previously, organizational forms—and with them, organization theory—were predicated on the existence of an antipathy between institutional systems that supported the accumulation of academic capital, on the one hand, and of economic capital, on the other. Yet, as shown by the rise of the biotechnology industry (and, we suspect, by other knowledge industries such as information technology, communications and nanotechnology as well), the accumulation of these two forms of capital has grown increasingly intertwined: now, firms seek to nurture the production of high prestige science in order to attract venture capital and other forms of financial investment, while universities seek out opportunities for the accumulation of economic capital as a means of fueling the production of high prestige science. As the circuit of capital gains institutional force, we suspect that the ordering of these respective priorities—indeed, the very distinction itself—will begin to acquire increasingly ironic forms. It is familiar to find that one partner in a university/industry initiative will seek out enhanced opportunities for publication and prestige, while the other seeks augmented revenues. But ironically, in any given transaction, it may increasingly be the firms that are interested in high prestige publications and scientists, and the universities that are concerned with establishing revenue streams.

It is important to note that the pattern we have identified was not uniformly found across the laboratories we explored. Provisions for academic practices seemed most highly pronounced at the more stable and successful firms that had survived for a number of years. Although much more research is needed on this point, this finding begins to suggest that a selection process may be at

work, in which the growth of biotechnology firms hinges not only on structural but also on cultural adaptations—that is, not merely on their embeddedness within relational networks (Powell *et al.*, 1996; Powell *et al.*, 2005) but also on their capacity to institutionalize academic norms, where the latter provide strategic means with which to attract and retain top-quality scientific expertise and, in turn, venture capital as well. This point compares intriguingly with recent findings reported by Owen-Smith (2003), indicating that the success of academic institutions increasingly rests on their ability to deploy hybrid strategies for growth, commercializing their scientific research and using such assets to support academic pursuits. The equivalent point may be true for biotech firms as well. The suggestion that emerges here is that managers and administrators on either side of the university–industry divide are increasingly led to adopt similarly hybridized strategies, combining previously distinct logics to achieve organizational goals.

Although much more research is needed on the conduits through which codes and practices from industry migrate to academia and vice versa, our research prompts a set of observations concerning the mechanisms that may facilitate such cultural exchanges. We believe that academic administrators, responding to pressure from state legislators and the general public, have promoted a vision of universities as economic development engines, with implications for the value that institutions attach to externally funded research as a criterion for tenure and promotion. At the same time, support from federal agencies and foundations for scholarly research increasingly comes with calls for commercial relevance. Likewise, our findings lead us to suspect that labour market conditions, borne of an oversupply of PhDs in life sciences, have encouraged university scientists to adopt an increasingly entrepreneurial ethos, compelling them to regard their research in an increasingly covetous or proprietary way.

For their part, biotech firms themselves have had a major impact on the logic that governs knowledge production in life sciences. By recruiting especially prominent scientists, emulating the culture of academic laboratories, and providing the material and intellectual resources needed to conduct cutting-edge research, commercial laboratories have powerfully reshaped prestige hierarchies (Leicht and Fennell, 1997), altering the professional norms and categories transmitted to junior scientists as well (Stuart and Ding, 2006). Straddling both worlds, finally, are conduits such as foundations (whose funding emphases increasingly underwrite entrepreneurial science), business schools (whose curricula in knowledge management provide administrative personnel) and university licensing or technology transfer offices as well (Colyvas and Powell, 2006).

It is worth reiterating why we call the process underway *asymmetrical* convergence: although codes and practices flow in both directions, it is the influence of

the commercial ethos that has enjoyed the upper hand, especially in an era of sharpening economic competition and the global diffusion of neo-liberal economic policy generally. Indeed, this is very likely why commercial values now pervade the university even in the absence of formal UIRs: few normative bases exist on which the dominance of market values might be challenged. Barring changes in the balance of power, we expect that the emerging knowledge regime will continue to reflect the greater power of commercial priorities, though in ways which are likely to assume a highly uneven form. Indeed, the nature of such disparities constitutes an important avenue for future research.

Our interview data suggest that university administrators are far more supportive of the commercial ethos than are the faculty members they oversee. This finding suggests that the dominance of a commercial logic may at least partly be a function of the power which administrators exercise within academic organizations. If so, then significant variations should exist in the manner with which asymmetrical convergence unfolds across distinct tiers of higher education within the United States. Within leading research institutions, for example, where faculty members have relatively greater power, we would expect the tension between commercial and collegial organizational logics to be especially pronounced, as faculty bring their professional orientations to bear on the changes that administrators seek to pursue (Owen-Smith and Powell, 2001). Outside the upper tier of universities, however, a different set of conditions is likely to obtain. Administrators will be especially prone to seek out venues for commercial pursuits as a means of enhancing their institutional rankings (Owen-Smith, 2003; Brint, 2005). Yet faculty members here enjoy significantly less power to police the boundary between entrepreneurial and commercial logics. As a result, we believe that the entrepreneurial logic is likely to grow increasingly pronounced within less prestigious contexts, where the academic counterweight is less firmly established. Given the relatively low frequency with which commercially oriented research actually succeeds in generating significant streams of revenue, the abrogation of academic norms may unfold with few material rewards to show in return. Thus asymmetrical convergence may differentially unfold, perhaps equipping the most prominent institutions to gain enhanced resources and prestige while imposing less advantageous or even deformed or distended effects on institutions that hold less privileged positions within the structure of higher education.

Yet, even within top-tier universities, any returns that flow from an increasingly commercial orientation may be offset by growing threats to the academic claim of objectivity and concern for the public good—the basis on which academy has long based its legitimacy claims (Bok, 2003). This point warrants careful consideration, as the accumulation of academic and economic capital grows more intricately interwoven and as questions arise about the independence

and integrity of scientific studies undertaken with industrial support and sponsorship. Ironically, academic scientists may find it increasingly difficult to maintain what Bourdieu (1977,p.171, 172) once called 'the sincere fiction of disinterested exchange' (cf. Zelizer, 2005). Our point here is that the structural reconfiguration of academic science generates an increasing tension between the 'ideal' culture of academic science and the 'real' culture of market-oriented logics governing the pursuit of capital in one or another form. How scientists and administrators manage this tension constitutes an important question for future research.

Finally, our study's findings speak to prevailing conceptions of organizational change. In an effort to respond to accusations of a bias towards stasis and continuity, institutional theorists have produced highly suggestive accounts regarding the dynamics of institutional change (see Schneiberg and Clemens, 2006). In certain respects, the resulting literature resembles Kuhn's (1962) theory of scientific revolutions. Institutional logics (for Kuhn, paradigms) arise and enjoy a taken-for-granted status until social structural conditions produce an accumulation of anomalies that discredit or de-institutionalize the previously *doxic* organizational form. A crisis then ensues until a coalition of actors emerges that can establish a new cognitive map. This reasoning is evident in work on corporate forms of organization (Davis *et al.*, 1994) and in the recent scholarship on health care by Scott et al. (2000). While this approach does address the question of institutional change, work in this vein has continued to presuppose the existence of uniformity and consistency within organizational fields. We suggest that the case of biotechnology is especially important because it begins to show how inherently conflicting logics can in fact endure over time, providing a relatively permanent organizational regime despite—arguably, even because of—such internal inconsistencies (Stryker, 1994).

We contend that biotechnology provides a case that is marked by an increasing commingling of normative codes and practices from two previously relatively distinct institutional domains, leading to the emergence of a knowledge regime that is fraught with tension, contradiction and inconsistency (Dubinskas, 1988). Far from demanding resolution, such tensions can in fact serve as a source of creative dynamism, dialogue and reflexivity, compelling the various parties to justify their domain assumptions, to engage in dialogue with those whose orientation differs from their own and thus to make possible a deeper and more innovative understanding of the major tasks at hand. This is precisely what Stark (2001), in developing a concept of 'heterarchy', refers to as the 'asset of ambiguity.'

There is certainly room for debate over the social and organizational conditions that affect the outcome of such contradictory states. What seems less open to dispute is the notion that institutional change takes a broader form than theorists have allowed, increasingly involving contexts in which rival

normative codes and practices compete for predominance within organizational fields. If so, then the case we have developed here may have broader relevance for models of institutional change, drawing attention to the ways in which organizational fields incorporate inherently conflicting codes and practices as an abiding feature of institutional life. Needed is research that allows for the multiplicity of normative codes and practices, especially in an era in which institutional boundaries are often blurred by technological developments, mergers and acquisitions, globalization and the shifting coordinates of public policy (Stryker, 1994 and Owen-Smith; Powell, 2001). Previous generations of organizational theory were often attentive to internal tensions and normative conflicts within organizations of various types (e.g. Lawrence and Lorsch, 1967; Meyer and Rowan 1977). The case of biotechnology seems to suggest that such contradictory or chimerical forms may have increasing currency, forcing us to broaden or extend currently dominant conceptions of institutional change.

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