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Interdisciplinarity: A Critical Assessment

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academic disciplines, interdisciplinary research, cross-disciplinary communication, knowledge diffusion, knowledge integration

Abstract

This article draws together disparate research and theorizing on interdisciplinarity. We first describe widespread efforts to promote interdisciplinarity in U.S. universities and critically examine the assumptions underlying these initiatives. Next, we present a cross-sectional view of interdisciplinary communication, knowledge diffusion, research assessment, and interdisciplinary research centers. We then describe research and theories that provide historical perspectives on the disciplinary system, interdiscipline formation, applied and professional fields, and institutional fragmentation. We present original findings on the prevalence of research centers, faculty hiring patterns in hybrid fields, and the diffusion of research across disciplines in the humanities and social sciences. The review concludes with a critical summary and suggestions for future research.

INTRODUCTION

In this article, we critically examine the status of claims underlying recent efforts to promote interdisciplinarity, which we define as communication and collaboration across academic disciplines. In recent years, numerous efforts to promote interdisciplinary scholarship and research have been advanced by academics and university administrators. For example, there have been calls for more interdisciplinary scholarship in such diverse social policy arenas as international migration (Boomes & Morawska 2005), leisure studies (Mair 2006), obesity (Tiffin et al. 2006), poverty (Hulme & Toye 2006), and public health (von Lengerke 2006), as well as emerging natural science research areas such as nanotechnology (Schummer 2004) and neurosciences (Toescu 2005).

The literature invoking interdisciplinarity as a topic for theory, research, education, and policy is vast. The breadth of this intellectual terrain is suggested by the forthcoming *Oxford Handbook on Interdisciplinarity* (Frodeman et al. 2009). This hefty volume, which promises 42 stand-alone chapters ranging from the physical and life sciences to ethics and design, confirms the premise that academic interest in interdisciplinarity is broad based. The literature is topically diverse as well, with discussions ranging from interdisciplinary pedagogy (Lattuca 2001, Mansilla & Duraising 2007) to interdisciplinary knowledge practices (Galison & Stump 1996, Weingart & Stehr 2000) and interdisciplinary epistemologies and formal theory construction (Faber & Schepper 1997, Fuller 2004), as well as observations on interdisciplinarity as a historical, political, and economic subject (e.g., Klein 1990, Nowotny et al. 2001, Shinn 1999; see also Weingart 2000, Klein 2000, Hackett 2000, Kockelmans 1979, Newell 1998, Berkenkotter 1995).

Among sociologists, interdisciplinarity is lauded as an ideal, scorned as a threat, and embraced as a practice. Scholars have commented on and mapped sociology's historical relationships with neighboring disciplines (Calhoun 1996, Camic 1995), chronicled the mounting insularity of the discipline with the rise of sociological positivism in the 1950s (Steinmetz 2007), and charted more recent sociological contributions to interdisciplinary scholarship across a wide range of areas of inquiry (Smelser 2003, Collins 2007). Reviews that have appeared in the *Annual Review of Sociology* have touched on issues related to interdisciplinarity but have not tackled this topic directly. Essays on the sociology of knowledge (Swidler & Arditi 1994) and scientific knowledge (Shapin 1995), the knowledge economy (Powell & Snellman 2004), and the nature of social and cultural boundaries (Lamont & Molnar 2002) bear on the topic of interdisciplinarity and its implications for sociological research, yet none attend explicitly to interdisciplinarity as such. Instead, these essays provide discussions of phenomena presumably constitutive of interdisciplinarity—such as hybridity or boundary crossing—but without drawing close connections to the broader set of processes that produce and transform relationships among academic disciplines.

The widespread attention that administrators, funders, and faculty alike are giving to interdisciplinarity—and the intensity of the debates that attention has generated—is striking given the fact that relatively little research on many of the underlying issues has been conducted. As a result, we are skeptical of a number of the assumptions advanced by advocates of interdisciplinarity, and we caution against a major reorganization of academic fields without a substantially stronger case being made on both theoretical and empirical grounds. We point out a number of areas where the critique of existing disciplines is not consistent with the available research and point to many topics that warrant further inquiry.

This review is organized into four main parts. First, we highlight current interdisciplinary research and scholarship initiatives and identify the major assumptions that underlie those initiatives. Next, we take a contemporary or cross-sectional view of the connections between disciplines, assessing the empirical case for interdisciplinarity as it relates to

communication and knowledge diffusion patterns, the assessment of interdisciplinary research, and the institutionalizing role of interdisciplinary research centers. The third part introduces a set of longer-term historical perspectives and questions that focus on the disciplinary system, interdiscipline formation, the rise of applied and professional fields, and institutional fragmentation. The fourth part draws together these findings and charts a research agenda on the determinants and consequences of interdisciplinarity.

This review focuses primarily on issues related to academic interdisciplinary research and touches on issues of undergraduate education and cultural practices of scientific work only tangentially. Given the breadth of the potentially relevant literatures, our treatment of these issues is necessarily selective. Our review does not cover the substance of interdisciplinary research studies undertaken by sociologists—for example, we do not review sociobiological work that combines genetics and social demographic or health data (e.g., Bearman et al. 2008) or research by environmental sociologists on coupled human and natural systems (e.g., Dietz et al. 2009). We also largely set aside questions of interorganizational research collaborations (e.g., Powell et al. 2005).

The literature we review is characterized by considerable terminological ambiguity. Some scholars draw clear distinctions between research that is cross-disciplinary or multidisciplinary (contributions from two or more fields to a research problem), interdisciplinary or pluridisciplinary (integration of knowledge originating in two or more fields), or transdisciplinary (knowledge produced jointly by disciplinary experts and social practitioners) (Aboelela et al. 2007, Salter & Hearn 1996). The underlying goal of these terms is to distinguish between low, moderate, and high levels of interconnectedness or intellectual integration. Others are more comfortable with looser distinctions. We count ourselves among the latter group and in this article use interdisciplinary and interdisciplinarity as general terms for describing interrelationships among academic disciplines.

INTERDISCIPLINARY INITIATIVES AND UNDERLYING ASSUMPTIONS

Top-Down and Bottom-Up Interdisciplinary Initiatives

Recent efforts to promote interdisciplinary scholarship have come from numerous sources, including federal agencies, private foundations, and universities. They have taken several forms, including dedicated grant support, competition for seed projects, interdisciplinary training programs, and hiring initiatives targeted at faculty whose expertise spans traditional academic boundaries. Specifically, in 2006, the National Science Foundation (NSF) set aside funds for an interdisciplinary training program for graduate research fellows called the Integrative Graduate Education and Research Traineeship (IGERT) (**http://www.igert.org**). In 2007, the National Institutes of Health funded nine interdisciplinary research consortia "as a means of integrating aspects of different disciplines to address health challenges that have been resistant to traditional research approaches" (National Institutes of Health 2007). As part of its ongoing capital campaign, Stanford University seeks to raise $1.4 billion for multidisciplinary efforts "to seek solutions to the century's most pressing global challenges" (Strout 2006). Since 2002, the Mellon Foundation New Directions fellowships have offered faculty in the humanities and social sciences the opportunity to "acquire systematic training outside their own disciplines" (Mellon Foundation 2008). In May 2008, the University of Michigan announced plans to hire 100 interdisciplinary faculty members over five years "in areas that advance interdisciplinary teaching and research" (University of Michigan 2008).

These are not isolated developments. Brint (2005) carefully documents a growing emphasis on interdisciplinary research initiatives by

university deans, presidents, and provosts, especially at leading private research universities. Common initiatives in this push for interdisciplinary creativity include hiring academic stars to promote interdisciplinary scholarship; organizing competitions for seed money for new, interdisciplinary initiatives; and promoting cross-disciplinary training. Brint's emphasis on government, foundation, and alumni funding highlights the importance of external financial support of these top-down initiatives. He also acknowledges the intellectual ferment bubbling up from the ranks of the faculty whose breakthrough research is driving many of these developments, especially in natural sciences.

Although the impetus for interdisciplinary research appears to be driven primarily by university presidents, provosts, and deans, there is also broad acceptance of the value of interdisciplinary knowledge on the part of faculty. A recent national survey of 1353 college and university faculty found that 70% agreed (strongly or somewhat) with the statement that "interdisciplinary knowledge is better than knowledge obtained by a single discipline" (N. Gross & S. Simmons, personal communication). This view is shared by scholars in the humanities, social sciences, and natural sciences. Indeed, a majority of faculty in 19 of 21 fields agreed with this statement; only mechanical engineers and economists disagreed. Economists' skepticism of research from other disciplines is also evident in their low rate of citation of other social science research (Pieters & Baumgartner 2002).

The bottom-up push for more interdisciplinarity has been accompanied by more discussion of this topic in academic journals. As a rough indicator of the growth of scholarship in this area, we have charted the use of the term "interdisciplinary" in the titles of journal articles, drawing on data from the Web of Science®. Nearly 8000 articles have been published to date using this term. As shown in **Figure 1**, research in this area has grown rapidly since the 1990s. The upward trend is remarkably consistent over time (see also Braun & Schubert 2003).

Table 1 displays the distribution of these articles by the academic discipline of the publishing journal. There has been interest in interdisciplinary scholarship across a wide range of subject areas, from education to chemistry,

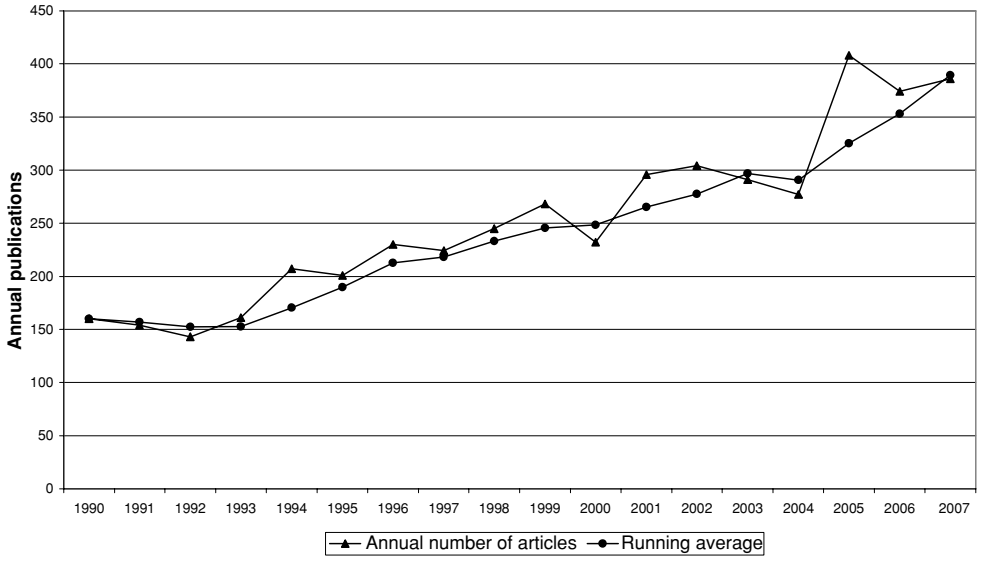

Figure 1

Trends in articles with the term "interdisciplinary" in title, 1990–2007.

Table 1 Distribution of articles with the term "interdisciplinary" in title, by journal subject category

	Record count (N = 7694)	%
Education and Educational Research	351	4.6%
Gerontology	347	4.5%
Medicine, general and internal	319	4.1%
Psychology, multidisciplinary	298	3.9%
Education, scientific disciplines	284	3.7%
Public, Environmental, and Occupational Health	270	3.5%
Rehabilitation	266	3.5%
Psychiatry	260	3.4%
History	257	3.3%
Sociology	228	3.0%
Multidisciplinary sciences	223	2.9%
Chemistry, multidisciplinary	218	2.8%
Information Science and Library Science	212	2.8%
Social Sciences, interdisciplinary	206	2.7%
Surgery	194	2.5%
Health Care Sciences and Services	186	2.4%
Oncology	174	2.3%
Nursing	170	2.2%
Literature	162	2.1%
Geriatrics and Gerontology	158	2.1%
Language and Linguistics	151	2.0%
Religion	148	1.9%
Clinical Neurology	147	1.9%
Psychology	142	1.8%
Philosophy	137	1.8%

Source: Thompson Scientific, 1956–2007. ISI Web of Knowledge℠. Web of Science®. Science Citation Index. Philadelphia, PA: Thompson Scientific Corporation. Available online at **http://isiknowledge.com.**

oncology, and philosophy, as evidenced by these data.

Assumptions Underlying the Current Push for Interdisciplinarity

Most advocates point to problem solving as the main promise of interdisciplinary research (Klein 1990, 1996; Frodeman & Mitcham 2007). Whether basic or applied, interdisciplinarity is supposed to integrate knowledge and solve problems that individual disciplines cannot solve alone. Despite its promise, advocates see numerous barriers impeding interdisciplinary research and scholarship (National Academy of Sciences 2004, pp. 30–39). Epistemic barriers involve incompatible styles of thought, research traditions, techniques, and language that are difficult to translate across disciplinary domains. Disciplinary structures reinforce these inefficiencies through specialized journals, conferences, and departments that route communication inward. Administrative barriers reinforce this intellectual balkanization. Thus, individual researchers must make extra effort and take on additional risk to pursue interdisciplinary research without the kind of support that

comes easily to researchers who remain within their home disciplines. The stakes are high and pressing. "To hinder [interdisciplinary] activity is to diminish our ability to address the great questions of science and to hesitate before the scientific and societal challenges of our time" (National Academy of Sciences 2004, p. 25). This line of argument is grounded in a number of underlying assumptions about the nature of disciplines, research communities, universities, and knowledge:

- Interdisciplinary research has vast potential for societal good in the form of new kinds of knowledge.
- More interdisciplinary research is better than less; its growth is fundamental to the health of the scientific enterprise.
- Disciplines and the institutional policies that reinforce them represent major barriers to interdisciplinary research.
- Reducing those barriers will enhance conditions for the efficient production of interdisciplinary knowledge.

Although these assumptions are broadly shared by advocates of interdisciplinarity, rarely have they been subject to empirical investigation. Case studies predominate in the empirical literature that does exist, many of which take the form of personal reflections (e.g., Salter & Hearns 1996). In contrast, there are virtually no comparative studies that investigate how disciplinary and interdisciplinary relationships develop and whether the consequences of those collaborative outcomes are meaningfully different. For example, there have been periodic efforts to promote interdisciplinary research dating back to the work of the Social Science Research Council in the 1920s, the Rockefeller Foundation in the 1930s, military science in the 1940s and 1950s, and applied social problems in the 1960s (Klein 1990, Pickering 1995, Abir-Am 1988). Yet the lessons from historical successes and failures are not systematically leveraged to clarify how current initiatives are similar to or different from those undertaken in earlier decades. As a result, the literature does not clearly establish the dual propositions that disciplines impede the development of knowledge and that interdisciplinary knowledge is more valuable than that emerging from within disciplines. Some studies have highlighted the organizational and epistemological challenges experienced by interdisciplinary research collaborations (e.g., various chapters in Kockelmans 1979 and Weingart et al. 1997). However, without comparative research designs it is not clear how many of these difficulties in collaboration are unique to cross-disciplinary teams. In other words, collaboration often involves the combination of researchers with complementary skill sets. As a result, even intradisciplinary collaborations may have their own challenges and result in different qualities of knowledge (Moody 2004). With these concerns in mind, we next bring some data on the contemporary situation to bear on the assumptions underlying the broad push for interdisciplinarity.

INTERDISCIPLINARITY: A CROSS-SECTIONAL VIEW

The Prevalence of Interdisciplinary Communication

As we note above, an underlying assumption of advocates of interdisciplinarity is that disciplines represent disconnected silos that inhibit innovation and stifle inquiry on topics outside the narrow confines of each discipline (Bitner & Brown 2006; see also Campbell 1969). Another image of science, however, emphasizes the interconnectedness of academic scholarship: a web. This is the dominant metaphor in bibliometric research. Researchers examine patterns of citations, and other ties, between scholarly research articles to reveal a web of connections between scholarly articles, with no discipline standing completely apart from the others.[1] Research nodes represent dense areas of connections within a broader map of

[1]Recent advances in scholarly databases hold the promise of expanding this line of research to include books as well as articles (Jacso 2005).

science (Small 1999, Small & Griffith 1974, Boyack et al. 2005). Disciplines are located nearer or farther from each other based on the density of connections as indexed by cocitations, that is, citations in common between articles. For example, Boyack et al.'s (2005) finding that biochemistry ranks high on interdisciplinary connections is consistent with Whitley's (1984) emphasis on interdisciplinarity in the laboratory-based natural sciences. The literature on citation patterns is large, with many substantive and technical issues, too large to be summarized here (e.g., Nicolaisen 2007, Gmur 2003).

For our purposes, a central question is how common the connections are between disciplines. The answer depends greatly on the level of aggregation of research specialties and the substantive distance between fields. Porter & Chubin (1985) find relatively few citations in common between demography, operations research, and toxicology, which they view as evidence of the wide gulf between engineering, the life sciences, and the social sciences. Van Leeuwen & Tijssen (2000), however, report very extensive connections across fields. They classified 2314 journals into 119 disciplines represented by ISI subject categories and report that most (69%) references are cross-disciplinary, that is, most references in a given journal are drawn from journals in other disciplinary fields. This remarkably high rate of cross-disciplinary citation in part reflects the detailed journal classification scheme they employ. Had they grouped journals into 20 or 30 fields rather than 199, van Leeuwen & Tijssen likely would have reported a lower rate of cross-disciplinary citations. Nonetheless, their research fits more closely with the "web of science" imagery than with the "isolated silos" assumption.

Classifying references into 11 broad fields, the National Science Foundation (2000) reports cross-disciplinary citation rates ranging from highs of 38.3% in biology and 34.5% in psychology to lows of 18.3% in physics and 16.8% in earth science. The social sciences fall in the middle, with 22.7% of references drawing from outside the social sciences. Delving within these 11 broad fields, the NSF data reveal that the social science field that draws most heavily on research from other disciplines is area studies, with a substantial majority (71.7%) of citations coming from journals in other disciplines. Sociology falls in the middle with 48.5% of references coming from outside sociology. In the social sciences, economics is the most insular, with only 18.7% of references based on research outside of economics.

Rinia et al. (2001) approached the issue of interdisciplinarity in terms of timing. They show that, in general, references to research within the discipline tend to be to more recent articles, whereas references outside the discipline tend to be more dated. They suggest that this finding is consistent with the diffusion of research from the home discipline outward to related fields. We were struck not by the existence of such a delay but by how small the differences typically are and by the fact that 4 of the 16 fields examined cited literature outside the field even faster than that within the field.

Thus, although studies of selected fields often reveal notable barriers to communication (e.g., Howey et al. 1999, Biehl et al. 2006), the broader picture suggests a web of intellectual ties that connects fields across the natural and social sciences. What is not clear is what distinguishes well-connected from poorly connected fields and what the optimum level of cross-disciplinary citation ought to be. Much of the disciplinary self-citation rates may reflect the nature of academic specialization rather than artificial barriers to communication posed by the disciplinary organization of academic departments. Without a standard for the "appropriate" level of cross-disciplinary citation, advocates of interdisciplinarity can always complain that the observed level is lower than it should be.

The Diffusion of Ideas Across Disciplines

Studies of interdisciplinarity assume that there is little if any diffusion of ideas across disciplinary boundaries, but as we note above, the

most influential statements on interdisciplinarity do not investigate this assumption. Rather than sum all citations by journal or discipline, as the studies noted above have done, we sought examples of the prevalence of specific ideas or terms in various fields. The data strongly support Crane's (2008) contention that some concepts successfully diffuse across the humanities and sometimes the social sciences as well. **Table 2** presents data on the prevalence of the term "postmodern" in academic journal articles cataloged electronically by Thompson ISI. This term appears in thousands of journal articles spread across disciplines in the humanities (e.g., literature, religion, philosophy), the social sciences (sociology, political science, psychology), as well as various applied fields such as education. This tabulation by no means captures the full range of diffusion of this term, given that the analysis focuses only on journal articles and omits books and other forms of writing.

We examined the term postmodern as part of the article title and then broadened our search to include the term as a subject category for the article. The latter approach yields a slightly different ranking of disciplines but leads to the same substantive conclusion. Even in the specialized context of academic journal articles, the term postmodernism diffused broadly. Indeed, the concept appears in journals from over 100 disciplines.

Because the term postmodern may mean different things to different scholars, we repeated this analysis with a narrower term that is less vulnerable to this concern, namely Bruno Latour's "actor-network theory." This term has been the subject of 317 journal articles. As is evident in **Table 2**, this concept has diffused across a number of disciplines, from environmental science to sociology to economics. It appears in many other disciplinary journals as well, including anthropology, business, ethics, law, public health, and urban studies.

We then analyzed citations to Latour's two most influential books (*Laboratory Life*, Latour & Woolgar [1979 (1986)], and *Science in Action*, Latour [1987]). Again, each book is different with a slightly different set of disciplines, but the same thrust remains: Latour's work is discussed by researchers in many fields. Whether these concepts diffused too quickly (becoming a fad) or too slowly (owing to unwarranted resistance) is not something these data directly address. Assessing this would require a baseline indicator of how much reception there should have been. Nonetheless, these data do appear to counter the simple assumption that ideas developed in one discipline are rarely adopted in another.

Table 2 Diffusion of terms and concepts in the humanities and social sciences

A. Presence of the term "postmodern" in the title of an academic journal article, by field of journal	
(2282 entries total)	
1. Literature	13.7%
2. Religion	11.0
3. Sociology	7.3
4. Humanities (multi-disciplinary journals)	6.5
5. Philosophy	6.1
6. History	3.9
7. Romance Literatures	3.9
8. Education	3.6
9. Political Science	3.3
10. Linguistics	3.1
B. "Actor-network theory" as a title or subject area of an academic journal article, by field of journal	
(389 articles total)	
1. Geography	18.8%
2. Sociology	18.5
3. Management	18.0
4. Environmental Studies	8.7
5. Information and Library Science	6.2
6. Computer Science	5.7
7. Social Science (multi-disciplinary journals)	5.7
8. History and Philosophy of Science	4.6
9. Social Issues	3.6
10. Economics	4.1

Source: Thompson Scientific, 1956–2007. ISI Web of Knowledge℠. Web of Science®. Science Citation Index. Philadelphia, PA: Thompson Scientific Corporation. Available online at **http://isiknowledge.com.**

The data on references to Latour can also be viewed as a case of the incorporation of interdisciplinary ideas into disciplinary contexts. Latour's work is stridently and explicitly nondisciplinary or postdisciplinary. This case thus raises questions about whether the acceptance of ideas by scholars and researchers depends on whether these ideas originate in a discipline or have an interdisciplinary origin.

We repeated this analysis using the works of such prominent humanists as Lacan, Derrida, and Foucault, along with prominent social scientists including Charles Tilly and Robert Putnam (results not shown). Although each of these authors has been influential in a somewhat different set of disciplines, nonetheless each has been the subject of articles in many fields in the social sciences and humanities.

Another common pattern of diffusion of ideas across disciplinary boundaries is in the area of methods, especially statistical techniques. For example, survival analysis is a statistical technique that has been used in tens of thousands of published journal articles since the 1990s. These papers appeared in public health journals; many types of medical journals, including oncology, cardiology, and surgery; statistics journals; computer science; demography; economics; ecology; and many other fields. In examining the spread of this powerful statistical technique, it is hard to see evidence of academic silos impeding its diffusion. Is this diffusion too slow? Perhaps, but it is hard to specify what the right rate of diffusion would be.

Of course scholars in certain disciplines often resist the ideas of those in other disciplines. One noted case involves the largely opposite explanations of improvements in health and declines in mortality advanced by McKeown and Preston. Thomas McKeown, a prominent British epidemiologist, argued that economic development was more important than medical advances or even public health measures in contributing to the advancement in human longevity (McKeown 1976). Samuel H. Preston (1975), at nearly the same time, argued that economic development was less important than commonly thought and that public health measures were more important. It is commonly believed that epidemiologists have tended to accept McKeown's side of the argument, whereas demographers have rallied to Preston's position. In a 2007 symposium on his original 1975 paper, Preston (2007) notes one possible reason for the continued difference of opinion, namely that both studies were based on indirect evidence. Both scholars advanced their arguments largely by the process of eliminating alternative explanations rather than providing data directly supporting their conclusions. Our analysis of citation patterns suggests that both the Preston and McKeown papers were cited in journal articles in epidemiology, public health, demography, and other areas, and thus differences of opinion were not the result of lack of visibility of these studies.

Is there a "citation penalty" for interdisciplinary research? In other words, do scholars pay a price in terms of the recognition of their work by pursuing interdisciplinary topics? Studies on this topic yield conflicting results. For example, Levitt & Thelwall (2008) find a disadvantage for interdisciplinary studies in the natural sciences but not in the social sciences. In contrast, Rinia et al. (2002) report no cost to interdisciplinary publications. The difference between these two arguments depends in large part on the status of interdisciplinary journals. If one adjusts for the relatively low status of interdisciplinary journals, as Rinia and colleagues did, then there is little or no additional penalty for interdisciplinary publications compared with similarly ranked disciplinary journals. However, advocates of interdisciplinarity might point out that there are relatively few interdisciplinary journals that have obtained high status, thus inhibiting scholars from pursuing interdisciplinary research.

The Assessment of Interdisciplinary Work

A concern voiced by many academic commentators is that interdisciplinary work is too often the product of "amateurism and intellectual voyeurism" (Davis 2007) and results in

knowledge of "dubious quality" (Mansilla & Gardner 2003). To address such claims, university administrators, funding agencies, and interdisciplinary researchers themselves rely on indirect measures of the efficacy of interdisciplinary research bundled in statistics on the number of patents, grants, publications, citation patterns, and the like. Yet scientists working in interdisciplinary contexts recognize the problem with such indicators, most critically that the standard measures of scientific productivity and quality represent the "disciplinary assessment of their interdisciplinary work" (Mansilla & Gardner 2003).

It may be useful to distinguish isolated forays into interdisciplinary topics from dramatically expanding interdisciplinary fields. Rapidly growing areas of inquiry such as neuroscience and nanotechnology may not need special criteria for evaluation: These emerging fields have grown explosively, have successfully competed for funds, have spawned many conferences and journals, and fare well on traditional criteria such as citation rates. The concern regarding special criteria for evaluation may be more compelling in the absence of this type of success.

Unfortunately, systematic efforts to develop evaluative criteria for judging interdisciplinary knowledge have been slow to develop, and direct empirical evidence on how the quality of interdisciplinary research is assessed remains thin. As Klein (1996) noted some years ago, "criteria for judgment constitute the least understood aspect of interdisciplinarity, in part because the issue has been the least studied and in part because the multiplicity of tasks seems to mitigate against a single standard." The gap remains a pressing one today and the central focus of a recent special issue of *Research Evaluation* (Klein 2006). Contributing authors to that issue are in broad agreement that the assessment of interdisciplinary work is both extremely complex—involving "multiple actors making multiple decisions in multiple organizational settings" (Feller 2006)—and requires new models for evaluating the new "cultures of evidence" that are emerging from interdisciplinary endeavors (Klein 2006). Empirical work to date, although limited, identifies a number of specific challenges associated with the practice and evaluation of interdisciplinary research.

The relative absence of epistemic clarity likely has impacts on the organization of interdisciplinary research and on the trajectory of interdisciplinary careers. Summarizing results from a survey of researchers working in five NSF-funded interdisciplinary programs, Rhoten (2005, Rhoten & Parker 2004) reports that younger faculty and especially graduate students express more enthusiasm for interdisciplinary work, claim more experience working in interdisciplinary contexts, and develop more interdisciplinary than disciplinary connections than do their more senior colleagues. At the same time, younger researchers were also more likely to identify particular costs associated with the decision to pursue an interdisciplinary research track, including expectations that they would encounter obstacles to employment and tenure.

Still other sorts of challenges derive from broader social forces that shape interdisciplinary outcomes. Combining primary data from three surveys on interdisciplinarity (the only three in existence at the time of their analysis), Rhoten & Pfirman (2006) find that women scientists are engaged in cross-fertilization activities, form cross-disciplinary collaborations, and participate in institutional efforts of emerging interdisciplines and problem-oriented research at greater rates than their male counterparts. Although provocative, these findings are highly constrained by the limitations of the data, which do not permit consideration of other intervening factors (e.g., race, cohort, institutional context), do not distinguish between push and pull factors, and do not consider issues related to the performance of interdisciplinary science. They also do not consider differences among interdisciplinary domains that are marginalized (e.g., women's studies) compared with those that are "hot" (e.g., complexity research). Nevertheless, these findings provide preliminary support for the thesis that interdisciplinarity is gendered, and, perhaps more importantly, they draw attention to the need for

research that attends not only to the social production of interdisciplinary motivations, practices, perceptions, and outcomes, but also to their consequences.

In a novel attempt to understand how interdisciplinary training affects the collaborative production of interdisciplinary ideas, Rhoten and colleagues (Rhoten et al. 2008, Hacket & Rhoten 2008) recently conducted a "real-life" experiment, modeled after design "charrettes" (discussion groups) popular in nineteenth century French schools of architecture, in which graduate students participating in NSF-funded interdisciplinary training programs (IGERT) were compared with students with disciplinary training. Students were placed into working groups that controlled for gender, field, and years of graduate training and were then given two and a half days to develop brief proposals that would chart the next generation of research on human-ecosystem sustainability. The collaborative group process was monitored by trained observers, and the groups' products (the proposal and a 20-minute presentation) were evaluated by a multidisciplinary panel of experts, with the goal of assessing "whether and in what ways educational experiences change how young scientists work together and the quality of what they produce" (Hackett & Rhoten 2008, p. 14). Contrary to the researchers' expectations, they found that IGERT groups with less training (one to two years) received the highest average scores of all groups, including interdisciplinary groups with three or more years training in the IGERT program.

In a series of papers and a forthcoming book examining how disciplinary experts judge interdisciplinary work (Lamont et al. 2006, Mallard et al. 2009, Lamont 2009), Michele Lamont and her colleagues asked 81 expert panelists from a dozen multidisciplinary fellowship competitions in the social sciences and humanities how they assess the quality of interdisciplinary research proposals and how collectively the panel negotiates fairness in selecting winners. In ways that complement results from Hackett & Rhoten's (2008) charrette experiment, this study finds that "discipline-specific ways of producing theory and methods are still the bedrock of peer evaluation" (Mallard et al. 2009, p. 22). Although idiosyncratic preferences play a role in experts' evaluations of proposals from other disciplines, the tendency is for panelists to abide by the epistemological styles and evaluative criteria of the discipline of the proposal under review. This finding suggests that the key to procedural fairness in assessing the quality of interdisciplinary work is not in giving up disciplinary autonomy, but in knowing when to give one set of disciplinary standards priority over others in the context of assigning greater value to proposals with intellectual breadth.

The Role of Research Centers

Research centers represent an important feature of contemporary research universities that has largely been neglected in the discussion of interdisciplinarity (Friedman & Friedman 1982; see also Klein 1996, chapter 6). Centers are often organized around applied topics, such as the problems of an aging society or the challenges of bioethics, but there are also many centers that focus on topics of enduring academic interest, such as the Minda de Gunzburg Center for European studies at Harvard.

Our research indicates that research centers are an increasingly common feature of U.S. higher education. Drawing on the census of organizations compiled by the Gale research group (Gale Group 2008), we found nearly 10,000 research centers located at colleges and universities in the United States in 2007. Research centers are most common at the leading research universities. Our analysis of the 25 leading research universities in the United States revealed that there were nearly 100 research centers (94.6) per school. There are thus often more research centers than disciplinary departments. A remarkable total of 2366 research centers are found at these 25 universities, representing nearly one-quarter of the total found at all U.S. colleges and universities.

Examination of a sample of these centers from university Web sites suggests that the

vast majority are ostensibly interdisciplinary, at least in name and in self-presentation. Given their sheer number and tendency to identify institutionally with interdisciplinary goals, research centers may function—imperfectly to be sure—as intrauniversity "boundary organizations" (see Guston 2000) that help to bridge disciplinary divides and serve as an organizational counterweight to academic departments. Strong disciplines combined with the flexibility to create diverse research centers as needed may be an attractive organizational solution to the challenges of organizing rapidly growing bodies of research and knowledge, perhaps not least by providing micromobilization contexts for recruitment into emerging interdisciplinary fields (Frickel & Gross 2005). Thus, although advocates of interdisciplinarity have lambasted the ostensibly hide-bound nature of academic disciplines, it is clear that university-based academic departments coexist with an increasing number and diversifying array of research centers that at minimum represent an organizational context for bringing together scholars from diverse backgrounds with shared interests.

Do such centers facilitate communication across disciplinary boundaries? Among the relatively few studies to address this question empirically, Rhoten (2005) offers a guardedly pessimistic analysis. On the positive side of the ledger, faculty in the six interdisciplinary research centers she studied reported spending half of their work time on center-related interdisciplinary activity, and 83% said that their relationships with other center members had positively influenced their own research agendas. She also reports that those centers with larger numbers of affiliated faculty yielded more information sharing but fewer substantive interdisciplinary connections.

Despite these encouraging findings, Rhoten's overall appraisal is pessimistic. She complains that the centers tend to be organized around catch-all themes rather than unifying problem definitions and consequently fall short of achieving the transformative levels of interdisciplinary synthesis. Although this valuable study identifies some important organizational problems, the question of whether research centers represent efficacious solutions to generating interdisciplinary research is far from settled. Our view is that a more modest standard of interdisciplinary awareness and cooperation puts her data in a more positive light. Furthermore, if voluntary participation in interdisciplinary research centers does not produce true interdisciplinarity, it is worthwhile to consider what types of organizational settings might be more conducive to interdisciplinary research and scholarship.

INTERDISCIPLINARITY: HISTORICAL PERSPECTIVES

Continuity and Diversity in the Disciplinary System

The nature of disciplines and relations among them is an old topic in the sociology, philosophy, and history of science, and there is no shortage of theories about them (Ben David & Collins 1966, Clarke 1998, Graham et al. 1983, Lenoir 1997, Lemaine et al. 1976, Sherif & Sherif 1969). The strongest recent statement regarding the durability of disciplinary social structures in the face of interdisciplinary pressures is offered by Abbott (2001). He maintains that the basic disciplinary structure of the academy has changed little since the turn of the last century and that virtually all universities and colleges have lists of departments mirroring the original set of natural science, social science, and humanities disciplines. Abbott traces this resilience to a "dual institutionalization" whereby disciplines structure the national academic labor market as well as hiring practices at individual universities, which cannot move away from the disciplinary organization of departments without undermining their graduate students' opportunities to find employment at other universities. Stasis is reinforced by the system of undergraduate majors that has been in place since the late nineteenth century. Like the academic structure of employment, the vast majority of majors are also organized by discipline. Anchored in this way by the structure

of faculty hiring and undergraduate education, "disciplinary departments are the essential and irreplaceable building blocks of American universities" (Abbott 2001, p. 128).

Abbott views interdisciplinarity as a direct consequence of this disciplinary social structure. He argues that interdisciplinarity is "old news" not only in that a hundred years ago "disciplines bred interdisciplinarity almost immediately," but also in that academic interest in interdisciplinarity has been relatively continuous over the decades since (Abbott 2001, pp. 131, 132). Despite this second-order stability, interdisciplinarity does not threaten disciplinary dominance. This is in part because the disciplinary organization of the academic labor market holds the employability of interdisciplinary researchers and thus their institutional reproduction in check.

Abbott suggests that the disciplines endure for intellectual as well as organizational reasons. Specifically, he suggests that the problem-driven knowledge that interdisciplinarity tends to produce is not sufficiently abstract to compete successfully with the theory-driven knowledge that comes from disciplines—knowledge that is often substantively sufficient for tackling many complex problems. Only a system-wide shift in the way academic careers are structured can overturn this "virtually unbreakable" system.

A similar argument for the durability of prevailing disciplinary distinctions derives from organizational theory (Frank & Gabler 2006, DiMaggio & Powell 1983). The force of institutional isomorphism induces colleges and universities to copy the patterns and practices of other institutions in order to maintain their legitimacy, meaning that a given university is likely to have a biology and a history department because other schools do the same. Creso Sa (2008), an advocate for interdisciplinarity, has suggested that the durability of disciplines is due in large part to institutional pressures of this nature.

Whereas Abbott sees the current disciplinary structure as impervious to all but the most powerful winds of change, a number of other scholars emphasize the historical contingency and variability of disciplines. Turner (2000), who shares a number of Abbott's premises, sees disciplines as employment markets, essentially economic cartels whose main functions are creating and regularizing internal markets for training and exchanging faculty. Disciplines hire from within, and this characteristic—not a distinctive canon, intellectual traditions, or forms of knowledge or expertise—differentiates disciplines from nondisciplinary or extradisciplinary efforts.

Turner differs from Abbott in his view of interdisciplinarity. For Turner, interdisciplinarity creates "novel divisions of labor in response to novel ends" (Turner 2000, p. 56). The ends differ, and so do the resource constraints interdisciplinary efforts must navigate. For example, they may need to secure regular funding, appease a public constituency, offer respite for displaced academics from other units, etc. These different ends and constraints help to account for why interdisciplinary efforts take so many different forms, as well as why they so often fail (e.g., Abir-Am 1987, Barmark & Wallen 1980, Frickel 2004b). Turner draws on examples from the marine sciences and oceanography to illustrate his framework (see also Mukerji 1989 on oceanography and Knorr Cetina 1999 on molecular biology).

Whereas Abbott sees interdisciplinarity as a residual phenomenon, structured by the social organization of disciplines, Turner sees disciplines and interdisciplinarity as distinct and largely independent systems. On this reading, interdisciplinarity is not so tightly dependent on disciplines as to be derivative. "Where researchers are not dependent on [students and clients], disciplinarity is weak and interdisciplinary and nondisciplinary forms flourish" (Turner 2000, p. 60).

Where Abbott anchors his argument empirically on the century-long stability of the basic disciplinary field, Turner sees this pattern as a historical anomaly. Turner maintains that the power of disciplines is in part an artifact of history, and he offers the recent fate of physics as an example of how once ascendant disciplines

can weaken when "cartels make themselves irrelevant" through the "fossilization" of their internal markets (p. 64).

Whitley (1984) also stresses the historical variability of academic disciplines based on a long view of organizational changes in systems of knowledge production and control over the past 300 years. But even during the initial heyday of discipline formation, he notes that not all fields became deeply entrenched in universities as disciplines. Some, like natural history, remained open to "learned gentlemen"—amateur scientists working on private estates outside the academy (see Worster 1994, chapter 1). But more importantly, the centrality of academic disciplines to the organization of scientific research has greatly diminished since then.

Whitley contends that over the course of the twentieth century, the degree to which scientific fields have become mutually dependent—for example by sharing technical procedures and instruments or by adopting evaluative standards from one another—has increased, albeit unevenly. Greater interdependence has meant that intellectual fields today generally exhibit (among other things) weakened boundaries, increased mobility of ideas and skills across those boundaries, and increased interfield coordination of research objectives, strategies, and results. Whitley argues that "traditional patterns of integration and control through academic disciplines seem to have broken down in many fields without any coherent and stable structure emerging to replace them" (p. 292).

Whitley presents interdisciplinarity as a variegated process of organizational change that is sensitive to the internal organization of fields, relationships among fields, and the relation of science to other social systems. Like Abbott, Whitley sees interdisciplinarity as an elemental feature of knowledge production systems, but also one that is highly variable from one field to the next and over time. In that sense, Whitley's perspective is far removed from Abbott's view of interdisciplinarity as a "standing wave" produced by and coextensive with the disciplinary system (Abbott 2001, p. 150). Where Abbott argues that transformative changes to the university system will be required to dislodge academic disciplines, Whitley contends that in the natural sciences this occurred long ago. And countering Abbott's argument that interdisciplinarity poses little threat to disciplinary autonomy and identity, Whitley's analysis sets increased interdependence directly against the persistence of disciplinary control. Thus, disciplines and interdisciplinarity are not distinct systems, as Turner argues, but neither is the relation between the two organizationally uniform or historically stable, as Abbott contends.

The contributions of Abbott, Turner, and Whitley differ on the historical stability of the disciplinary system and the role of interdisciplinarity within this framework, but each takes disciplines as a starting point for their analysis. Steve Fuller's work on interdisciplinarity provides a counterweight to their discipline-centric views. For Fuller, disciplines are utterly conventional results of knowledge-makers' successful bids to gain access to various kinds of resources that, once secured, are then controlled largely through the rhetorical construction of disciplinary boundaries (Fuller 1991; see also Gieryn 1999). Instead, and in stark contrast to Abbott, Turner, and Whitley, Fuller (2003, pp. 1, 3) views disciplines as "artificial holding patterns" that provide "the legitimating ideology of the makeshift solutions that define the department structure of particular universities" and whose histories tend to be presented in ways that make the current regime of disciplines appear inevitable (see also Pickering 1993).

For Fuller (2003, p. 4), the real source of creative knowledge is to be found in interdisciplinary inquiry, which he sees as a central "internal motivator of sustained epistemic change." The position that interdisciplinarity is primary and not derivative (like Turner, above) takes its historical grounding from the observation that today's disciplines began as interdisciplinary social movements "that aspired to address all manner of phenomena and registers of life" (Fuller 2003, p. 4) and its political grounding from the ubiquity of contemporary calls for interdisciplinary solutions to disciplinary problems (e.g., Wallerstein 1996).

The point of interdisciplinarity, Fuller (2004) argues, is not to build on methods and insights from existing disciplines—a common, but misguided approach that mistakenly assumes combining methods makes for better knowledge. Instead, the transformative promise of interdisciplinarity lies in its capacity to interpenetrate disciplines, changing what they do by providing communicative forms and channels for renegotiating disciplinary boundaries and generating new epistemic standards. These observations provide ballast for the position of the most committed enthusiasts for interdisciplinarity (Klein 1990, 1996; Rhoten & Parker 2004). Fuller's theory also shifts the empirical focus of research from the structural nature of disciplinary interrelations to questions of process: Specifically, where do interdisciplinary fields come from?

Interdiscipline Formation

Recent scholarship has come to view the formation of disciplinary hybrids or interdisciplinary fields as the result of collective action that is in many ways analogous to that found in social movements. Scientific and intellectual movements (SIMs) are "collective efforts to pursue research programs or projects for thought in the face of resistance from others in the scientific or intellectual community" (Frickel & Gross 2005, p. 206; see also McLaughlin 2008). The SIMs framework is based on the assumption that, however delimited, new knowledge fields are fundamentally political outcomes, the result of struggles for resources, identities, and status. The framework has particular relevance for studying the emergence and legitimation of "interdisciplines" (Frickel 2004a).

A growing body of historical research documents the diversity of these processes in relation to a variety of institutional contexts and historical eras. These include studies of interdisciplinary SIMs that are more or less internal to the scientific, medical, or academic fields, with biochemistry and cognitive sciences being two well-studied examples (Bechtel 1986, Kohler 1982). Other studies situate interdisciplinary SIMs as straddling the academy and other institutions. For example, SIMs as diverse as mid-nineteenth century demography (Schweber 2006) and 1970s-era genetic toxicology (Frickel 2004b) have origins rooted in state administrative and research bureaucracies. Others are tied more or less directly to social movements, as the cases of black studies (Rojas 2007) and women's studies (Boxer 1998) illustrate. Taken together, this body of work provides mixed support for the notion that interdisciplinarity is something that can be straightforwardly manufactured through top-down administrative policies. Although scholars have identified cases of interdisciplinary SIMs that directly benefited from administrative mandates—California Institute of Technology's use of Rockefeller Foundation funds to promote molecular biology is a classic case in point (Abir-Am 1988, Kohler 1991)—in general, interdisciplinary SIMs are better understood as intellectual insurgencies generated and sustained from below by faculty and graduate students organizing collective challenges to the disciplinary order.

This framework also has implications for theories of disciplinary interaction, reviewed above. We learn, for example, that interdisciplinary pressure in the academy is punctuated, rather than continuous, as suggested by Abbott's "standing wave" argument. It also suggests that interdisciplines are shaped by social forces beyond disciplinary labor markets, as Turner argues. Research suggesting that the movements for civil rights, women's equality, and environmental protection contributed to student demand for programs in African American studies, women's studies, and environmental studies (Brint et al. 2008) is consonant with Frickel & Gross's (2005) framework, although the latter does not require political disruption per se. Institutional instability of any form that creates opportunities for insurgent intellectuals to press the legitimacy of their claims can provide conditions for the emergence of interdisciplinary SIMs. Although the concentration of new interdisciplinary fields in the 1970s in the social sciences and humanities is related to that decade's signature social movements, the

creation of area studies programs in previous decades is more likely an outcome of national security interests, whereas interdiscipline formation in the 1980s and 1990s in the life sciences was likely spurred by instabilities created by technological innovation and changes in the legal structures governing proprietary knowledge (i.e., intellectual capital, patents, licensing agreements). Researchers have yet to study in any detail the rise of interdisciplines comparatively or over broad historical periods.

The Rise of Professional and Applied Departments

The degree to which the current disciplinary structure has been endured historically is a question over which the theorists discussed above differ. Frank & Gabler (2006) document long-term shifts in the relative size of different academic fields (see also Gabler & Frank 2005). Their work is distinctive in emphasizing the global nature of these trends: Their analysis draws on data they compiled on universities in 89 countries spanning the course of a century.

Some academic domains and historical eras are likely to be more conducive to SIM-type activity than others. Brint (2002) highlights the growth of applied and professional fields of study and a corresponding decline in the dominance of the traditional arts and sciences disciplines. He envisions a future in which the influence of the traditional discipline is diminished. In a more recent paper, Brint et al. (2008) documents the growth in undergraduate enrollment in interdisciplinary fields.

One key point of contention between Brint and Abbott is Abbott's suggestion that the disciplines will maintain their influence because the more applied fields hire faculty from the disciplines. Thus, if faculty members in schools of communications or business continue to be drawn from psychology, sociology, and economics departments, then the emergence of such applied fields will pose less of a threat to the disciplines. Brint (2005), however, presents data that indicate that the applied fields have developed their own doctoral programs and are relying less on the academic disciplines to recruit their faculty.

We compiled data from the 2004 National Survey of Postsecondary Faculty (NSOPF) that addresses this issue in more detail (see **Table 3**). The data summarize the fraction of faculty in each discipline, program, or school that has their highest degree in the same field in which they are currently teaching. The findings on the disciplines in the arts and sciences confirm Abbott's (and Turner's) emphasis on the concordance between degrees and departments: The overwhelming majority of faculty in disciplines such as economics, sociology, and psychology have PhDs in these fields. But the same pattern now holds for applied fields as well: Most faculty in business, communications, education, engineering, and medicine are homegrown, and are not imported from the basic disciplines in the social or natural sciences. While some fields, such as business and communication, draw a significant minority of their faculty from the traditional disciplines, in most cases a clear majority of faculty report that they obtained their degrees in these applied and professional fields and not in the basic disciplines.

Thus, the emergence of applied and professional fields of study in higher education appears to be related to a decline in the role of the traditional disciplines. With the possible exception of the very top tier universities, Abbott's confidence regarding the continued influence of the traditional disciplines in the hiring practices of applied and professional programs appears to be misplaced.

Differentiation and Fragmentation

How interdisciplinary are interdisciplinary fields? One possibility is that the rapid growth of a new interdisciplinary field results in higher than anticipated levels of internal differentiation. Successful interdisciplinary research areas thus may generate a new set of journals, subspecialties, internal conflicts over resources, in short, the same fragmentation that certain advocates of interdisciplinarity hope can be overcome.

Table 3 Faculty hiring patterns by field of department. For both columns, the data indicate the percent of faculty whose degree is in the same field as their current department. The first column is for all four year institutions; the second is for research universities

	Percent of faculty with degree in same field as current teaching position—all four-year institutions	Percent of faculty with same area teaching position—research universities
No degree	1.7	3.1
Agriculture and home economics	68.6	70.3
Business	73.5	76.6
Communications	68.8	69.9
Teacher education	85.3	86.7
Other education	78.8	72.9
Engineering	83.6	81.5
Fine arts	89.4	84.8
First-professional health sciences	85.0	86.0
Nursing	73.5	67.8
Other health sciences	52.3	53.9
English and literature	87.0	87.9
Foreign languages	88.8	89.8
History	91.6	90.0
Philosophy and religion	85.8	88.3
Law	92.6	98.4
Biological sciences	81.0	79.9
Physical sciences	93.0	96.8
Mathematics	85.0	88.0
Computer sciences	58.3	64.9
Economics	91.2	89.9
Political science	94.0	93.4
Psychology	93.2	93.0
Sociology	92.3	94.7
Other social sciences	69.4	68.0
Occupationally specific programs	50.1	58.9
All other programs	67.0	67.7

Source: National Survey of Postsecondary Faculty 2004.

Bibliometric research on nanotechnology has explored this issue but is thus far not definitive in resolving it. An early study suggests a high degree of interdisciplinary citations in nanotechnology research (Meyer & Persson 1998). However, a more recent study of coauthorship patterns (Schummer 2004) suggests that nanotechnology is not a single field but rather offshoots of physics, chemistry, electrical engineering, mechanical engineering, and materials science. Schummer's strong conclusion is that nanotechnology's "apparent interdisciplinarity consists of largely mono-disciplinary fields which are rather unrelated to each other and which hardly share more than the prefix 'nano'" (Schummer 2004, p. 425).

We also think it is important to consider the possibility that interdisciplinarity might lead to its own type of fragmentation. One example we found when we were investigating

university-based research centers illustrates the point. Pennsylvania State University has endeavored to promote research related to homeland security (see the HSI: Homeland Security Initiative Web site, for example: **http://homelandsecurity.psu.edu/discovery/centers)**. This worthy goal does not fall within the purview of any single academic discipline and thus is typical of the examples used to argue for the development of organizational models that mobilize the insights and skills of diverse scholars. Yet the Penn State example suggests that interdisciplinarity does not mean the unification or integration of knowledge. They have developed no less than 21 research centers focused on various aspects of homeland security. These include the International Center for the Study of Terrorism, the Center for Information Assurance that addresses issues of cyber security in the context of threats to computer systems, the Protective Technology Center that focuses research and development activities with the goal of protecting people and infrastructure from terrorist attacks, and other centers focused on crisis management, infectious diseases, nonlethal defense technologies, and a host of other issues. Each of these may represent a laudable endeavor, but the proliferation of these research centers, institutes, and laboratories underscores the fact that there are many aspects of any issue and that interdisciplinary initiatives can lead just as easily to the multiplication of academic units rather than their consolidation.

CONCLUSION AND RESEARCH AGENDA

We have reviewed the recent trend toward the promotion of interdisciplinarity on the campuses of many U.S. research universities. This development appears to be widespread and fueled by many different sources. Given these efforts to change one of the basic building blocks of our current scholarly system, we believe the assumptions underpinning this effort warrant careful scrutiny.

We do not believe that the case has been fully made, theoretically or empirically, for the general superiority of interdisciplinary over disciplinary knowledge. The established disciplines are not as static or as isolated as advocates of interdisciplinarity sometimes suggest. Although there are certainly successful examples of interdisciplinarity, established academic disciplines remain dynamic centers of knowledge production that are open to external developments even while insisting on internal standards. Furthermore, the more than 10,000 research centers currently occupying the campuses of U.S. colleges and universities provide considerable opportunities for those interested in building bridges between fields, even if that potential is often underutilized. Additionally, the traditional disciplines are not as dominant as they once were. Enrollment, degree, and faculty employment data all indicate that the traditional disciplines represent a smaller share of the academy than was the case only a generation ago. We are also skeptical about the notion that interdisciplinarity will substantially advance the integration of knowledge. Many interdisciplinary projects make only limited gains (as do many disciplinary-based investigations), and those that are spectacularly successful can become established as new fields of inquiry, leading to a new round of differentiation and fragmentation.

The rapid growth of interdisciplinary research and university-wide effort to promote such scholarship raises many questions for research. Most of the topics discussed above warrant much further inquiry. For example, in what contexts is the centralized promotion of interdisciplinarity effective, and in what circumstances is interdisciplinarity more successful when it percolates from the bottom up? Do departments with faculty from multiple disciplinary backgrounds promote interdisciplinary scholarship or just an additional level of faculty infighting? What types of interdisciplinary research centers are most dynamic? Which tend to be most enduring? Is the hiring of established senior scholars whose work crosses disciplinary

boundaries more effective as a strategy than hiring newly minted PhDs with cross-disciplinary training?

There is a clear need for more studies with a comparative research design. How does interdisciplinary scholarship compare with otherwise similar scholarship? Just as there are intellectual and social gulfs between disciplines, there are also many chasms in research approaches and styles within disciplines. What are the similarities and differences between boundary-spanning research within disciplines compared with similar efforts that cross disciplines?

History also provides an important terrain for research. What can we learn from the history of disciplinary and interdisciplinary research that would give us further insights into the efforts to promote interdisciplinarity? For example, there have been efforts to establish interdisciplinary fields in the past. What can we learn from the successes as well as the failures of these efforts that would help academic faculty and administrators best advance scholarship in general and interdisciplinarity in particular?

Many topics in this area require serious conceptual advances as well as creative collection of new data. For example, can general criteria be developed that would indicate the appropriate level of communication between disciplines? Can general criteria be developed for the evaluation of interdisciplinary research? The renewed efforts to promote interdisciplinary scholarship have given impetus to these and other research questions.

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