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Navigating Among the Disciplines: The Library and Interdisciplinary Inquiry

Carole L. Palmer
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University of Illinois
Graduate School of Library and Information Science
Library Trends, a quarterly thematic journal, focuses on current trends in all areas of library practice. Each issue addresses a single theme in-depth, exploring topics of interest primarily to practicing librarians and information scientists and secondarily to educators and students.

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Library Trends is published four times annually—in summer, fall, winter, and spring—by the Graduate School of Library and Information Science at the University of Illinois, Urbana-Champaign, 501 E. Daniel Street, Champaign, IL 61820-6211.

Subscriptions: Institutional rate is $75 per volume (plus $7 for overseas subscribers). Subscriptions for an individual are $50 (plus $7 for overseas subscribers). Registered students may subscribe for $25 (plus $7 for overseas subscribers). Individual issues are $18.50; back issues other than those from the present year are $10. Claims for missing numbers should be made within six months following the date of publication. All foreign subscriptions and orders must be accompanied by payment.

Address orders to: University of Illinois Press, Journals Department, 1325 S. Oak Street, Champaign, IL 61820. For out-of-print issues, contact University Microfilms International, 300 North Zeeb Road, Ann Arbor, MI 48106. Postmaster: Send change of address to University of Illinois Press, 1325 S. Oak Street, Champaign, IL 61820.

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Periodical class postage paid at Champaign, Illinois.

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This journal is abstracted or indexed in Current Contents, Current Index to Journals in Education, Information Science Abstracts, Library Literature, PAIS, and Social Sciences Citation Index.

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Introduction

CAROLE L. PALMER

Every library is a complex of information systems that promotes the process of intellectual exchange. Bibliographic systems, indexing systems, document delivery systems, and the librarians who design them and provide assistance, work interdependently to foster the use of our huge stock of knowledge. The collections, tools, and services within each library make up an ecology of information systems dedicated to passing knowledge from one person to another. According to the late economist Kenneth E. Boulding (1968), without professions of intellectual exchange, the body of knowledge would be a "mere pile of intellectual accumulations instead of an organic and operating whole" (p. 147). However, do our systems really function as an operating whole? The stock of knowledge is continually increasing in both scope and specificity. It is in a state of flux, an ongoing process of growth and reconfiguration, with the exterior boundaries expanding and the internal geography becoming more and more complex. Creating and sustaining information environments that allow the unrestrained interchange of knowledge is, undoubtedly, one of our field's greatest challenges.

In our attempts to make functional systems out of piles of intellectual content, librarians make many decisions that influence the course of exchange. They decide what to include in collections, what each item is about, and where it will reside—physically and virtually. Some of our most important work is navigational. We plot intellectual connections by deciding how to represent materials and how they relate to each other. We further influence intellectual directions by steering, or failing to steer, users in advantageous directions. The established academic disciplines and
our current systems of information do not always explicitly represent newer territories and the interdisciplinary associations that link them. To find the answers that lie in the networks between disciplines, we learn to collect and combine elements by engineering paths around and through disciplinary divisions.

The division of knowledge has long been a concern of library and information science. In 1968, the librarian of Johns Hopkins University, John H. Berthel, predicted that the dichotomy within universities between specialization and synthesis would become a critical problem for research libraries. While specialization creates new divisions, synthesis dismantles old ones, and the partitions and mergers between disciplines impact all phases of the information transfer cycle—i.e., production, access, use, and distribution. Our profession has the often dissonant responsibilities of building frameworks for controlling information and breaking down the barriers that disrupt the free flow of information. As a result, libraries lie in the balance of tensions between established disciplinary structures and the growth of interdisciplinary knowledge.

Interdisciplinarity has become a topic of wide interest, penetrating the sciences, social sciences, and the humanities. Many researchers practice it, and others study it. Scholars in the emergent area of knowledge studies have made many observations that call attention to the importance of interdisciplinary inquiry for the advancement of knowledge. For example, they have claimed that path-breaking ideas usually come from cross-disciplinary investigation (Turner, 1991), and that disciplinary boundaries are the fault lines that conceal future scientific revolutions (Fuller, 1988). Perhaps even more important for library and information science is the assertion that upgrading our knowledge systems will require more than bridge building and spot repairs if we wish to maintain the cultural and intellectual integrity that underlies our institutions of education and research (Klein, 1993; Allan, 1986). Accordingly, as preservers and purveyors of cultural and intellectual materials, librarians will need to resist superficial solutions to the complex problems of knowledge exchange. Constructing a strong and useful foundation for research and education depends on an in-depth understanding of knowledge structures and how people interact with information and produce new knowledge.

This issue of Library Trends is a forum for dialogue on the interdisciplinary nature of knowledge and the information work involved in inquiry that crosses disciplines. The collection is, in itself, an interdisciplinary compilation. It includes articles by a professor of humanities and two social scientists, whose earlier work in knowledge studies has been particularly opportune for our field. These contributions—by Klein, Pahre, and Dogan—provide an analytical framework for the volume, shedding light on contemporary patterns of knowledge production. Their
articles are interwoven with those by library and information science researchers and practitioners, who draw from these and other allied scholars for their research and practice-based analyses of interdisciplinary information use. As a group, the authors provide a range of perspectives. They cover the context and practice of interdisciplinary inquiry and the cross-disciplinary communities that produce knowledge. A group of studies addresses specific integrative information techniques, followed by a discussion of structural consequences of integration. The concluding articles examine the implications for the administration of library services and the profession as a whole.

The true introduction to this collection is by Julie Thompson Klein, the author of two pivotal books on interdisciplinarity (1990, in press) that are highly relevant to our field. Her opening piece lays the groundwork for this issue of *Library Trends* with an evaluation of the activities and problems involved in interdisciplinary inquiry and the encompassing institutional structures. Her analysis ultimately calls into question the alignment between the current arrangement of knowledge and the needs of information users. This criticism appears particularly astute next to the review of LIS research by Marcia J. Bates. The lack of fit between users and information systems and services seems inevitable considering the dearth of research on the information-seeking behavior of interdisciplinary researchers. The literature shows there is much to learn from this unique group of users, and Bates makes informed recommendations for both basic and applied approaches to the problem.

My study of interdisciplinary scientists begins to address the lack of empirical work described by Bates. The results indicate that the interdisciplinary research process involves the exchange of many types of information and exploration in unfamiliar subject areas. I propose initiatives for making research libraries more supportive of the information strategies used by boundary-crossing researchers. While my analysis mentions the threat of information overload and other deterrents to interdisciplinary progress, Patrick Wilson examines the problem in depth from a policy perspective. He compares the risk of overload in team and solo interdisciplinary research and identifies barriers that can limit the attainment of expertise in new specialties. The potential of social policies on knowledge production is apparent within the context presented by Wilson, and this important theme surfaces again in the concluding discussion offered by Michael F. Winter.

One of the problems with studying, or serving, interdisciplinary information needs is that it has become increasingly difficult to define what constitutes a user group. Wilson’s delineation between individual and team research presents one possible breakdown for analysis, and I have suggested that the actual research problems may be the best grounds for grouping interdisciplinary researchers. Robert Pahre argues that our
knowledge communities are best understood through a combination of social and intellectual explanations. He demonstrates how purely epistemological or sociological investigations are insufficient for analyzing communities and their information environments. Ostensibly, the information practices of individuals and groups display the reconfiguration of knowledge communities. As evidenced by Patricia Clark's study of Internet discussion groups, the nonlinear aspect of networked electronic information is of particular interest, since it appears to disclose interdisciplinary connections as well as cultivate them. She examines cultural aspects of electronic information use, highlighting the self-organizing and transdisciplinary nature of networked electronic communication.

Our professional expertise takes on an added dimension when directed toward the discovery of interdisciplinary connections. Three contributors, White, Smith, and Fiscella, illustrate the critical role of information specialists in cross-disciplinary intellectual exchange. Howard D. White explicates how bibliographic search techniques can reveal interdisciplinarity as well as promote synthesis across disciplines. As White's article suggests, assessing degrees of integration is a very complicated matter. Our field has not yet undertaken this type of evaluation, but we have developed services that enhance interdisciplinary research. Jack T. Smith, who is part of a meta-analysis team, provides background on integrative research and an account of the librarian's role in a multidisciplinary research group. Through an analysis of two methods of bibliographic compilation, Joan B. Fiscella documents the utility of "pragmatic" bibliography for research that crosses disciplines. Clearly, information services, if performed in the interest of interdisciplinary investigation, have much to contribute to the integration of research and knowledge.

While interdisciplinary inquiry may produce integrative results, Mattei Dogan emphasizes the fragmentation that occurs when science grows and reconfigures. He challenges the very notion of interdisciplinarity, suggesting that the term hybridization is a more accurate description of the process. Complementing Pahre's discussion of the formation of communities around different types of information, Dogan provides further insights into how concepts, theories, and methods function in the hybridization process. His concern with specialization foreshadows the approaches taken by Searing and Winter, who have differing perspectives on general and specialized approaches to serving interdisciplinary information users.

Susan E. Searing cautions that we need to address interdisciplinary issues broadly—across all levels of library operations. She contends that transforming our research libraries will require institution-wide awareness of trends in scholarship, since the organization of universities and prevailing political climates complicates the administration of libraries.
Michael F. Winter also presents a macro-interpretation, discussing the profession of librarianship within the social environment of knowledge. He advises that subject specialization may be the only way that librarians can cope with the highly specialized nature of research and scholarship. Winter also envisions an expanded role for the profession, where librarians function as evaluators and integrators and contribute to "social policy studies" of knowledge.

Indeed, the authors of this volume have demonstrated that interdisciplinary inquiry is firmly within the purview of library and information science. Yet many questions remain. How can the dynamics of knowledge and the associated patterns of information use be monitored? What methods can libraries use to assess how well their services support the contemporary intellectual environment? What principles should guide the construction and reshaping of our rapidly growing complex of information systems? Our profession is in a strategic position to tackle the information service and policy problems that affect the quality of intellectual exchange within the ever-changing body of knowledge. Moreover, it would seem that our vested interests and commitment to the free flow of information obligate us to do so.

REFERENCES
Interdisciplinary Needs: The Current Context

JULIE THOMPSON KLEIN

ABSTRACT
MEETING THE INTERDISCIPLINARY NEEDS of today's library users begins with understanding the activities that create these needs. The answers to three basic questions provide the basis for a common discourse about those activities and their place in the knowledge system: (1) why and how do interdisciplinary activities emerge? (2) what form do they take? and (3) where are they located in institutions? Interdisciplinary activities are the result of historical and contemporary developments in disciplines, professions, and new interdisciplinary fields. Recent accounts indicate that interdisciplinarity is no longer peripheral to the academy but is regarded in many quarters as essential to the knowledge system. The cumulative effect of alternative organizations of knowledge and new social and cognitive forms exposes a lack of fit between interdisciplinary needs and existing knowledge taxonomies and classification schemes.

INTRODUCTION
Meeting the interdisciplinary needs of today's library users begins with understanding the activities that create them and their place in the knowledge system. The task of understanding is complicated by the "jungle of phenomena." Interdisciplinarity, as Ludwig Huber put it, is on "everyone's agenda" (Huber, 1992a, 1992b, p. 285). Borrowed tools and methods stimulate cross-fertilization. New concepts and theories transform the ways that objects are treated in traditional disciplines. New subjects generate interlanguages and hybrid knowledge communities. The challenges of the modern world require integrative problem solving and,
at a more comprehensive level, holistic thought and transdisciplinary schema promote unity of knowledge.

The information needs created by these activities land squarely on the desk of the librarian, whose job it is to organize knowledge and make it accessible. Yet, Susan Searing (1992) remarked earlier, interdisciplinary approaches call into question the familiar verbal, numerical, and spatial systems on which we rely. Classification systems function as a "hegemonic representation of human knowledge." Interdisciplinary studies and many modern subjects "must be squeezed into pre-existing outlays of knowledge that no longer fit the shape of current scholarly output" (pp. 9-10).

The problem of interdisciplinarity is the problem of fit. The metaphor of fit, Lynton Caldwell (1983) observed in a genealogy of environmental studies, prejudges the epistemological problem at stake. Interdisciplinary approaches arise because of a perceived misfit among needs, experience, information, and the structure of knowledge embodied in conventional disciplinary organization. They represent a "latent and fundamental restructuring of knowledge and formal education" (p. 247). Recent accounts of interdisciplinary activity affirm Caldwell's claims. They indicate that interdisciplinarity is no longer peripheral to the academy. In many quarters, it is regarded as essential to the knowledge system (Salter & Hearn, 1993; Klein, in press; Klein & Newell, 1996).

The current extent of interdisciplinary activity and the attendant rise of alternative organizations of knowledge underscore the need for a common discourse about interdisciplinary needs. The answers to three basic questions provide the basis for such a discourse. Why and how do interdisciplinary activities emerge? What form do they take? And where are they located in institutions?

**INTERDISCIPLINARY ACTIVITIES**

Klein and Newell grappled with the first question—Why and how do activities emerge?—when they wrote the chapter on "Interdisciplinary Studies" for the new edition of the *Handbook on the Undergraduate Curriculum*. They found familiar reasons alongside new ones:

- general education, liberal studies, and professional training;
- social, economic, and technological problem solving;
- social, political, and epistemological critique;
- holistic systems and transdisciplinary approaches;
- cross-fertilizations of borrowing and subdisciplinary interactions;
- new fields, hybrid communities, and inter-institutional alliances;
- faculty development and institutional downsizing. (in press)

The intermingling of older and newer reasons is not surprising. "Interdisciplinarity," Geoffrey Squires (1992) reflected recently, "is both a permanent and a transient issue in higher education" (p. 201). Any restructuring of knowledge creates the possibility of questioning, altering,
or transcending those structures. Yet interests come and go as a result of factors internal and external to the higher education system (p. 201). Consequently, current activities exhibit both historical and contemporary influences (for histories, see Kockelmans, 1979; Klein, 1990).

In the West, the underlying ideas of general knowledge, integration, synthesis, and unified science developed in ancient philosophy. "Interdisciplinary," nonetheless, is a twentieth-century word. The earliest dictionary citations are references to a December 1937 issue of the *Journal of Educational Sociology* and a subsequent notice regarding postdoctoral fellowships of the Social Science Research Council (SSRC). Yet, ideas of "interrelation," "interfiliations," "intercommunication," "cross-relationships," and "interpenetration" appeared in the social sciences during the 1920s (Frank, 1988, pp. 93-94). In the previous decade, the idea of integrated curricula also appeared in the first general education reform movement in the United States. The current plurality of activity is the result of developments that have made heterogeneity, hybridity, complexity, and interdisciplinarity characterizing traits of knowledge in the latter half of the twentieth century (Klein, in press).

Mapping interdisciplinary activities can be as mind boggling as serving their needs. They comprise a complex and contradictory set of practices located along shifting coordinates (Gunn, 1992, p. 249). Moreover, despite a large literature on the subject, there is no consensus, although there are authoritative terminologies and typologies (for an introduction to the literatures, see Klein, 1994). Differences emerge because activities vary not only across domains but also within them.

In the social sciences, for instance, the earliest prominent interdisciplinary approaches included the unity of science movement, the culture-personality movement, and behavioralism. Throughout the modern history of the social sciences, hybrid domains, such as social psychology and symbolic interactionism, have continued to form. In recent decades, a notable shift from physical processes to symbolic forms has occurred, heightening interactions with the humanities. Clifford Geertz (1980) commented on this "reconfiguration" of the social sciences in the aptly titled and widely read "Blurred Genres."

In the humanities, the ideas of integration and synthesis have strong historical roots—i.e., from the works of Plato, Aristotle, and the Renaissance humanists to early twentieth-century approaches to general education. One of the oldest interdisciplinary fields, American studies, evolved out of English and history departments. More recently, the humanities have experienced a marked increase in genre mixing. Social contextualizations of once discrete disciplinary objects, such as artistic works and literary texts, have blurred traditional boundaries, while new fields, such as feminism and cultural studies, have created "critical interdisciplinarities" that oppose traditional notions of unity and organic relation.
In science, historical precedents range from agricultural research and the Manhattan Project to space research and new work in manufacturing, biotechnology, and computer sciences. New theories, from plate tectonics to chaos, have also had an impact on traditional disciplines of science, and new hybrid interdisciplines, such as materials science and molecular biology, have continued to form. The complexity of modern research problems is often cited as the reason for heightened interdisciplinarity in science today. Yet, with equal force, pragmatic economic and technological problems have stimulated widespread crossing of traditional divisions of science and technology.

Even this thumbnail sketch suggests that interdisciplinary history is not separate from disciplinary history. The dominant pattern of knowledge growth over the course of the century has been the fracturing and refracturing of disciplines into new specialties (Scott, 1984, p. 6). Specialization has been a self-amplifying phenomenon, resulting in 8,530 definable knowledge fields by the year 1987 (Clark, 1995, p. 245; Crane & Small, 1992, p. 197). Yet, while the long-term trend of academic institutions has been in the direction of greater professionalization, departmentalization, and fragmentation, a counter tendency has appeared—the proliferation of crossfertilizations, overlaps, and exchanges (Dogan & Pahre, 1990, p. 85). As a direct result, members of traditional departments are showing up in libraries these days with interdisciplinary needs spawned by new developments in their disciplines and professions, as well as interdisciplinary fields that do not appear on standard organizational charts.

Widespread boundary crossing and genre mixing have promoted a belief that knowledge is increasingly interdisciplinary. As specialization has expanded into new problem areas, the scope of knowledge has extended into new areas of experience and phenomena (Blume, 1985, pp. 145-46). Intensification of interests in new areas has produced new domains that fall between older disciplines, such as sociobiology and biochemistry and, at the extremes of prior capability, particle physics and cosmology. Extensification of interests has produced new areas that draw together existing disciplines to model more complex phenomena, such as concrete economic and public health problems (Fuller, 1988).

A significant number of new specialties have evolved from crossfertilizations of hierarchically unrelated fields, mission oriented fields, and interdisciplinary subject fields. Examples range from political geography and energy politics to sociology of science and the field of communications (Dahlberg, 1994, p. 60). Interdisciplinary fields constitute a second form of specialization that is focused on areas missed or only partially examined by traditional disciplinary specialties (Van Den Daele & Weingart, 1975, pp. 254-55). In order to study new subjects that do not fit into the domains of established subjects, or even take on the classical
characteristics of a discipline, boundaries have been further redrawn through "ontological gerrymandering" (Davis, 1995, p. 133; Woolgar & Pawluch, 1984; Fuller, 1988, p. 197).

As a result of these developments, disciplines have become epistemologically complex (Clark, 1995, p. 252; Klein, in press, p. 55). Disciplines are deeply fissured sites comprised of multiple strata, and they are often influenced by other disciplines (Easton, 1991). They now routinely experience the push of prolific fields and the pull of strong new concepts and paradigms (Jantsch, 1980, p. 306). As dynamic systems—not static structures—disciplines evolve and adapt to changing environments, producing reformulations of the present body of knowledge (Heckhausen, 1972, p. 83). Research tracks and specialties grow, split, join, adapt, and die in an ecology of ideas and influences (Bateson, 1972, pp. 35-46, 62-79; Abbott, 1988, pp. xi, 33). Conventions of interpretation remain but, as Geertz (1980) observed of the social sciences, they are more than ever built to accommodate a situation that is "at once fluid, plural, uncentered, and ineradicably untidy" (p. 166).

These conditions stem, in part, from a process of hybridization. Hybridization reflects the need to accomplish tasks at the boundaries and in the spaces between systems and subsystems (Gibbons et al., 1994, p. 37). In studying the social sciences, Dogan and Pahre (1990) found more recombinations and border crossings by innovative scholars over the past three decades than in the previous millennium. They attribute the development of hybrid fields to a process of specialization-fragmentation-hybridization. As specialization reaches a point of density at the core, defined in terms of relative mass of people, room for innovations opens up at the margins, and innovative scholars recombine specialties across disciplinary lines.

Hybridization is both cause and effect. A relatively recent phenomenon, it produces two types of hybrids:

1. formally institutionalized subfields of one or another formal discipline or permanent "cross-disciplinary" committees or programs that regularize exchanges among scholars from different disciplines;
2. informal hybridized topics, such as development, that may never become institutionalized hybrid fields. (Dogan & Pahre, 1990, p. 63)

The first type, which encompasses many of the examples already mentioned, is the most visible evidence of interdisciplinary activity. Yet the second type, informal hybrid topics, is an equally important index of change. By 1990, roughly 8,000 research topics in science alone were being sustained by specialized networks that are not always bounded by universities, including specialties that require a concentration of funds, equipment, and personnel that are difficult to contain in traditional locales of teaching and study (Clark, 1995, p. 193). Some topics arise from perceived social problem areas and produce new programs of research and
education. Crime, for example, is a social concern addressed by every social science discipline. Interdisciplinary research is conducted on the subject, and interdisciplinary programs have been organized in criminology and criminal justice. The concept of "area," the basis for area studies, is another topical focus and, in response to labor-management conflicts, research institutes and academic programs in industrial relations emerged. Later, responding to other needs, urban studies, gerontology, and environmental studies emerged (Miller, 1982, pp. 12-20).

Different subjects and topics imply different networks of issues, disciplinary structures, and academic values (Fiscella, 1989). In literary studies, a major site of interdisciplinary activity today, new subjects range from the history of the book and materialism of the body to the semiotics of signification and ideologies of gender, race, and class. Each topic, in turn, attracts and projects further lines of interdisciplinary investigation: "The threading of disciplinary principles and procedures," Giles Gunn (1992) found, "is frequently doubled, tripled, and quadrupled in ways that are not only mixed but, from a conventional disciplinary perspective, somewhat off center" (pp. 248-49). The term "off-center" is much to the point. Hybrid topics are stimulated by, as they further stimulate,quiries that do not map easily onto conventional knowledge taxonomies or classification schemes:

Studies like The Body in Pain by Elaine Scarry, for example, have woven psychoanalytic, cultural, materialistic, neo-Marxist, and new-historicist strands of disciplinary interrogation; studies of representation such as Stephen J. Greenblatt's Shakespearean Negotiations have drawn into new combinations historicist, reader-response, cultural materialist, hermeneutic, semiotic, and often deconstructionist inter- and cross-disciplinary modes. But in much of the new interdisciplinary scholarship, studies of the body become studies of representation. (Gunn, 1992, pp. 248-49)

The perception that knowledge is increasingly interdisciplinary further derives from daily cross-fertilizations of borrowing tools and instruments, methods and techniques, data and information, concepts and theories. The better-known examples span science and technology, the social sciences, and the humanities:

- computers, lasers, the electron microscope, and techniques of gene splicing;
- statistical methods, formal mathematical models, data sets, and systems engineering;
- game theory, organizational theory, and factor analysis;
- survey and interview techniques, participation/observation, thick description, and explication du text;
- evolutionary theory, information theory, structuralism, systems theory, and chaos theory;
the concepts of role, status, decision-making, information, and communication;
feminist and Marxist analysis. (Klein, in press, pp. 61-62)

One of the added reasons for increased interdisciplinary activity and significant evidence of the current hybridity and complexity of knowledge is the problems that people work on.

PROBLEMS

It is no longer controversial to suggest that research problems fall between the cracks of established disciplines (Chubin, 1976, p. 466). All problems, though, are not the same. In his contribution to Sigma Xi's study of boundary crossing in science, George Reynolds suggested that scientists address three different kinds of problems. His formulation is valid across knowledge fields, not just science.

1. Problems of the first kind: "intellectual problems within a traditional discipline";
2. Problems of the second kind: "multidisciplinary problems that are basically intellectual rather than policy-action in nature but that cannot be successfully undertaken within the boundaries of a single discipline";
3. Problems of the third kind: "distinctly multidisciplinary problems generated increasingly by society and distinguished by relatively short-time courses calling in some cases for a policy-action result and in other cases for a technological quick-fix." (Sigma Xi, 1988, p. 22)

Disciplining is at its strongest in problems of the first kind. The underlying action of disciplining knowledge is control. Control extends across the entire system of disciplinary technologies, from the structure of the curriculum, organization charts, and knowledge taxonomies to choice of dissertation topics, decisions about tenure and promotion, and judgments about publication and the awarding of grants. Disciplines control problems by naming the things that will be attended to and framing the context in which they are attended (Schön, 1983, p. 40). The problem of "poverty," for example, appears simultaneously in economics, policy studies, sociology, and women's studies. Similarly, the problem of "disease" appears in social medicine, anatomy, gerontology, and a host of medical specialties. Yet "poverty" and "disease" are constructed differently in each disciplinary domain. Boundaries are drawn along particular disciplinary, professional, and interdisciplinary lines.

That said, problems are not contained simply or neatly within academic domains. The pull of problems is so strong that they are often depicted anthropomorphically, with researchers following them wherever they may "lead." One of the major effects of interdisciplinary activity has
been to redefine problems of the first kind as problems of the second kind. This reformulation occurred when textuality, traditionally constructed as a literary problem, became a problem in anthropology and sociology. Reformulations of problems exert centrifugal pressure on conventional definitions of disciplinary domain, departmental structure, and individual identity (Halliday, 1992, p. 26).

Geography provides an extended illustration. Over the course of the twentieth century, the discipline has expanded to include subfields of human, cultural, economic, political, urban, and regional geography as well as biogeography, geomorphology, climatology, environmental science, and cartography. Each subfield, in turn, relates to specialties outside the discipline. Current links with sociology, for example, include human ecology, environmental sociology, rural sociology, and urban studies (Dogan & Pahre, 1990, p. 94). As a result of this history, geographers often use the word “interrelation” to describe the problems they address (Bulick, 1982, p. 46). They have also adopted compound names, identifying themselves as cultural, social, behavioral, regional, physical, historical, Marxist, and economic geographers, as well as geomorphologists, climatologists, and human ecologists (Warrick & Reibsame, 1981, pp. 422-23).

Biology is another example. The boundaries of biology’s subfields are not always easy to discriminate, and biologists may identify themselves differently from the work they are doing at a particular point and from external definitions of their disciplinary domain. One researcher that Kenneth Ruscio interviewed admitted he might be called a biologist but can no longer do so in good conscience. Another usually replies that immunology is his discipline because that is his research area. Yet he coordinates a cell biology course and admits that he is really a cell biologist even though, in studying how cells function, he is involved in problems that go beyond immunology into genetics (Ruscio, 1985, pp. 14-15). These days an embryologist and a geneticist may be more alike in knowledge, techniques, and interests than two chemists. In this circumstance, is it proper to call the collaboration between a geneticist and an embryologist “interdisciplinary” while classifying the joint work of two chemists who labor to understand each other as “disciplinary” research? (Wolfle, 1981, p. 6). Is the scientist who investigates certain molecular structures of DNA a molecular biologist, a geneticist, a biochemist, or a quantum mechanic? (Swoboda, 1979, p. 53).

Problems of the third kind are widely perceived as the major reason for increased interdisciplinarity. Because their impetus lies outside the boundaries of the academy, they are outside the scope of classical problems of the first kind or intellectual problems of the second kind. In 1972, when the Organization for Economic Cooperation and Development (OECD) presented results of the first international survey of interdisciplinary research and education, the first reported force driving
Interdisciplinarity was the development of "science," meaning knowledge in the European sense of the word (OECD, 1972, p. 44) or, by inference, problems of the second kind. A decade later, when presenting results of an international survey on relations between universities and their communities, the OECD declared that exogenous interdisciplinarity now takes priority over endogenous interdisciplinarity (OECD, 1982, p. 130). The term "endogenous" refers to the internal development of knowledge, the term "exogenous" to problems originating in the community and its practical needs.

The OECD's assertion of pragmatic primacy is valid to the extent that demands for social and economic relevance have heightened the legitimacy of practical problem-solving projects, many of them funded by public money. The share of problem- and mission-oriented research in the university has increased to the point that a significant portion of basic research now includes the adjective "mission oriented" (Ruscio, 1985, p. 16). In order to accommodate this type of research, the number of problem-focused structures and collaborative work modes has increased. Disciplines involved in mission-oriented research are also exhibiting fuzziness at their boundaries, and, in some areas, knowledge production is no longer occurring strictly within disciplinary boundaries. Leading examples include the Human Genome Project and the fields of biotechnology, molecular biology, risk assessment, and technology assessment (Gibbons et al., 1994, pp. 138, 147).

Problems of the third kind are also prominent in professional fields. The problems professionals face in day-to-day practice pull research away from disciplinary formulation as problems of the first kind. By their very nature they are open-ended, multidimensional, ambiguous, and unstable. Considered "wicked" and "messy," the problems at the heart of many professional fields cannot be bounded and managed by classical approaches to the underlying phenomena (Mason & Mitroff, 1981; Rittle & Webber, 1973). In the field of planning, for instance, modern planning theory was formed when the special model of rational behavior adopted by neoclassical economics developed into a general theory of rational decision-making. Despite its scope and wide applicability, though, the theory was framed by the paradigm of economic rationality. The gap between technical rationality and the day-to-day problems of practice has stirred challenges to the paradigm. The challenges, often cast as signs of disciplinary crisis, include interdisciplinary approaches, ecological concepts, systems theory, and contingency models that advocate contextually determined decision making (Klein, 1990/91, p. 30).

In the curriculum of professional schools, the problems of interrelating constituent elements are not usually discussed in terms of interdisciplinarity per se, but rather as "integration," "coordination," or the role of "service" courses taught by other departments. Yet, the broader
trend toward interdisciplinarity is being reinforced by growing inclusion of new elements in professional courses, management studies in engineering, social studies in medicine, and foreign languages or computing in others. In keeping with problems of the third kind, interdisciplinarity in professional schools is usually perceived in pragmatic or organizational terms, not theoretical terms (Squires, 1992, p. 206).

Both problems of the second and third kinds posit alternative organizations of knowledge. Exogenous interdisciplinarity forever questions the disciplines on the validity of demarcations they apply to life. If the concept of health, for example, is the starting point for interrogating biological sciences, no boundaries can be accepted between physiology and ethnology or between biology and psychology. If the starting point is the concept of education, the interaction of sociological and psychological aspects or the functions of an institution and teaching practices are perceived as necessary. Similarly, industrial practice can no longer be viewed as simply applied physics or applied economics. Each time, “reality” must be approached from different angles and a vital role accorded to relations among them (OECD, 1982, p. 130). Yet, despite the alternative conceptual status of their underlying categories of knowledge, such as “health” or “ecosystem,” problems of the third kind are usually treated in instrumental terms, rendering interdisciplinarity an empirical problem.

When interdisciplinarity is treated as an epistemological problem, a different condition of knowledge exists. Bryan Turner’s (1990) analysis of the medical curriculum illustrates the difference. Interdisciplinarity in social medicine and sociology of health emerged as an epistemological goal. Researchers focus on the complex causality of illness and disease and the corresponding assertion that any valid therapeutics must be based in a holistic view of the patient. In research centers based on teamwork and solving social and technological problems, interdisciplinarity has been an unintended consequence of economic necessity, not scientific theory. A pragmatic stance renders universities instruments for the production of skills, replacing questions of epistemology with the pragmatics of reliability, efficiency, and commercial value.

Both problems of the second and third kinds also propel movement away from purely disciplinary criteria, although the shift is more widely associated with problems of the third kind. Aant Elzinga (1985) coined the term “epistemic drift” to mark the movement from strictly internalist criteria and reputational control to externally driven criteria that are more open to external regulation in the policy arena (p. 209). Public interest in exogenous problems and political intervention in order to create new facilities to address those problems have propelled interdisciplinary activity in areas of high technology, genetics, space, and cancer research. In this instance, interdisciplinarity is drawn more closely to the problem
of knowledge policy, not epistemology (Fuller, 1993, p. 33) or critique, which is highlighted in critical interdisciplinarities. In this instance, interdisciplinarity serves the political economy of national needs and market trends.

Similarly, Burton Clark (1995) speaks of "restless research." Restless research moves out in many directions from traditional university settings. As an increasing share of research activities becomes located outside teaching departments and outside universities, a "research drift" is occurring (pp. 12, 195). Gibbons et al. (1994) theorize this development as a new mode of knowledge production. Mode 1, the traditional form of knowledge production, is primarily academic, homogeneous, and hierarchical. Comprised of ideas, methods, values, and norms embodied in the Newtonian model of science, it emphasizes disciplinary boundary work and certification. The new mode is framed by the context of application and use. While it is still at an early point, the effects of Mode 2 have already weakened disciplinary and institutional boundaries.

Mode 2 is characterized by closer interaction among scientific, technological, and industrial modes of knowledge production. It is non-hierarchical and transdisciplinary, and it is distinguished by heterogeneously organized forms. Research problems are not set within a disciplinary framework. Human resources are also more mobile, and the organization of research is more open and flexible. In contrast to the simple sharing of resources in Mode 1, Mode 2 entails ceaseless reconfiguration of resources, knowledge, and skills. Each new configuration becomes a potential source of knowledge production that is transformed, in turn, into the site of further possible configurations in a process of ceaseless reconfigurations. In a dynamic and socially distributed system with feedback loops, markets set new problems more or less continuously.

Mode 2 is strongly associated with "science going to be market," but the underlying process is apparent in the humanities as well. The growing fuzziness of disciplinary boundaries that is characteristic of postmodernism, social contextualizations, the crossing of boundaries between elite and mass/popular forms of culture, the heterogeneity of forms and sites of knowledge production, and the impact of the massification of research and higher education are major indicators. In addition, powerful interdisciplinary movements, such as textualism and the Annales school of society history, have reconfigured traditional humanities disciplines and their relations with social sciences for a wider range of reasons than Gibbons et al.'s emphasis on utility allows.

Epistemic drift, restless research, and Mode 2 knowledge production are linked, as well, to the second and third questions—What are the forms of interdisciplinary activities? And, what are their institutional locations?
INSTITUTIONAL STRUCTURE

The location of interdisciplinary activity may be visualized in terms of a spectrum. At one end of the spectrum, overt visible activities appear in the surface structure of institutions. At the other end, concealed invisible activities appear in the shadow structure (Klein, in press). In reviewing the track record of interdisciplinary experiments of the 1960s and 1970s, Keith Clayton (1984, 1985) concluded that little progress had been made in “overt interdisciplinarity.” The “concealed reality of interdisciplinarity,” though, suggests that interdisciplinary studies are probably flourishing most where not labeled as such—e.g., in medicine, veterinary science, agriculture, oceanography, and geography. Behind the “‘subject’ façade,” interdisciplinarity is flourishing.

The most visible forms are self-consciously interdisciplinary universities, colleges, programs, centers, laboratories, and other research facilities such as experiment stations. Some are sufficiently large or prestigious to be regarded as part of the surface structure of a particular college or university. In the curriculum, they include interdisciplinary approaches to general education, new fields and specialty interests, professional training, the educational functions of research centers, individual courses and course segments, as well as internships, practica, and travel-study (for an overview of research activities, see Klein, in press; for an overview of the curriculum, see Klein, 1990, pp. 19-54; Klein & Doty, 1994; Klein & Newell, 1996).

Invisible and concealed activities are embodied in shared interests, common problem domain, the borrowing of methods and tools, faculty learning communities and networks, individual participation in interdisciplinary fields, and team teaching and collaborative research. From the perspective of buildings and equipment, they include shared use of facilities, instrumentation, and databases. The least visible part of the shadow structure is the grassroots presence in disciplines. Activities at this level encompass the interdisciplinary traditions and practices of a discipline, borrowing, problem-focused research, and connection-making in the curriculum. The Association of American Colleges and Universities' (AACU) three-year study of the undergraduate major yielded ample evidence of connection-making—i.e., from problem-focused study and cultivation of integrative skills to contextual inquiry and capstone courses (AACU, 1990).

Activities at the level of disciplines may go unrecognized because faculty often retain traditional labels. Yet their migrations across research specialties are an important form of interdisciplinary activity. As interests change, new discourse patterns emerge, hybrid knowledge communities form, and disciplines fragment along other lines. A member of a French department who was educated in traditional modes of reading literary texts may migrate to a new hybrid specialty such as interpretive theory, or contribute to an established field such as women’s studies, or move to a
new field such as cultural studies. A member of a chemical engineering department may temporarily join a team designing a new urban transportation system, or develop a new line of research on chemical properties in manufacturing design, or relocate to a materials science program or research center (Klein, in press).

The evidence lies not only in the activities of persons but also in institutional structures. Since 1945, the number and variety of institutions devoted to knowledge production have increased dramatically (Gibbons, et al., 1994, p. 141). For the first half of the twentieth century, disciplines were contained and controlled within departmental units. As disciplines have differentiated into increasing numbers of specialties, they have become decentralized into smaller units that neither certainly nor inevitably lie within conventionally defined boundaries. In one public research university, the subject of biology was spread across thirteen discipline-based departments and seventeen interdisciplinary programs (Clark, 1995, p. 142). Alternative sites of research—programs, centers, institutes, and laboratories—have further weakened disciplinary control over subject definition, conceptual approaches, cognitive structures, goals, and norms (Whitley, 1984, pp. 12, 18-20). Three of the most prominent institutional sites are research centers, educational programs of interdisciplinary studies, and new alliances that bridge the academy, industry, and government.

Centers augment the traditional department structure, primarily for the purpose of conducting research. They also collect resources that are used directly for research, such as computers, survey-research facilities, small-group laboratories, specialized libraries, and specialized data. The multi- and interdisciplinary nature of problems is often highlighted when research is located in centers: when, for instance, a polar research center addresses problems of ice core research, polar ecology, Antarctic tectonics, or glaciology (OSU, 1991, p. 18). Most centers, though, are either dominated by a single discipline or bring together a multidisciplinary mix of disciplines. In a large center, the portfolio of projects may include a mix of single-discipline projects, isolated or loosely linked multidisciplinary inputs, and some collaborative activity.

Some centers are connected with recognized interdisciplinary fields such as women's studies, Judaic studies, policy studies, and molecular biology. Others serve localized interests such as regional studies, manufacturing and transportation projects, and employment training. Others yet promote research in areas sustained by national and international networks, from polar research, global change, peace and conflict studies to developmental disabilities and cancer research. The collective presence of centers reinforces the view that official partitions of knowledge are too rigid, as demands for task-, mission-, and problem-orientation reinforce the view that centers are not peripheral to, but a necessary part of, the system of knowledge production.
The same claim is made about educational programs of interdisciplinary studies. Over the past two decades, a notable increase in interdisciplinary approaches to general education has been occurring in the United States. The greatest growth in subject matter areas of general education encourages interdisciplinary approaches in areas such as international studies, American multicultural and gender studies, and the inherently synoptic areas of historical consciousness and ethical understanding (Casey, 1994, p. 56). In the United States, interdisciplinary studies are also being mainstreamed in the form of topical first-year seminars, required core courses, advanced courses on problems or intellectual themes, and senior “capstone” seminars and projects (Stember, 1991, p. 3). In Europe, renewed calls for coherence and connectedness are being heard in the professions and across university subjects. The contexts include environment and ecology; energy, health, Third World; and development policies; information technology; media studies; European unification; and intercultural communication (Huber, 1992b, p. 297).

Like centers, many programs of interdisciplinary studies are connected with new hybrid fields, drawing research and education into parallel trajectories. Examples encompass a range of subject and problem areas, from gerontology and environmental studies to cultural and urban studies. Some fields are quite new. Others have developed to the point that they utilize discipline-like strategies. Cognitive science, for example, has a professional association, an identifiable set of journals, degree programs, and a special library classification. The educational programs that represent these fields are the curricular face of new categories of knowledge. Categories of knowledge are institutions, not in the conventional sense of buildings and organizations but a set of constructed and maintained marks in cultural space. The underlying epistemological categories of interdisciplinary studies—such as “urban,” “environment,” “border,” “area,” “women,” and “culture”—appear in a number of disciplines in partial form. Alternative organizations of knowledge in order to develop them in interdisciplinary fashion have been a major aspect of knowledge production over the latter half of the century.

Alternative organizations of knowledge cannot be fully understood without factoring in socioeconomic and political realities. Conditions of enactment in the interiors of institutions differ widely (Clark, 1995, p. 239). Hence, the same field does not assume the same form from one campus to another. Correspondingly, perceptions of faculty and students differ, a major factor in shaping their sense of information needs. The variable conditions of interdisciplinary studies are especially striking in the United States with its system of over 3,400 post-secondary institutions (Oakley, 1992, p. 282). American studies, to illustrate, may be the primary research interest of a single faculty member, a cross-departmental program, a research center, or a well-established program offering both undergraduate and graduate degrees. Period studies, ranging from the
ancient world to the late twentieth-century or even future studies, may structure departmental curricula or be enclaved in a research center. Likewise, textual and discourse studies, comparative literature, and biochemistry may occupy discrete domains or be dispersed. Biochemistry is sometimes structured as an independent department, sometimes linked to biophysics, joined with physiology, and sometimes organized by an interdisciplinary committee composed of members of departments of biology and chemistry (Bechtel, 1986, p. 16).

In the realm of problems of the third kind, alliances bridging academic, governmental, and industrial sectors have gained increased presence over the past two decades. They include not only familiar structures (science parks, experiment stations, and research centers) but also new structures (offices of technology transfer, industrial liaison programs, joint mergers, and entrepreneurial firms), new affiliations (patent and licensing operations, research consortia, teamwork, and contract research), and new linkages (industrial appointment of academics, venture capital for entrepreneurial faculty, university equipment projects, and the flow of personnel across academic and industrial laboratories) (Klein, in press, p. 182).

As Gibbons et al.'s (1994) theory of Mode 2 knowledge production suggests, the older boundary between basic science and applied science is also being blurred by heightened interplay between differing forms of scientific and technological investigation and of investigative technique and product development. Science and higher education, Clark (1995) adds, have been drawn into fuller and more complicated relationships with patrons who have their own agendas and expectations, especially in fields requiring expensive equipment and large bureaucracies. In some cases, government interests have encouraged a drift of research out of higher education into a wider field of institutions and sites across civilian government agencies, the military establishment, the nonprofit sector, and industry. In the United States, this form of research drift has been slowed by the historic entrenched strength of American research universities as places of inquiry, in contrast to greater reliance on separate research institutes in other countries. Even in the United States though, a significant share of research is appearing outside the university framework (Clark, 1995, pp. 2-4, 197, 208). Clearly, institutional complexity parallels knowledge complexity, yet simplified views often prevail.

**Representing Knowledge**

Simplified views add to the problem of operational realities that out-run old expectations, especially older definitions and historic ideals that view one part or function of the university as its “essence” or “essential mission.” The thrust of complexity has been in the direction of turning universities into multiversities, then into conglomerates. Universities, pushed and pulled in many directions, are less likely to be characterized
by the tight linkage of unitary organization and more by the loose coupling that is characteristic of federations. The main commodity of higher education—knowledge—becomes more diffuse, opaque, incoherent, and centrifugal. As a result, older images of unifying central values and institutional simplicity no longer apply to the fast-changing reality of opaque complexity. The problem of responding to complexity and contradiction is not simply a matter of achieving philosophical reconciliation of ideas. It is overwhelmingly a problem of organization (Clark, 1995, pp. 154-55, 189, 247-48; Scott, 1991).

General systems theory, Klein and Newell (1996) suggest, provides a metaphor for conceptualizing what is happening. Briefly stated, simple systems operate according to a single set of rules. Even if they have multiple levels, connections are arranged in a hierarchy. Complicated systems are variations on the themes of simple systems. Complex systems, in contrast, have nonhierarchical structures. They obey multiple conflicting logics, utilize positive and negative feedback, reveal synergistic effects, and may have a chaotic element. The terminology and methods for understanding the system change as those in the system move through it. To understand what is happening, reductionist thinking must be replaced by nonlinear thinking, pattern recognition, and analogy. Activities may be interconnected in a shifting matrix, replete with feedback loops and unpredictable synergistic relationships in an array of nested contexts (Klein & Newell, in press).

Signs of the shift from simplicity to complexity in academic systems echo across countless reports of learned societies, research advisory bodies, and educational commissions. In its recent report, the Commonwealth of Virginia’s Commission on the University of the 21st Century recalled the words of one university president. The fact that much exciting teaching and research is called “interdisciplinary,” he lamented, is a mark of shame. Concluding that the disciplines are no longer adequate to what we know and the problems we must solve, the commission called for nothing less than a basic transformation in the ways Virginia thinks about higher education, the ways colleges and universities think about their responsibilities, and the ways faculties think about knowledge and their disciplines (Case for Change, n.d., pp. 2, 13).

Language, as librarians well know, is another sign of change. New terminology has been developed to classify interdisciplinary interests. The term “aggregative approach,” for example, labels fields such as gerontology and urban research, which share the focus of different disciplines and exhibit a methodologically and theoretically integrative approach. Usually, though, indicators are more subtle, and obvious keywords—“multidisciplinary,” “interdisciplinary,” “crossdisciplinary,” “transdisciplinary,” and kindred labels—are not used. New words enter the vocabulary and old words take on new meaning, marking shifts in perspective and new ways of seeing (Suleiman,
"The interface between physics and chemistry," the National Research Council reported recently, "has been crossed so often in both directions that its exact location is obscure." Passage across the interface is signaled more by gradual changes in language and approach than sharp demarcations in content. These changes have been a source of continual advances in concept and application all across the science of molecules and atoms, surfaces and interfaces, and fluids and solids (National Research Council, 1986, p. 53).

Metaphors are equally revealing. Whether implicit or explicit, arguments about knowledge are often guided by metaphors (Becher, 1990, p. 333). In the latter half of the century, metaphors of knowledge description have shifted from the static logic of foundation and structure to the dynamic properties of network, web, system, field, and topological metaphors that describe relations among elements, such as joints, points of connection, overlaps, interconnections, interpenetrations, breaks, and cracks (Goldman, 1995, pp. 222-23). In descriptions of interdisciplinary work, a dual rhetoric appears. Metaphors of place—turf, territory, boundary, and domain—call attention to the ways that categories and classifications stake out differences. Metaphors of connection call attention to the crossing and reconstruction of categories and classifications.

"Interdisciplinarity," Roland Barthes (1977) pointed out almost three decades ago, "is not the calm of an easy security." There are few genuine breaks. In contrast to a mere declaration or wish, interdisciplinarity begins effectively when the solidarity of existing disciplines breaks down. This breakdown may occur suddenly, even "violently," through disruptions of fashion, and the interests of new objects and new languages that lack a place in the fields being brought together. The starting point is an "unease in classification." From there a "certain mutation" may be detected. This mutation must not be overestimated, however: "it is more in the nature of an epistemological slide than of a real break" (Barthes, 1977, p. 155).

In a companion metaphor, William Paulson (1991) likens interdisciplinarity to the concept of self organization from noise. The metaphor comes from information theory. When there is noise in an electronic channel during transmission, the information received is diminished by a function known as ambiguity of the message. The message received is neither pure nor simple. Importing terms and concepts from other disciplines creates a kind of noise in the knowledge system. Perceived as unwanted noise in one context, variety and interference can become information in a new or reorganized context. Noise is a signal: "What appears to be a perturbation in a given system turns out to be the intersection of a new system with the first" (Paulson, 1991, p. 44).

Critical interdisciplinarities dispute and disorder conventional understandings of relations between the most fundamental concepts of knowledge description—between origin and terminus, center and periphery, fo-
cus and margin, inside and outside (Gunn, 1992, p. 249). Yet perturbation, disequilibrium, and noise occur to some degree in all interdisciplinary activities, whether in the simple borrowing of a method or concept or in the creation of a new social and cognitive structure to solve a problem. When the day is over, the computers are turned off, the indexes restaked, and the library doors locked, the problem of fit remains. If the structure must be changed to accommodate new fields and new needs, Caldwell (1983) admonishes, perhaps the structure itself is part of the problem.

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Learning About the Information Seeking of Interdisciplinary Scholars and Students

Marcia J. Bates

ABSTRACT
The information needs and information-seeking behavior of scholars and students in interdisciplinary fields has been studied very little. The few scattered studies available suggest that such fields may require striking and distinctive information-seeking adaptations by researchers that mark this area as different and very much deserving of research. Kinds of research needed at both basic and applied levels and with respect to both scholars and students are discussed.

INTRODUCTION
Successive decades of research on information needs and information-seeking behavior have emphasized the study of different broad constituencies of specialists. In the 1950s and 1960s—in part because of the availability of U.S. Federal grant money—the emphasis was on the needs of scientists and engineers (see Meadows, 1974). Needs in the social sciences were attended to in the 1970s, especially with some major research studies that were performed in Great Britain (see review in Hogeweg-de-Haart, 1984). Finally, in part through the support of, and activity of, the Getty Trust in the arts, attention turned to the arts and humanities in the 1980s and 1990s (see Watson-Boone, 1994; Bates, 1994; Bates et al., 1993, 1995).

At least two more broad constituencies remain woefully lacking in research on information seeking:
1. The performers—as distinct from the scholars in the arts—the artists, designers, musicians, actors, dancers.
2. Interdisciplinary researchers—people engaged in the study of fields that span two or more of the established academic disciplines.

It is the second of these two groups that is the focus of this article.

Prior Suggestive Research

Research on information use and information-seeking behavior of people in interdisciplinary fields is sparse to nonexistent. To those whose studies have been missed, my apologies, but a literature review in the conventional places and under conventional terms resulted in the same low hit rate encountered in the past. With increasing interest in interdisciplinary work in scholarship, in fields such as popular culture, film studies, ethnic studies, gay and lesbian studies, and women's studies, it is high time research on information seeking was done in this area.

But research on the information-seeking behavior of scholars and students in interdisciplinary fields would do even more than fill in an obvious gap in our knowledge of this segment of academia. There is reason to suspect that the problems and information-seeking patterns of this group may be dramatically different from those of the scholars in the classical academic disciplines such as history, literature, etc. even where an interdisciplinary field may draw its inspiration and researchers from people trained in these very same established disciplines.

In 1962, L. J. B. Mote published a study which contained some provocative results. Mote divided the scientific users of the Shell Thornton Research Centre Library (United Kingdom) into three groups according to whether their fields of research were low, medium, or high scatter. Low scatter fields were defined as those in "which the underlying principles are well developed, the literature is well organized, and the width of the subject area is fairly well defined" (p. 170). In high scatter fields, the number of different subjects is great and the organization of the literature is almost nonexistent. The medium group fell between the other two in degree of scatter.

Mote (1962), drawing from a sample of 178 people, found that the average number of inquiries requiring thirty or more minutes to answer per person during a three-year period was, for the low to high scatter group, 1.4, 3.6, and 20 (yes, twenty!), respectively. No one in the low scatter group made more than six inquiries and no one in the high scatter group made fewer than ten inquiries (p. 172). In a smaller sampling, the same pattern was found with requests that required under thirty minutes to resolve.

The low and high scatter groups diverged from each other by a factor of over ten to one. This is a most striking and suggestive result. Even
though the study was done in the sciences and engineering, we may well wonder if such divergences might also be found in "high scatter" fields such as area and ethnic studies where the researcher must cross several disciplines to locate all relevant background material for a research project. Could it thus be the case that a researcher in an interdisciplinary field could have ten times as many problems with the process of gathering information for research as people in conventional disciplinary fields?

More recently, Packer and Soergel (1979) also studied scientists (chemists, in this case) in fields with low and high scatter. They focused on techniques used for keeping up to date, or "current awareness" techniques. They found that taking advantage of selective dissemination of information (SDI) services helped the scientists' efficiency in high scatter fields and actually reduced efficiency for those in low scatter fields. To put it differently, diametrically opposing strategies were optimal for researchers in high versus low scatter fields. (SDI is a technique whereby bibliographic citations or copies of new materials received in the library are selectively sent to individual researchers. The selection is based on profiles prepared of each researcher's interests.) So again we see the high/low scatter difference in the character of fields producing a marked effect—in this case, scientists needing to engage in different strategies depending on how focused or scattered the field.

Support comes from another quarter as well for the premise that interdisciplinary information seeking is particularly plagued by problems. The Group on Interdisciplinary Searching of the International Council for Scientific and Technical Information studied the problems specific to interdisciplinary information seeking. Their Journal of Documentation article (Weisgerber, 1993) consists of a dense twenty pages of problems and possible remedies in six areas: "1) coverage and technical content of the database, 2) bibliographic information, 3) textual content, 4) numeric data, 5) file organisation, and 6) interdisciplinary searching on multiple hosts" (p. 231). An example of an information-seeking problem is that conference proceedings are cited in a number of different ways within and across databases (p. 238).

Still another study produced results that have enormous implications for the provision of information services to researchers. Again, working in the sciences, Julie M. Hurd (1992) studied the journal citation patterns in the research papers produced by chemistry faculty at her university (University of Illinois at Chicago). She found that a great many of the citations were to work outside the researcher's discipline. Over 49 percent of the journals cited in her sample's publications were in fields outside chemistry. Individual chemistry professors differed in what percentages were from the outside—the range was 0 to 100 percent. On the other hand, there were practically no citations outside the sciences (p. 293) (earlier, Paul Metz [1983] had found similar outside-of-field
circulation of books to faculty. Also, Howard Pikoff [1991] found that professors, when offered the opportunity to see new acquisitions lists for subject areas all over the Library of Congress classification, frequently selected topics outside their discipline as well as intradiscipline areas).

Hurd (1992) found, further, that chemistry researchers with high citation rates outside the field of chemistry were those researchers who were working in fields that were, by definition, interdisciplinary—e.g., biochemistry and physical chemistry. These chemists cited, respectively, 85 percent and 64 percent of their references to nonchemistry journals, mostly in biology and physics. On the other hand, chemists at the core of the discipline, in inorganic and organic chemistry, cited nonchemistry journals only 29 percent and 24 percent of the time, respectively (p. 294). These results suggest that there is indeed higher scatter in interdisciplinary fields but also that even core fields have connections outside the core.

Hurd (1992) describes some of the implications of her results for provision of information services to scientists as follows:

The high level of interdisciplinary information use measured for these chemists appears to argue against the narrow departmental library type of organization. A chemistry library, narrowly defined and stocked, would only partially meet their needs; a broader, divisional science library seems better suited to support their highly interdisciplinary research. (p. 295)

Over the years there has been a strong pattern at major universities of developing discipline-sized libraries in parallel to discipline-oriented departments. Hurd’s results suggest that the assumption behind that practice—that libraries, in their size and organization, would do best to mirror the intellectual “turf” organization of disciplines—is misguided.

Prospective Possibilities in Basic Research

All the studies discussed in the previous section are notable for their striking results. In each case, the implications are major, not minor, ones involving small adjustments. These results suggest that there may be dramatic differences in the kinds of strategies needed and the amount of effort needed to seek information, depending on the degree of coherence of the bibliographic resources of a field. In sum, studying researcher information seeking in interdisciplinary fields may tell us not only about the needs and problems of people in those fields—something we very much need to learn about—but also about what factors, in general, contribute to ease and difficulty in information seeking in scholarship.

In fact, the results of the Mote study touch on one of the most fundamental—and therefore rarely examined—assumptions in our field. It is taken as a given in library and information science that the organization, description, and indexing of information in indexes, catalogs, and refer-
ence books contributes to the successful and speedy retrieval of information by users. Do we know that it does this in fact? Both the Mote (1962) and Packer and Soergel (1979) studies indirectly suggest that such information organization does make a tremendous difference.

On the other hand, Stoan (1984) has argued persuasively that the model librarians have developed of information searching in academic libraries bears little resemblance to actual research techniques used by scholars and their graduate students. Our conception of the kinds of information access and library organization that will be useful to scholarly users might, in fact, match poorly with their real needs. Thus the question remains open as to whether libraries' access apparatus is, in fact, optimally supportive of scholars' library research.

We might learn much more about just what kinds of organization produce what sort of an effect were we to compare fields that are well controlled—such as conventional academic disciplines—against fields that are not well controlled—such as interdisciplinary concentrations.

The Mote (1962), Packer and Soergel (1979), and Hurd (1992) studies were all done in the sciences and engineering, and we know that there are major differences between the sciences and the humanities and humanistically-oriented social sciences that are the emphasis in this article (see Bates, 1994; Bates et al., 1993). Nonetheless, these studies are highly suggestive.

It certainly seems to be a reasonable preliminary hypothesis that scholars in interdisciplinary fields may have to engage in both substantially more information seeking—and of a different kind—than scholars in a conventional discipline.

In reflecting on the activities of scholars in these fields, one can identify several possible sources of these differences. A scholar can be seen as the cynosure of an extensive social and documentary infrastructure. Academic fields develop a common vocabulary and research style, establish journals, found academic departments, create professional associations, hold conferences, and communicate informally in a number of ways. Libraries, special collections in libraries, and archives are set up with a focus or emphasis that may influence the kind of research done. (For instance, what might be the impact on historical or political science research of having separate presidential libraries around the country, making it easy to concentrate on a single administration, and hard to cut across several administrations?) Bibliographic and other research reference sources are published and collected in scholars' own libraries and in academic libraries. When failures, changes, and gaps anywhere in this extensive scholarly communication apparatus can be identified in interdisciplinary—in contrast to conventional—academic fields, these differences could reasonably be expected to have a substantial impact on the conduct of research.
This scholarly apparatus is in fact so extensive that one could generate dozens of hypotheses about possible differences among the fields. Instead, whole classes of hypotheses will be condensed by talking about broad areas where we might expect differences to be found.

First, we need basic descriptive information: Are there differences between interdisciplinary fields and conventional disciplines in the information needs and information-seeking behavior of their member scholars? Is research and "keeping up" harder for people in interdisciplinary fields? Must the scholar know two or three times as many information resources of each type to cover the territory of interest across two or more fields, or, likewise, must the scholar know and stay in touch with two or three times as many fellow researchers?

Or do compensatory mechanisms develop, mechanisms unique to interdisciplinary research, that make the scholar’s task no more difficult than that of scholars in conventional fields? We do not know the answer to these questions at this point.

Second, we might ask whether there is a natural life cycle to the study of a research specialty topic. Diana Crane (1972) found this to be so in her investigation of communication among scientists in subfields of sociology and mathematics. She charted periods of initial slow growth, followed by explosive growth as new researchers are drawn into the field, and finally, a tapering off of research and publication as a subject matures as a topic of interest (p. 172).

Is an interdisciplinary field simply a new field that has not yet earned full separate-field status? In other words, do disciplines generally feel “interdisciplinary” when they are new? This might evolve because scholars are often drawn to a new field from existing fields, and ideas and research problems in existing fields may be the stimulus for the development of the new field. On the other hand, might some fields remain genuinely interdisciplinary through time, continuing to draw on people from several fields and continuing to need nourishment from several different intellectual traditions? These are hard questions to answer and should probably be left to researchers in scholarly communication and the sociology of science.

For our purposes in information science, these questions might be constructed in the following manner: What is the life history of development of various channels of communication and various forms, or genres, of information resources in a field? Do interdisciplinary fields go through characteristic stages of development, each stage associated with certain typical patterns of ease and difficulty in gathering primary and secondary information for research purposes? Have different interdisciplinary fields responded differently to the challenges of such research with some fields, perhaps, more successful in their response than others?

In the process of studying these various questions, much work needs to be done to define “interdisciplinarity” operationally. Is it, in fact, detectable through high scatter of information resources? Or is there some more essential measure that is closer to the heart of the meaning of the concept?
Do we start from formal theoretical categories and define what the real-life consequences should be based on the theory, and then test the theory? Or do we take a bottom-up approach and identify one or more characteristics, such as Hurd’s out-of-field citation rate, study that statistic in a variety of environments, and develop hypotheses to test further? There are so many possible measures to be taken and questions to be tested in this area that a final decision on methodology must await more specific hypotheses in each.

However, this author confesses to a bias toward the latter approach at this stage of our knowledge. Questions of what is interdisciplinarity have generated a small blizzard of books and articles (e.g., Chubin et al., 1986; Becher, 1989; Klein, 1990; Easton & Schelling, 1991). At this stage, our empirical (as opposed to theoretical) understanding of what it means to work in, and search for, information resources in an interdisciplinary field is minimal. Some basic descriptive work, perhaps using several operational empirical measures to discover the “lay of the land,” will likely turn up results as novel and stimulating as the studies discussed earlier. Based on those findings, the next steps in the study of interdisciplinary information seeking could be planned more rationally.

**Prospective Possibilities in Applied Research**

In addition to doing basic research, we in library and information science are also engaged in a profession with many practical questions to answer regarding the provision of services to meet information needs and uses. It seems reasonable to hypothesize that certain types of resources and services would be particularly useful for the interdisciplinary scholar:

- “One-stop searching” could readily be done in resources that are themselves multidisciplinary, such as the “Dialindex” database of index terms and hits on terms across databases provided by DIALOG Information Services, as well as DIALOG’s “OneSearch” capability in which several databases can be searched simultaneously for topics of interest. Indeed, scholars in the Getty Online Searching Project were particularly taken with the OneSearch capability and found that it revealed work in other fields relevant to their own work of which they had been unaware previously (Bates et al., 1995). Likewise the “Permuterm” subject indexes—i.e., indexes of title words of articles—of the three citation databases produced by the Institute for Scientific Information (ISI)—Arts & Humanities Citation Index, Social Sciences Citation Index, and Science Citation Index—each function as subject indexes across a wide range of subject fields.

- Citation indexes themselves would be particularly useful for interdisciplinary research as well. The principle of ISI’s citation indexes is that they list all the materials ever published that happen to be cited in a given time period, such as a year, in a carefully selected set of thousands of scholarly journals. The scholar may be surprised to discover that someone in another field has used his or her work or that the study of a favorite topic of interest is going on in another field one has never heard of.
Making these links through citations instead of through subject terms is particularly valuable because the same theme or issue is often discussed in different vocabulary from one field to another (see Weisgerber, 1993, pp. 241-44, for a catalog of problems associated with subject indexing access. Smith [1974] also found difficulties with mapping subject terms from database to database). By following up citations to works of proven value, there is no need to know another field's vocabulary in order to locate the information.

The provision of selective dissemination of information services would be particularly valuable to interdisciplinary scholars compared to those in conventional disciplines. This hypothesis coincides with the Packer and Soergel (1979) findings discussed earlier. It is by no means clear, however, that this hypothesis will be demonstrated to hold true in the humanities, where scholars like to do their own searching and browsing in the literature.

Practical testing of the above hypotheses could be done in a variety of ways. For example, bibliographic instruction classes could be offered specifically for people in interdisciplinary fields and which included the above sorts of sources. Plumbing people's reactions at the time and later, after some experience with these sources, could give a sense of how beneficial researchers found them to be. Though scholars are ordinarily loathe to admit to any deficiencies in their information-searching techniques, they might be more inclined to take a special class if it is offered as a way to learn new online sources.

Next, if, as assumed, it is more difficult for interdisciplinary scholars to do research in documentary resources, then might it not also be so for students? Some work has already been done in this area (SantaVicca, 1986; Bartolo & Smith, 1993), but much remains to be studied. Should students in such fields have more intensive—and different—training in library research and targeted to their special needs? An experiment could be conducted to test a bibliographic instruction package directed to students of interdisciplinary fields. We can surmise in the short term as to what kinds of training they need, but clearly the best long-term solution is to get the basic research data, discussed earlier, upon which to base course design.

To this point of the discussion, secondary sources—the kind that are the principal concern of libraries—have been the focus. But some primary archival sources in some interdisciplinary fields may be different also from those in conventional disciplines. Scholars in all the ethnic studies fields, as well as women's studies and gay and lesbian studies, may not have the usual range of documentary sources available to them. Because the people being studied in these fields were often outsiders and relatively powerless in the establishment structures of society, information must be gathered in unconventional ways, including through oral histories.
CONCLUSION

Altogether, the mix of research and library techniques needed by scholars and students in interdisciplinary fields may be unique to such fields. As such, these people constitute a significant and distinctive class of scholars, much deserving of research on their information needs and information-seeking behavior. Results from such studies would shed light as well on deeper questions regarding the life history of fields and disciplines and the inherent nature of interdisciplinary research.

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Information Work at the Boundaries of Science: Linking Library Services to Research Practices

CAROLE L. PALMER

ABSTRACT
Before information professionals can begin to improve existing services in research libraries, they need to understand the information work involved in the research processes of contemporary researchers. In the sciences, research is becoming more broadly based and collaborative and, increasingly, information, techniques, and tools are being imported and exported across disciplinary boundaries. This article examines the information practices and strategies used by interdisciplinary scientists as they perform "boundary work." As researchers gather and disseminate information outside their core knowledge domains through personal networks, conferences, and the literature, they interact with objects, methods, people, and words. Much of their information work is devoted to probing and learning in new subject areas, and they often rely on intermediaries to help collect and translate material from unfamiliar territories. Libraries that wish to facilitate cross-disciplinary inquiry will need to design information environments that support learning, provide tools that function as "boundary objects," and offer intermediary services that assist in the transfer and translation of information across scientific communities.

INTRODUCTION

Over a decade ago, Clifford Geertz (1983) observed that the lines separating scholars "are these days running at some highly eccentric angles" and that disciplinary categories no longer reflect how people think about things and write down what they think (pp. 6-7). Established disciplinary frameworks bear ever less resemblance to the way researchers...
and scholars work and group themselves, obscuring the actual composition of intellectual communities. Who really talks to whom through the scholarly and professional literature and through other formal and informal means may, in fact, have no common factor other than the problems being addressed. Researchers who work across disciplines often have a wider topical orientation than those addressing problems from a disciplinary perspective. Clearly, this complicates the research process, and researchers must take steps to manage this complexity.

As research and knowledge become more interdisciplinary, the academic subjects represented in our research libraries become increasingly ill-suited to the conduct of research. They are becoming obsolete for the research activities that create knowledge (Pinch, 1990) and for organizing the products of research. Library services, collections, information tools, and criteria for allocating budgets often do not account for interdisciplinary and emerging fields of study (see Searing in this issue of Library Trends), at least not until they become part of the formal curriculum. However, before information professionals can begin to improve existing services or develop new approaches that account for the complex needs of contemporary researchers, they need to understand the activities and patterns involved in the cross-disciplinary research process.

Librarians are participants in the networks of research activities and are responsible for helping to advance the research process. With researchers and scholars extending their range of inquiry into multiple disciplines, fitting information to the needs of the individual becomes a greater challenge, in part because interpreting the user’s world is much more difficult. Once we understand the information worlds of contemporary researchers, reference librarians, managers who organize and implement service programs, bibliographic compilers, and designers of information systems and collaboratories may be able to build information environments that are more supportive of cross-disciplinary research.

**Approach**

User studies within library and information science have provided important insights into the information-seeking behavior of researchers, but the groups studied have generally been discipline based. Studies of interdisciplinarity have tended to examine disciplinary relationships as reflected in the content of literature, with citation analysis being a favored method of study. Much of this work has focused on the import of information and ideas from one discipline to another. These studies have offered sufficient evidence that cross-disciplinary inquiry is practiced and to a significant degree. We know little, however, about how discipline-crossing research is conducted or about how information is used in the process.
My recent study of scientists at an interdisciplinary institute (Palmer, 1996) combines quantitative and qualitative methods to gain an understanding of the practices and conditions involved in the cross-disciplinary research process. After identifying a sample of boundary-crossing researchers through citation analysis methods, interview data were collected and analyzed to explore how researchers gather and disseminate information in multiple knowledge domains. Based on results from that study, this article examines the discipline-crossing information practices and strategies described by highly interdisciplinary scientists. They are members of a research organization (referred to hereafter as "the Center") devoted to the study of "living and non-living systems of increasing complexity." The Center houses research programs that span the physical sciences, engineering, computational science, the life sciences, and the behavioral sciences. My approach follows a recent trend in studies of science where work is examined within an institutional niche. Labs, institutes, and departments provide a context for examining practices within the user's local organizational and social environment.

Chubin's (1976) notions of "core and scatter" are useful for understanding the dynamics of knowledge within the research process. Disciplines are centered around an intellectual core and, at the same time, they overlap through scatter. Drawing on research done by Crane (1969) and Bradford (1953), Chubin asserts that, without scatter, scientists would be divided into small groups, only speaking to each other and reading and citing each other's work. Knowledge development within the core permits science to cumulate and grow, and scatter (communication outside the core) keeps it from becoming a "sect-like phenomenon" (Chubin, 1976, p. 459, citing Crane, 1969, p. 349).

The researchers at the Center cross into areas outside their knowledge core, interacting with information and people from other domains through "boundary work." Gieryn's (1983) initial conception of boundary work emphasized the boundaries that separate science from everything else. Fisher (1990) later applied the idea to the boundary-crossing activities involved in interdisciplinary science. As the scientists at the Center cross boundaries, certain elements assist with their work. According to Star and Griesemer (1989), "boundary objects" help people come together to solve problems by inhabiting "several intersecting social worlds" and satisfying "the informational requirements of each" (p. 393).

While boundary work has been defined as the cooperative pursuit of tasks in spite of boundaries that could prevent separate social worlds from achieving goals (Gieryn, 1995), many researchers at the Center practice types of independent boundary work. Individual efforts to traverse multiple disciplinary worlds do not seem to be as productive as cooperative pursuits, however, unless there is a focal point or a vehicle that fits the informational criteria of a boundary object. For example, reading the
published research literature, in general, is not a very effective way of crossing into another discipline. On the other hand, a particular conceptual essay, an author who is a talented communicator, or a single analogy can be instrumental in moving beyond interpretive barriers to make use of material from an outside subject area. In general, literature, methods, data, and results can serve as boundary objects, but colleagues, students, machines, and concepts seem to function most effectively in this role.3

AN OVERVIEW OF BOUNDARY ELEMENTS

Physical objects can be the focal point of a boundary-crossing activity. Data (numbers) and data sources (rabbits) are shared between labs and sometimes brought together for comparative analysis. Banks of raw data are amassed and then added to by allied researchers. Molecules built by one research group may be analyzed by another, with both sides bringing insights to the final results. It is common for one lab to borrow apparatus from another community of scientists and apply it in new ways and to different types of data. New computational technologies are often combined with established disciplinary science to “push the frontier end of studies” in a problem area. Computer modeling has helped to break down the boundary between experimental and theoretical work, but the computer’s role between disciplinary boundaries is less clear. At the very least, sophisticated computation may enable boundary crossing by producing models that can be applied broadly across sciences.

Methods move across boundaries in a number of ways. Researchers bring techniques and procedures from a variety of disciplines to their research problems. One psychologist listed the following measures as part of his investigative repertoire for just one of his two major research areas: reaction time and accuracy measures from cognitive psychology, event-related brain potentials from neuroscience, and magnetic resonance imaging from physics and chemistry. Several other cases illustrated how experts use their methodological training in one discipline as a point of entry into another disciplinary domain. For example, a computational neuroscientist learned computer modeling and simulation as a physicist. He later transferred these skills to neurobiology, where he currently contributes to the experimental side by building on his electronics experience, while using his physical science expertise to address theoretical questions.

People are involved in every aspect of cross-disciplinary work. “The big guys” loom over disciplinary territories long after they die, influencing the direction of science through their followers.5 Colleagues give researchers a sense of place or belonging, and personal contacts continue to be one of the most important vehicles for transferring information across borders. Students play a versatile boundary role by functioning as human conduits for the passage of information. They are traded
between labs, used as translators between theoretical and experimental work, and sent as emissaries to other parts of academia and out into industry.

Words can also be the meeting point for different sciences. Metaphors act as models, creating new frameworks for addressing scientific phenomena. Several researchers talked about using metaphors as tools to help groups of people from disparate backgrounds think about a problem in the same way. Words and concepts cross borders and, over time, the vocabularies of different communities change and merge. As certain terms become more broadly applicable, there is more cross-communication between disciplines. A bioenergetics specialist gave the example of how the terminology used by a biologist working on charge separation may gain the attention of physicists interested in electron transfer as well as chemists working in catalysis who are interested in protons. The exchange of words seems to depend more on reading than writing. Many researchers try to read across disciplinary boundaries, while few make large leaps in their writing and publishing. Words are, perhaps, the most tenuous of boundary elements. They can generate cross-disciplinary understanding, but at the same time they create serious impediments to communication between scientific cultures (Palmer, 1996, in press).

WAYS OF WORKING ACROSS BOUNDARIES

The researchers at the Center are not particularly comfortable with any categorization of what they do. From their perspective, their research is not disciplinary, multidisciplinary, or interdisciplinary; it is "problem-centered." As a theoretical physicist explained:

The world doesn’t know about physics, chemistry, and biology. The world’s problems developed independently of them, so to solve them you really have to try to go at it from all angles.

The strategies used by researchers to gather and disseminate information across disciplinary boundaries are constructed around the problems they address. Beyond this common problem-centered approach, the information practices of interdisciplinary scientists are varied and complex. In their attempts to "go at it from all angles," they “accumulate” knowledge in many ways. They import and export information through formal and informal channels; apply individual and group approaches; and take advantage of written, oral, and electronic information formats.

Information probing is an important type of information work for cross-disciplinary researchers at the Center. Probing is investigative in nature and takes place outside of the scientist’s core knowledge domain. Researchers probe broadly to increase their breadth of perspective and to generate new ideas. Skimming through a wide range of journals and
general science magazines, hoping to latch onto a new idea, is a probing activity. Researchers also probe deeply to explore or upgrade their knowledge level in peripheral subject areas. For instance, one scientist attends an intensive workshop in an outside discipline on a regular basis for this purpose. While all the researchers were concerned about the difficulties in finding and keeping up with information, particularly in subjects outside their core research area, probing was discussed as an important cross-disciplinary information strategy. However, since probing can lead to an expansion or shift in research interests, it may further complicate a researcher’s information work by altering the scope of relevant subjects to search and changing where pertinent information will be found. Moreover, with each new domain, there are new terms and concepts to learn and analytical approaches to understand.

Cross-disciplinary researchers may work with information differently than more discipline-based information users, but the general sources of information appear to be much the same. The researchers rely on both formal and informal channels for gathering information, depending primarily on personal networks, conferences, and the published literature. As they work to move into new knowledge domains and overcome disciplinary barriers, there are serious challenges to overcome. The researchers need to make sure that they spend their time and effort targeting relevant material and making the right contacts in outside fields. None of the scientists was at ease with the process of importing or exporting information across disciplines; it was a practical and intellectual challenge for all. Experienced researchers feel like novices as they look for information in unfamiliar contexts and attempt to become oriented and knowledgeable in new subjects. Two information work patterns were particularly trenchant: the gathering of information as part of a learning process and the reliance on intermediaries to help manage the collection and translation of information across boundaries.

Networks

"Normally, maybe 85 percent of what is going on
I just know by keeping in contact with people
and by going to our own conferences"—device physicist

For researchers at the Center, personal networks are the most important vehicle for information exchange. Colleagues and students are rich sources of information because they are efficient and yield quality results. This is consistent with other studies of scientific communication. Conversations and correspondence have been found to be important methods for exchanging news and getting feedback on preliminary work (Garvey & Griffith, 1968; Griffith & Miller, 1970). In cross-disciplinary research, feedback from knowledgeable sources is crucial because of the uncertainty involved when venturing into unfamiliar domains.13

Conversing with people in allied fields makes researchers aware of their own knowledge gaps, and establishing personal contacts in other
fields promotes cross-disciplinary understanding and integration. Researchers consult with contacts from different backgrounds to explore the various ways a problem can be approached, to grasp the long-term hopes for a solution, and to learn how their research relates to other work on the problem. The exchanges that take place in these multidisciplinary networks constitute small, yet crucial, steps toward scientific convergence. A vision specialist used the metaphor of a huge interactive database to illustrate how two people from different disciplines converge on relevant information about a problem.

“Someone will say, Oh, this guy did something, so and so, you should look at his paper. This will happen after they have summarized the significance of that, which they did not know until I told them what I was looking for. So it’s an interactive search for the right thing. They have their own huge database and, if we talk, then we are converging on the right references or people.

The interactive process narrows down the discussion to a specific concern and centers it within the perspective that is needed.

Researchers who do a lot of information probing are frequently faced with the task of sifting and evaluating all the ideas and “pet theories” that they come across. Personal contacts from outside fields are called on to evaluate the viability of newly discovered ideas and approaches from unfamiliar domains. Connections are established based on shared interests and tend to be made with trusted colleagues who have the authority to help evaluate information. Even researchers who prefer reading about emerging areas of interest almost always follow up by discussing particulars with network members. Information gleaned from an outside body of literature can be turned into usable knowledge by discussing it with someone from the other field.

As might be expected, e-mail has been welcomed for managing the exchange of information within personal networks and for collaborative work. E-mail was talked about as an indispensable part of the research process. It is used “perpetually” as the primary means for keeping in contact with colleagues. It has made a real difference for two activities in particular: planning and collaborating. It is how researchers “get organized—arrange to do this and that.” It is especially appreciated for editing and cooperative writing projects. Researchers can keep in touch with many authors simultaneously and compile and edit texts at a pace that suits their schedule.15

Conferences

“If it weren’t for conferences I really would be lost”—photosynthesis specialist.

“Everybody who matters is there and for a week you get saturated in this stuff. For what I am doing, I have to be at that conference”—complex systems chemist

While the large discipline-oriented conferences were rarely mentioned by the researchers, small specialized meetings were considered by
many to be as critical as personal contacts for keeping up with information. The most valued meetings are those that congregate at the problem level, where researchers feel part of a “closely knit group” that shares specific research interests.\footnote{16} In fact, it seems that, for some researchers, these meetings are an extension of the information exchanges that take place with network members and, like those networks, the conferences satisfy a multitude of information needs. According to a neurophysiologist, “you kill a lot of birds with one stone; you get the social interaction, you get the professional interaction, and you get the references [to the literature].” The meetings provide the efficiency, focus, and interpersonal aspects of personal networks, held physically captive for days. In addition, this framework for intensified exchange is an ideal setting for establishing new connections with people who can enhance one’s personal network.

People met at specialized meetings may become future research partners. Finding collaborators seems to be a natural part of the act of assembling and talking about research.

The way it happens is by finding the people just in the normal sort of processes of social intercourse at meeting. “You find the people who are talking in a way which you have some affinity for, the people who are making an effort. And then you talk to them and, after awhile, you get to know them well enough so that you can ask them stupid questions without feeling really idiotic. And really, there are some people who turn out to be just absolutely wonderful expositors of complex ideas—people who themselves have thought about, you know, why am I doing this? And you latch onto those people (bioenergetics specialist).

The bioenergetics specialist has seen a tremendous influx of theoretical physics, computational studies, and both theoretical and experimental chemistry into biological protein research. It has become a “real melting pot.” Understandably, at events with very diverse populations, cross-cultural issues come into play. This scientist described one of her regular meetings as “a bit like a convention at Star Trek Deep Space Nine.”\footnote{17} There are all sorts of different species around, some of whom can’t talk to each other, no doubt about that.” Overall, the communication difficulties encountered at conferences seem to be much less frustrating than those faced in the literature. As with other person-to-person information activities, the element of exchange brings value to the information—discussion is productive and satisfying research work.

The type of information acquired at conferences can be quite different from what appears in the published literature. A computational neuroscientist attends conferences to get in touch with “the undercurrent.”\footnote{18} The information he gathers is especially valuable because it is “raw, not polished—because it is speculative” with no deep ideas attached to it.
Hearing about "pieces of data that people don't quite know how to put together yet" offers a different kind of intellectual stimulation than the seamless research reports published in journals.

**Literature**

"If you can’t look at far more literature than anyone has time to look at you get into this tiny little corner where you keep reinforcing your preconceived notions”—complex systems chemist

This quote brings together two of the most prominent characteristics of literature for cross-disciplinary information work. First of all, there is much more to read than anyone can possibly keep up with. The sheer magnitude of potentially relevant material seems insurmountable. Literature dispersion is the other distinctive problem experienced by these researchers. The chemist, who recently shifted from a specialization in chemistry instrumentation to complex systems research, explained:

There was a time not that long ago when I could go to the physics library and walk from one end of the shelves to the other and inside of a half hour see everything I needed, and be pretty sure I hit everything that mattered, because I knew what journals it was going to be in.

In the past, searching electronic databases had been productive as well, because one's interests could be covered in "only about ten keywords." There are so many sources and terms that relate to his current problem area that his old reading and searching routines are no longer adequate. Moreover, he claims that the increase in subject scope has made it too expensive for him to have literature searching done by a commercial service.

The Internet has made the dispersion problem even more frustrating for the complex systems chemist. He compared the chemistry information available through the Internet to the state of chemistry literature before *Chemical Abstracts* began.

It doesn't matter how marvelous the stuff is that is out there if you can't get at it—except if somebody says, By the way, I was talking to a guy when I was at a conference last week and he says that if you go onto this computer here you can find an address to go to that computer over there, which supposedly will tell you of another place over there where you can get what you want. Now what kind of nonsense is that?

In fact, this scientist was one of the few who emphasized the importance of electronic networks for functions other than e-mail. For most researchers, electronic formats did not seem to be included in their conception of literature. The subject did not naturally come up in our discussions of literature use, and when asked specifically about it, the responses were
very limited. Many commented that they “should” or “wished” they could take advantage of available technologies for finding or exchanging information and documents.\textsuperscript{20}

Despite the problems identifying and accessing dispersed literature, reading continues to be an important information practice for most of the researchers, yet there were a few who claimed to not read at all or only rarely. Many researchers described a type of broadly based reading, geared toward the infusion of new and more generalizable knowledge:

“What I read in the literature—I mean the research literature—I think is generally much broader than most people in my area. And I think that really has helped feed into—I mean, it gave me knowledge of just the way proteins in general function rather than keeping me very focused, and rather narrowly so, on what was being considered by the central part of my field. And I think that it did give me some ideas as to what might be happening that wouldn’t have occurred to me otherwise” (bioenergetics specialist).

Broad reading can help maintain a cross-disciplinary edge and sustain a wide perspective, developing new interests, and opening “broader vistas.” However, researchers who read broadly do not necessarily read carefully. Some recall a time when they had been able to read entire articles and some journals cover to cover on a regular basis. Now, documents are usually skimmed rather than read. In fact, a 1992 survey of researchers at the Center revealed that 83 percent of the respondents tended to skim literature instead of read it. Larger bodies of literature are browsed.\textsuperscript{21} As precious as time is to these scientists, the potential for discovery is great enough that browsing is worthwhile. The researchers browse to gather information and to probe new and peripheral areas. One researcher commented that he has found significant works by scanning contents pages at bookstores and at publisher’s displays at conferences. Some scan vast amounts of literature hoping to “trip over something by accident”—a reference, a mention of an idea, or a vein of thinking that might be important to their work. One researcher explained: “You can’t narrow things too much in the hopes that you are going to catch something. You’ve got to keep that peripheral vision up.” Some browse electronically but, in general, the electronic databases seem to be relied on more for finding information about something specific. Only a few researchers placed much importance on the bibliographic databases available in the campus libraries and on the campus electronic information network. The 1992 survey of researchers at the Center showed that 43 percent never used the electronic abstracts or indexes available in the campus libraries and 62 percent never used them from their office or other campus sites.\textsuperscript{22}

Broad conceptual and “summary books” that take a comprehensive view of science are important to some for the insights they provide. Gen-
eral and comparative journals were also emphasized, and multidisciplinary titles like *Science* and *Nature* were cited as regular browsing and reading material. A molecular network specialist reads *Scientific American* religiously because it enables him to “dip into things like software design and immunology,” things that he has “a smattering of knowledge about.” Then, once the vistas are opened, it is time to “put on your boots and slog through the literature.” Once researchers move outside their core, reading feels more like slogging because the content and terminology are less familiar. A specialist in an area can easily skim titles and abstracts; a novice will need to spend more time and read deeper to determine what information is relevant.

The journal literature can be useful for keeping current if there are publications that concentrate on the right disciplinary intersections. For a neurophysiologist, *Neural Networks* is a key journal because it covers research on a wide range of scientific processes. This same title is also a primary source for a psycholinguist, who has a very different subject orientation. A protein specialist praised the changing profile of journals over the past ten or fifteen years. Many new titles have appeared that are intended to fit cross-disciplinary audiences. In his research area, the journal *Proteins* has become influential. The title would also interest biophysicists working on membranes, biologists in photosynthesis, and physicists doing drug design, among others. For network modelers in biology, psychology, physics, or physiology, *Biological Cybernetics* is an important publication. The combined practice of browsing both the general multidisciplinary titles and the more specialized cross-disciplinary journals provides an important balance of breadth and depth, both of which seem necessary for interdisciplinary progress.

Cross-disciplinary review articles can supplant extensive and difficult information gathering. Research reviews offer packages of collected, filtered, and partly synthesized information. They function as successful boundary objects because they are integrative in nature, representing an intersection of multiple scientific worlds. They can provide the references needed for a concise introduction to a research area or a way to catch up on work in a peripheral subject. Review writing is practiced occasionally, although there are not many incentives for scientists to take on this type of project. “There is some feeling that anybody can write a review, but it takes a real first rate scientist to do experiments.”

Learning

“Every good research group strikes a good balance between learning and doing. Even a seasoned researcher must keep a good balance of learning”—theoretical physicist

For many cross-disciplinary researchers, learning is a significant part of the research process and the intention behind many information-seeking activities. Knowledge development is time consuming for the
scientists, and it is difficult. Most were very cognizant of their limited capacity to learn new material, especially at the level necessary to enhance problem solving. They felt the "burden of comprehension" inherent in interdisciplinary work (Klein, 1990, p. 110). The more subject areas a scientist spans, the greater the burden, and the work is especially taxing because the researchers are not just responsible for specifics that are borrowed from another field. They must also understand the history, surrounding context, and the current status of the material. White (1987) maintains that any meaningful crossing of disciplines "must take place through a process of translation that is based upon rather full knowledge of the practices that define each community" (p. 11). Researchers must understand theory, technique, and particulars.

Learning is often the explicit goal of probing, as when researchers explore general and multidisciplinary literature to expand their knowledge base or attend workshops to deepen their understanding in a peripheral subject area. Other import practices and combinations of activities are well suited to the pursuit of learning. Colleagues, on an individual basis, can function as pointers, directing researchers to the most important and useful literature in outside subject areas. They work as quality filters, helping their contacts to find effective learning material. The process of collecting, filtering, and learning can also be performed by groups.

Team learning is practiced by some of the larger, more organized, research groups at the Center and within many other self-organizing research groups on the campus. In order to maintain active learning environments in their laboratories, some researchers have developed formal group methods for gathering and filtering literature within their laboratories. A neuroscience laboratory manager thinks of his lab members as a "roving information source"; they meet regularly to share new discoveries in the literature. A photosynthesis lab manager organized what he calls a journal club. Each student is responsible for scanning a set of journals in an area of interest to the lab members and then reporting back to the group. Once a month, they get together and each person presents the most interesting studies from their assigned titles. After using this technique for four years, the manager has decided to add another layer of filtering to the process by having the Center's library provide article titles and abstracts based on keywords selected by the group. The group meets on a regular basis to teach each other what they have learned through their exploration of the literature.

Frequently, the next stage in this process is footnote chasing. Once a group member identifies an important paper for learning about a new area, they follow the channels of references through the literature. This is a standard practice for researchers and scholars in most fields, but because of the dispersion problem in cross-disciplinary work, this technique
may be the best or only way of identifying pertinent material in peripheral bodies of literature. Name-based searching is a related technique. Many researchers watch for, or search out, papers by the people they respect or recognize in a problem area. The photosynthesis specialist acknowledged the limitations of the name recognition strategy:

“If Joe Block published a paper and you know Joe is a bright guy, then it is going to have something interesting to say. Where if Bill Scum publishes a paper, you can be pretty sure that it will be the same old stuff, and you will waste your time reading it. Unfortunately, Bill Scum every now and then has a bright idea, and then no one reads it.”

Joe Block has achieved a level of scientific authority that is accumulated by others when they choose to reference or build on his research. It is possible that name recognition may not play as great a role in cross-disciplinary work, however, since an author’s reputation is not always known by those in an outside field.

We have seen that colleagues in personal networks add context and meaning to new information, thereby helping to transform it into useful knowledge. Reading followed by discussion appears to be one of the most valuable information routines for research-related learning. This is the sequence of activities that is applied in the standard college seminar and in the photosynthesis specialist’s journal club. This type of deliberate learning is also practiced informally in small groups and pairs. Two researchers from different fields, an experimentalist and a theoretician, combined reading and discussion in a dedicated interactive way for an extended period of time to learn the basics of biochemistry. They met regularly to discuss readings from a standard textbook. We “picked up a couple of new biochem books and met for lunch every Thursday for a year and ground our way through.” A number of other researchers cited textbooks and other “basic” derivative works as good sources for learning in new subject areas.

Some accomplish the difficult task of new learning by attending workshops and classes. One psychologist attends a series of classes each summer in order to “retool” and to keep up with the “complex formal systems” in linguistics. A language modeler, who was collaborating with a lawyer, devoted a substantial amount of time one semester to learning more about the law:

It must have been my sabbatical year, otherwise I would not have possibly had time to hang around the law school and go to an evidence class every day and do the readings for it. But I learned a lot doing it that way.

The quality of learning through course work and workshops is obviously very high, but few take advantage of formal teaching forums. Most learning is self or group sustained.
The Center attempts to promote cross-disciplinary understanding through a general interest colloquia series. The director had been disappointed by the attendance, however.

The idea is, I am a neuroscientist and I am going to listen to this guy from computational electronics tell me in layman’s language what he does and why he finds it interesting, but the program never really worked very well. I mean, the people who came to the talks were largely the people who were in the disciplines from which the faculty member came. There was not very much crossing over.

More distinguished speakers drew a little better crowd but also fell short of fulfilling the cross-fertilization function that the director had hoped for. While the numbers attending these programs may not have been great, certain individuals considered them an important part of their research learning process. They seemed to be most stimulated by the presentations on topics that were very distant from their own field. The neurophysiologist gave a specific example of how his research benefited from a lecture that appeared to be in an unrelated research area:

So this guy came and talked about his model of swarms, swarms of ants, the dynamics of swarms of insects, and how they can accomplish things. . . . I just thought it sounded interesting, and of course the guy who presented this also had the idea that this could be applicable. He didn’t know where, but more broadly in a general way. When I went to the seminar, I thought it very interesting, and now recently we’ve been able to apply a model like that to learning in the nervous system, where learning is autonomous and cooperative. Where individual elements kind of search around randomly like ants, and when they do the right thing, then they persist at that; they cooperate.

Researchers attend lectures in outside fields hoping to learn something pivotal or experience a flash of insight. To them, discovering an exciting new idea or research direction is well worth the investment in time.

Even though the Center makes this kind of learning convenient by hosting a variety of lectures, most researchers felt they still did not have time to take advantage of the programs. Those who did not go to the presentations understood that they were missing something valuable and wished they could fit them into their routines. The researchers who emphasized the importance of these talks tended to be interested in concept and theory development and made learning a clear priority in their research work.

Collaboration offers a valuable working structure for project-focused learning. The collaborative projects described by the scientists varied in “range of connections” and in terms of integration. The director characterized integrative collaborations as “something that requires real doing back and forth on both sides.” “Additive research,” he explained, is “where it is just a cookie cutter sort of thing.”
One of the things that makes for a collaboration is where work has to be done at both ends. That is, the theory isn’t ready made to solve this, to attack the data, and the experimental data at hand aren’t precisely the data which the theoretician would ask for if he were going to test his theories.

This type of cooperative work, that spans broad domains and strives for integration, offers an excellent opportunity for knowledge base development:

Where you have the least in common you learn the most because you are stretching yourself more. On the other hand, for productivity, you are far better off working with somebody you already can work with. . . . If there is one person way over there and another person here and they are trying to find common ground in the middle, well, sometimes it works and sometimes it doesn’t. But in trying to get to that common ground, you are covering a lot more territory (complex systems chemist).

Strenuous collaborations that require extensive new learning and translation between disciplines progress gradually. Researchers described this type of work as challenging and frustrating, and it is clearly a strain on young scientists who must produce published results on a regular basis in order to advance their careers. Getting to the stage where a coherent cross-disciplinary proposal can be written is a significant achievement in itself.

**Intermediaries**

Compared to all the other types of boundary elements, people are the most vital. We have observed that they play a critical role by acting as nodes for information transfer in personal networks. They also perform another critical boundary-crossing function. Certain people serve as conduits, enhancing the exchange of information by learning, filtering, analyzing, and making intellectual connections for the scientists. They function as transfer mechanisms or intermediaries between scientific communities. An intermediary may bridge the work of two different labs, act as a carrier of knowledge between academic research and industry, or provide the link between experimentation and theory. Within the context of this study, this unique research function is most often allotted to graduate students.

For an applied computation project, a database specialist trained a graduate student to work as an emissary. The student went out into the private sector for an extended period of time to live in and learn about the needs of the community and to establish a solid connection for the future. Researchers also use students to gain knowledge from other academic camps. A structural biologist explained that “if we don’t know a certain technique, we will send people to an expert’s lab to learn how to do it.” The photosynthesis specialist conducts a trading program between his and several colleagues’ labs. The students cross the border and stay
long enough to learn the practices of the other community and, when they return, they can apply the new knowledge to their own work and teach others in their own lab.

Students from my lab work in Mac's lab, and Mac's students work in my lab. So my students learn molecular engineering, and some of Mac's students learn to do biophysical experiments. Through that I've got students and post docs who do biomolecular engineering in my lab as well.

One student's internship turned out to be particularly beneficial for both sides. When he came back to the home laboratory, he had the ability to set up a new molecular engineering facility. Shortly after doing so, he proceeded to invent an entirely new method. "It actually works better than the one used [in the other lab], and now they are using our new method in their lab."29

Frequently, information must be translated before it can be understood or applied. All the researchers seemed to be acutely aware of the communication difficulties across disciplinary boundaries, and a few recognized the need for intermediaries who can interpret and convey the basics about problems and approaches. The complex systems chemist is part of a project that is trying to span an extensive experimental/theoretical divide. He is responsible for the experiments, and his research partner, a physicist, is developing the theory. They have assigned a series of graduate students to translate and mediate between them on this very ambitious project. According to the chemist, the main problem is:

It is not clear how to take [the physicist's] results and translate it into a computer file to send over to the computer to say turn these pumps on at this and so time and run them at thus and so rate—this is what the output is supposed to be. We are now on our second physics graduate student trying to act as the lubricant to translate the two.

The student intermediary has the task of determining what can be maneuvered in the chemical world of one scientist and how it relates to the symbols in the other scientist's physical world. The chemist seemed to be confident that, with time and a lot of concentrated work, the students could succeed in functioning as translators. However, turnover is a complication. This project is a complex long-term undertaking, and before new graduate students can make a contribution, they need to get situated in the problem and learn the specifics of the study.30 After the intermediary develops the translation skills, it is not clear how much is transferred back to the chemist and the physicist and how much is lost when the student leaves the project.

Many of the research groups at the Center are applying the most sophisticated computer methods available to biology and physics. As a result, numerous students must bridge these domains as well, providing
the intersection between modern computational technology and more
traditional discipline-based sciences. Intermediating between the two
involves blending experimental expertise with competence in current
computer methodologies, each of which takes a tremendous commitment
on the part of the student. An individual who comes from a rigorous
physics background has to develop computer science expertise and learn
biology. Those trained in computer science lack the physics and biology
background. The demands of developing the combination of intellec-
tual grounding and skills can be overwhelming, and several of the scien-
tists talked about their programs as if the expectations they place on stu-
dents are unrealistic. The theoretical physicist feels obligated to discour-
age some students:

It's very hard and, actually, I have quite a number of people who do
not finish. It is very tricky, and I am a very open person in telling my
students that they may want to consider not getting their Ph.D. in
this. . . . I tell a certain fraction at an early stage that they have little
chance. Those who have stayed on with me actually all finished.

A protein specialist admitted that he was very tough on his students
and that he expects them to be as diverse as him. A movement specialist,
who has worked for the aerospace industry, government, and within uni-
versities, does not recommend interdisciplinary research for students who
are planning to work within university structures. He believes it is unre-
asonable to expect people to follow a cross-disciplinary path within the
confines of academe. He does not think, however, that interdisciplinary
training is wasted on the students who want careers outside of the acad-
emy. Two of his recent graduates have found positions where the advan-
tages of an interdisciplinary research orientation can be actualized. One
is working at NASA and the other at General Motors—sites that are very
problem oriented in their research aims.

**THE IMPORT/EXPORT IMBALANCE**

There is a considerable difference in the amount of effort researchers
put into importing and exporting information across boundaries. Import
strategies, although not standard across cases, are practiced regularly by all
the researchers. The scientists all rely on multidisciplinary personal net-
works and specialized conferences, and many integrate individual and group
learning practices into their research processes and utilize intermediaries in
their information work. Cross-disciplinary export—that is, the active deliv-
ery of information across boundaries—is much less common. Only a couple
of researchers try to reach multiple audiences, and the few who have at-
ttempted to write for general audiences are not convinced that they have
done so effectively. The researchers appreciate the "really good communi-
cators," but their research practices do not necessarily include trying to be
one. While researchers were highly aware of the language problems involved in importing across disciplines, only a few consciously use language differently for different audiences.

Overall, the lack of equilibrium between import and export appears to be an accepted condition of research. Even at the Center, where the exchange of information across boundaries is a high priority, increasing export is not stressed, except in terms of making information, as it currently exists, more accessible electronically. At the time of the interviews, a few of the research groups had made some information about their projects more widely available via the Internet, and the administration had started exploring ways of using electronic networks to increase visibility of the Center's activities.

In a study of cross-disciplinary research, it is easy to focus on cooperative approaches to science and neglect the competitive aspects of the enterprise. Cooperation is often necessary to complete a specific project, but within and between fields there is intense competition for resources, authority, and territory. Rivalry could be a factor in the differential between import and export. Aggressive import helps individuals advance their careers by enhancing problem solving and, in some cases, the practice may lead to important new discoveries. Aggressive export, on the other hand, enriches adjacent domains and could lead to the advancement or encroachment of another discipline.

According to the theoretical physicist, leading scientists have a “Darwinian urge to carry on their species.”

They recognize endangerment of their field early on, eliminating competing research fields by outgrowing them, stealing opportunity for growth in new areas by continuing growth in their own disciplines. Worse, scientists of established disciplines are the gatekeepers for hiring, tenure decisions, academic honors, and funding. In the Darwinian struggle of the disciplines, these scientists make use of their power. It would be malicious to state that this is done consciously. The scientists are deeply convinced that they do the best thing, but the outcome is disastrous for emerging disciplines.

The above theoretical physicist used a sporting metaphor to describe the competitive nature of science, comparing the defensive tactics of scientists to a tactic used in soccer:

Basically, you kick very far away from the goal so there is no chance [for the other team]. . . . Scientists will kick it way over there (points in the other direction) if they know a guy has intentions to go here. . . . They realize that it might one day endanger the field they are defending.

Clearly, active export conflicts with the motives behind prechecking. Competition may continue to keep researchers from actively disseminating their findings and ideas into other domains, with import remaining
the emphasis of their boundary-crossing information work. There is a clear opportunity here for information professionals to assist in the information transfer cycle by facilitating the dissemination of information across disciplinary boundaries. To do so, we will need to set our goals beyond providing access and begin concentrating on how to promote interaction and synthesis.

SHIFTING EMPHASIS TO THE PERIPHERY

According to Chubin (1976), knowledge is centered around an intellectual core and, at the same time, overlaps in the periphery through "scatter." Compared to discipline-based inquiry, cross-disciplinary research puts more emphasis on information in the peripheral areas. The problem-centered research process accumulates peripheral knowledge and attempts to integrate it into the core knowledge unit. Researchers' activities channel dispersed knowledge toward a specific problem, reconfiguring the core by reinforcing and initiating links to relevant peripheral areas. For many scientists at the Center, the core is already a mix of disciplines, a hybrid specialization (see Dogan in this issue of Library Trends and Dogan & Pahre, 1990). For example, the vision specialist considers computer vision his core research area, and the peripheral domains that he draws from are the less specialized areas of psychophysics, neurophysiology, and graphics.

Many researchers find that to play the science game strategically, they need to sustain a firm position in a discipline-based specialization while they target cross-disciplinary opportunities. Therefore, as the scientists explore new problems, many do not necessarily abandon their disciplinary concentrations. They maintain dual or multiple research focuses, continuing to build on their core area as they make the transition into a newer hybrid area. Core maintenance can keep a career intact and sustain funding while a researcher starts as a novice in a territory where he or she is not recognized. At the same time, boundary objects and accumulation strategies make it possible for researchers to capitalize on the periphery in order to create a broader and more powerful base for understanding and investigating scientific problems.

Unplanned events and unexpected discoveries can also steer researchers into the periphery. The scientists were forthcoming about the role of serendipity, happenstance, and coincidence in science. A human factors psychologist compared science to dating: "It's like meeting someone in a bar—connections are often made by chance." Nevertheless, strategies are employed to increase the chances of serendipitous discovery. The researchers who practice undirected broad reading and attend talks that are far afield from their core are engineering situations where fortuitous discoveries might occur in the periphery. Through the process of experimentation, scientists may shift their investigation away from the initial
focus. For example, a biophysicist accidentally disproved a hypothesis about how plants adapt to drought. During an experiment, he recognized that his data were inconsistent with his understanding of a certain biological system. He had enough grounding in a peripheral area to see that his data conflicted with his assumptions, and this discovery put him on a completely new research track.

**FACILITATING BOUNDARY-CROSSING INFORMATION WORK**

Having asserted from the outset of this article that information professionals are part of the research process, what can we do to advance the cause of interdisciplinary integration? The first step is to understand how information is used in the cross-disciplinary research process. Clearly, we need considerable work in this area (see Bates, 1996); however, with a baseline understanding of the research practices of successful interdisciplinary scientists, we can begin to formulate the types of information initiatives that may promote boundary-crossing inquiry. This study suggests that information environments for cross-disciplinary researchers should be conducive to probing and learning. Moreover, information systems need to include tools that function as boundary objects, and librarians need to be equipped to serve as boundary intermediaries, providing services that transfer and translate information across scientific communities.

Fortunately, recognizing and addressing the important role of faculty learning in cross-disciplinary research should enhance, rather than detract from, the pedagogical aspect of academic library services. Some of the information needs of boundary-crossing researchers parallel those of students who are developing backgrounds in new subjects. The researchers' reading practices show that multidisciplinary periodicals and general texts are central to maintaining a broad perspective. Collections that support learning need to include derivative works—such as textbooks, handbooks, and review literature—which are important counterparts to the masses of reports published in scholarly research journals. These more general works are studied and consulted frequently and would make good candidates for a working digital collection that can be shared by many and accessed remotely. Texts could be gathered based on the reading preferences of hybrid communities and centralized electronically around problem areas.

Integrative reviews of research (see Smith's article in this issue of *Library Trends*) written by experts provide syntheses of quality-filtered information. Reviews that bring together work from different disciplines are textual products that can serve as organizational outlines for consolidating disparate literature on developing interdisciplinary topics. Tools for discipline crossing can be created by digitizing these synthetic works and providing a link to the full text of each reference. The process of linking references to the source texts creates a web of information that
spreads out from the problem, much like the process of footnote chasing, a common practice of researchers. The framework is reflective of the way knowledge connects, spreads, and grows. This type of boundary service can also help combat overload for, as one researcher indicated, compiling reviews saves “generation after generation from hitting their heads against the same problem.” Since there are few incentives for scientists to take on bibliographic compilation projects, information professionals need to initiate collaborative arrangements with experts to produce high quality problem-centered information tools.

Exchange is the essence of cross-disciplinary work, and researchers rely on context and explanations in order to make meaningful, rather than superficial, use of material from outside subject areas. Information exchange systems need to be aligned with the types of interactions researchers find the most useful. We have observed the important role of undeveloped research, what the computational neuroscientist called results “with no deep ideas attached yet.” Exposure to raw results allows scientists to think about a study in relation to their own research problems and methods before it is formulated into a paper that has been composed to fit the profile of a discipline-based journal or the preferences of an editorial board. This is why researchers find specialized conferences so worthwhile. They are a forum for discussing their work at an unrefined level—a place where they can talk shop on an enlarged multidisciplinary scale.

Research progress is dependent on many types of exchange. Perhaps we have been overly concerned with the question of how to control the quality of digital information, especially if in doing so we overlook the researchers’ need for materials at different stages of development. As we dismantle the barriers among disciplines, we should also be working to build permeable boundaries among different types of information. Some progress has been made in networking data archives and making them available electronically. Attention should also be given to making raw data and unprocessed results accessible in separate, yet linked, archives—side by side with refereed research articles. As we upgrade our libraries and information service organizations, it would be a mistake to continue to emphasize only the published product or the electronic equivalent. We will need to develop new standards and criteria for the presentation of raw data and results and create platforms for discussion around materials.

It may be true, as Pahre (1995 and his article in this issue of Library Trends) suggests, that actual communities do not organize around concepts. However, the neurophysiologist and other researchers in this study attach great value to the metaphorical application of concepts across scientific communities for communication purposes as well as for the development of theory. At present, there are few concept-based information
Mapping concepts across disciplines can help us identify, and perhaps even predict, broader knowledge structures that are not bound by specialization or the existing scientific networks. In addition, tracing terms may provide some insights into how concepts cross borders and change meaning over time. The vision specialist spoke of how the term "accommodation" migrated from studies of the human eye in psychophysics to ocular machines in artificial intelligence. Mapping of the concept could be taken much further to include the use of accommodation in linguistic theory, spatial orientations in architecture, and adaptation in biology. Likewise, it is possible that the complex system chemist, who studies oscillating systems, might benefit from knowing how oscillation is applied to the notion of noise in information theory.

While researchers are somewhat ambivalent about their audiences, they clearly benefit from intellectual comrades, and those who come from different backgrounds can make invaluable consultants and collaborators. For the scientists in this study, the Center is a place where a "stew of really disparate elements" has produced a functional pool of "creative and atypical people." Librarians can provide boundary services that foster similar intellectual associations by actively disseminating work across domains and helping to link scientists to others who have complementary expertise. Improved capabilities for searching multiple files and databases are needed, but we must also increase our understanding of how concepts and terminology relate across user groups and information products. Moreover, current awareness programs that concentrate on literature in peripheral knowledge domains, instead of core research areas, may be considerably more beneficial to researchers and scholars with interdisciplinary interests. After all, scientists are likely to need more assistance in areas where they have not had extensive training.

Cross-disciplinary researchers need to probe, retrieve, and learn within core and peripheral knowledge domains, and the borders between domains are mutable. Information environments should be flexible enough to accommodate changing boundaries. Undoubtedly, many users will continue to have a need for disciplinary approaches to information. Hypertext capabilities allow us to create adaptable systems that can place in the foreground either the periphery or the core, whichever framework is best suited to the researcher's problem area and approach. Unfortunately, as the World Wide Web develops, we often see disciplines differentiated first, and then there is an attempt to fit the innumerable fragments of information into these ill-suited categories. As we come to understand our clientele within problem-centered user groups and work toward comprehension of overarching conceptual territories, we will gain a better understanding of potential organizing units. We can then become informed and active participants in the export process by making linguistic and electronic links that will promote freer exchange across boundaries, and by creating information tools that are con-
figured around the actual research problems and information work practices of contemporary researchers. Information professionals who work to design systems and services that maintain open channels between scientific and scholarly communities will be taking on part of the information burden experienced by individual researchers, while enabling the ongoing boundary-crossing dialogue that is essential to the integration of knowledge.

NOTES

1. See Palmer (in press) on the need to organize information around problem areas.

2. Klein (in this issue of Library Trends; in press) presents a panoply of claims that knowledge is becoming more interdisciplinary. Twentieth-century assertions date back to the Social Science Research Council in the 1930s and the Manhattan Project. After a resurgence of interest in the 1960s and 1970s, the importance of interdisciplinary approaches is now widely acknowledged. As Klein (in press) points out, even The New York Times periodically heralds “new research developments under the banner of interdisciplinarity” (p. 13, unpublished manuscript).

3. T. D. Wilson (1981) defines the “user’s life world” as the “totality of experiences centred upon the individual as an information user” (p. 6). He calls attention to the need to explore the role of information in the user’s organizational and social settings, rather than studying information sources and systems.

4. See Bouazza (1989) for a review of previous user studies. He outlines the major studies on scientists, social scientists, and humanists. However, none of the works mentioned specifically address interdisciplinary researchers.

5. Citation studies are also done in other fields to define or describe the intellectual content of a discipline or specialty. See, for example, J. A. LaPonce’s (1980) study in political science.


8. See Pahre (1995, also in this issue of Library Trends) on how methods, data, results, and concepts influence the formation of intellectual communities.

9. In a recent review in Science of “yet another” festschrift honoring the life and work of Dobzhansky, Jerry A. Coyne (1995) comments on how “ancestor awareness” has become a form of “ancestor worship” in the field of evolutionary biology.

10. The term “problem-oriented research” was used by F. A. Long (1986) in his Science editorial on the need to support interdisciplinary research at universities. Klein (1990) uses “problem-focused research” to describe research teams working between the poles of pure theory and informed action. My use of “problem-centered” incorporates the various types of boundary-crossing that occur during problem solving, including movement into other disciplines and between theory, experimentation, and application. Problem-centered research has been practiced outside of academic contexts, in organizations such as NASA and Bell Laboratories, and is a common orientation for the research performed in industry and medicine.

11. Bruno Latour’s (1987) definition of knowledge as a “cycle of accumulation” incorporates the many dimensions of knowledge development. He explains that “knowledge cannot be defined without understanding what gaining knowledge means....knowledge is not something that could be described by itself or by opposition to ignorance or to belief but only by considering a whole cycle of accumulation: how to bring things back to a place for someone to see it for the first time so that others might be sent again to bring other things back (p. 220).

12. The importance of both formal and informal communication has been explored in various scientific contexts. For example, as part of the important APA Project on Scientific Information Exchange, Garvey and Griffith (1964) found that literature and conversations with colleagues are emphasized in different stages of the research process.
Management research has shown that, when there is high uncertainty in a situation, an individual is likely to prefer oral over written communication (O’Reilly, 1982).

While Cronin (1982) does not specifically talk about integration, he notes that informal communication “facilitate(s) boundary spanning, i.e., helps transmit ideas across disciplines.” He summarizes other advantages as follows: increases match between information needs and delivery; encourages feedback and increases motivation; helps establish priority in discovery; allows reality-testing; current awareness; allows researchers to screen information; and bonding effect on groups (p. 224).

Sproull and Kiesler (1991) document similar advantages of electronic communication for group coordination in organizational work.

There is evidence that only 18 percent of all conferences are meetings of large societies. The majority are being organized around specific problems or topics (Oseman, 1989, p. 3).

Star Trek: Deep Space Nine is a science fiction television series about a remote space station at the edge of a new frontier in outer space. “Travelers of all kinds are drawn here, and with hostile alien empires bordering every side, Deep Space Nine becomes the most strategic point in the galaxy” (description from a Paramount Television Current Productions home page, November 1995).

This search for the “undercurrent” by cross-disciplinary researchers is done through formal and informal means. The researchers in this study found both channels important; however, the 1963 APA studies indicated that 80-90 percent of useful information at conferences was gained by attending formal presentations and events. Paisley and Parker (1967) report comparable results. Compton (1966) may have tapped the “undercurrent” advantage of conference information when she found that attendees receive a substantial amount of useful, but “unsought,” information.

See Wilson (in this issue of Library Trends) and Weick (1970) for in-depth discussions of information overload.

In their survey on the impact of electronic networks on scholarly communication, McClure et al. (1991) also found that researchers commented most about the ability of networks to enhance interaction between colleagues. Based on my follow-up interviews, less than two years after the initial data were collected for this study, it appears that many of the researchers are beginning to incorporate the Internet into their information practices.

There are many definitions of browsing in the library and information science literature. Here I have adopted Chang and Rice’s (1993) notion of browsing as searching that can be goal directed or nongoal directed and unplanned.

The percentages are almost the same for the subset of researchers selected for this study—40 percent and 60 percent respectively. This level of use seems somewhat higher than in other studies of scientists. Hilz (1984) determined that 30 percent of her respondents found the Electronic Information Exchange System “extremely valuable” for retrieval and searches. McClure et al. (1991) found that functions such as online database searching and remote data sources are used infrequently relative to e-mail, file transfer, and other computer resources.

In a 1973 study of physical scientists, Skelton (1973) found otherwise. Review literature was not considered to be especially useful. I would speculate that the interdisciplinarity of the researchers in this study accounts for the difference in attitude. These researchers are specifically seeking sources that will function as boundary objects.

See Palmer (1996; in press) for a discussion of the knowledge levels required for interdisciplinary work.

In the Handbook of Research Synthesis (1994), White refers to footnote chasing as “scholarly intelligence” (p. 46). The practice provides evaluated and highly conditional references compared to the listings of subject-based bibliographies.

Name searching, like footnote chasing and consultation, can introduce bias because it is selective and tends to be homogeneous. See Cooper (1989) for a discussion of the limits of invisible colleges as reference groups for integrative research.

Bourdieu (1975) analyzes scientific authority as a kind of “social capital,” the value of which is reflected in reputation, prestige, and authority. There is, however, “no arbitrating
authority" that can legitimate authorities: "there are no good judges, because there is no judge who is not also a party to the dispute" (pp. 23-25). Kenneth Boulding (1968) also provides an economic analysis of scientific knowledge, while recognizing the important role of librarians as "specialized intellectual middlemen" in the exchange of intellectual capital.

Klein (in press) identifies faculty learning communities as important contributors to interdisciplinary knowledge production.

In his study of the U. S. steel industry, Eric von Hippel (1988) links innovation to informal "know-how" trading that takes place between companies. He demonstrates that even rival firms exchange specialized knowledge within networks of engineers with common research interests.

See Lave and Wenger (1991) for a theoretical development of situated learning, the process by which a person is transformed from a "newcomer" to an "old-timer" and becomes a member of a community of practice.

Fisher's (1990) notion of a knowledge core is aligned with cross-disciplinary inquiry; he describes the core itself as an integration of domains. Subjects within the core may be specialized and fragmented, but they exist in open relation to each other, equal in emphasis and interdependent. Subjects outside the core are less integrated units of knowledge.

See Palmer (1996) on how work conditions influence individual levels of core and periphery and how abundant resources, rewards, sense of community, validation, and technological capability provide the leeway that accommodates ventures into the periphery.

This is especially true in the social sciences, where data resources such as the Interuniversity Consortium for Political and Social Research, The Roper Center, and various university-based archives are beginning to provide World Wide Web access.

Progress has been slow in this area. Broad cross-disciplinary and conceptual classifications are beginning to appear on Internet gateway indexes and are becoming more common as access points to online databases and print bibliographic resources.

In their work on automatic thesaurus generation, Chen et al. (1995) propose "time-tagging" concepts to increase precision and to address the problem of vocabulary fluidity in scientific domains over time.

Dialindex on Dialog begins to address this problem, although the file groupings offered reinforce traditional disciplinary delineation. Very large multidisciplinary databases, like the Institute for Scientific Information's (ISI) citation indexes, are available but have limitations for searching subjects across disciplines.

Bates (in this issue of Library Trends) provides a review of studies on information use in high and low scatter fields.

Pahre's (1995 and in this issue of Library Trends) construct of metaphorical communities may prove useful for understanding and defining these territories.

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Interdisciplinary Research and Information Overload

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ABSTRACT

INFORMATION overload is a problem for all those involved in research but seems especially threatening to interdisciplinary research. Teamwork supplies the remedy, but most research in the social sciences and humanities is done by scholars working alone. That fact limits the scope for interdisciplinary work. In this article, we examine several ways in which actual and potential overload affects research choices for the solo researcher, paying special attention to the creation of ad hoc idiosyncratic specialties. As a matter of policy, should solo interdisciplinary work be encouraged? A strong social preference for interdisciplinarity might discourage solo practice as just another example of the huge disparity between individual and collective capacities.

TYPE OF OVERLOAD

Everyone engaged in research is aware of the problem of information overload. It is always a threat if not a reality. It is perhaps most familiar as a problem of maintaining currency. A basic requirement for the maintenance of expertise, and of a reputation for expertise, is that of staying current—i.e., keeping up with what other research workers are doing that is relevant to one’s own work (Wilson, 1993). One wants to be able to claim intellectual command of a field, and this requires deep and wide knowledge of what has been done and is being done by others in the field. Just how wide and how deep one’s knowledge must be is not something on which there are (or could be) any precise rules, and it is very clear that wide differences in the scope of current knowledge will be
found among different people working in the same area. But the requirement is there and ordinarily means that one must devote time and effort to reading what others have published or are going to publish or have otherwise communicated. How much time is needed will vary with the size and level of activity of the field—a small field of slow producers will present no problem of keeping up; a large and very active field of fast producers may tax or overwhelm one's capacities. Specialization in research is partly a response to, and defense against, overload—i.e., one adjusts the size of the field over which one hopes to maintain expertise so that the burden of keeping up is manageable. The field cannot any longer be the size of a conventionally recognized discipline; even in philosophy, not an especially populous discipline, it has long been impossible for American philosophers to keep up with what their colleagues were writing, says Nicholas Rescher (1993), and philosophy "which ought by mission and is by tradition an integration of knowledge, has itself become increasingly disintegrated" (p. 730). As time goes on, one may discover the necessity of narrowing one's scope: "Every scientist who has been in business for a long period knows perfectly well that in order to remain an expert in some area he has to cut down the width of his interests more or less continuously" (Bar-Hillel, 1963, p. 96). This is by no means the only thing that limits the size of an individual researcher's area of expertise, but limiting width of interest is definitely unavoidable and increasingly important.

A different problem of overload arises in the context of particular inquiries or research projects. Here the problem is the overabundance of available data relevant to the particular inquiry—i.e., experimental results, field observations, historical records, statistical and survey data, and the like. Data may be scanty in one case but torrential in another to the point that no one could hope to analyze and evaluate them all or integrate them into a coherent picture, even supposing that there were no problems of locating and assembling them in the first place (Wilson, 1994). The kind of overload involved in maintaining currency we might call "upkeep" overload—the price of maintaining the intellectual capital that is the research worker's chief asset; the kind of overload presented by information relevant to a particular inquiry we might call "task" overload (the two kinds will frequently overlap).

In both cases there are a variety of ways of coping with overload. A certain amount of upkeep overload may be accepted as normal, though inevitably leading to nonuse of relevant, but less than top-priority, information. Task overload can be dealt with by the adoption of strategies of inquiry that allow the elimination or ignoring of huge categories of relevant information (Wilson, 1995). In both cases, one consequence of overload is that relevant information does not get used. Whether or not this is a problem, it does seem a clear failure to meet conventional stan-
standards of rationality, which call for the use of all available relevant information. The conventional understanding is reflected in statements like: “These estimates are rational, in the sense of taking account of all available information” (Elster, 1989, p. 109) or: “The common understanding [of the term ‘rationality’] is ... the complete exploitation of information, sound reasoning, and so forth” (Arrow, 1987, p. 206). So overload is of theoretical, as well as of practical, interest; one cannot simply disregard the fact of large-scale ignoring of relevant information if that is what happens in research. Of course it is of both practical and theoretical interest to library and information studies, where the chief criterion of success in information retrieval has been the provision of all and only relevant information, a goal that loses some of its allure in the face of persistent problems of overload.

OVERLOAD AND TEAMWORK

How does the matter of overload affect the possibility and the actuality of interdisciplinary research? Interdisciplinarity must, at the very least, involve the use of the knowledge and skill involved in two specialties from different disciplines, and for the moment we will assume that the interesting cases are those involving the application of expertise in the two specialties, not an insider’s knowledge of one specialty and an outsider’s knowledge of a second. Is there something about interdisciplinary work that raises especially troubling problems of overload? There is a quick answer to this question: it all depends on how narrowly the burden is concentrated. A group of workers can easily do what a single individual would find impossible. Think of the process of drawing up requirements for a research project—i.e., skills required, bodies of knowledge needed, as well as facilities and equipment needed. There is no theoretical limit to the number and variety of specialties that might be specified in the cognitive budget, and no problem of bringing them to bear on a single project if each different specialty can be contributed by a different individual. You can add an ethicist if you need one, an expert in witchcraft, a deconstructionist, and a risk assessor. You can add information specialists to search the literature, and literature specialists to serve as designated readers, reporting to others on what they need to know of the literature. Each specialist may continue to face the problem of upkeep overload, but the problem need not be exacerbated by the social situation of working on a team; indeed it may well be mitigated (if for instance there are others to serve as filters to screen out literature one need not bother to examine). And while the problem of task overload may be horrendous—if, for instance, the task is to explore real social problems and find plausible solutions—still it can be treated as a collective problem, not an individual one. So the conduct of research by teams or groups is a way of increasing the amount of expertise and information that can
be brought to bear on a problem without increasing the burden of overload on the participating individuals. This is not to avoid the problem of information overload entirely, but at least it makes it possible to do what overload would otherwise make impossible.

**INTERDISCIPLINARY WORK AND THE SOLOIST**

The place to look for the real trouble in interdisciplinary research is in the work of the lone researcher—the soloist. While research and development in natural science and technology is increasingly done by groups, solo research still predominates in the humanities and social sciences. Research in natural sciences and applied fields is increasingly collectivized or industrialized (Weinberg, 1972; Ziman, 1981, 1983, 1987), but humanities and social sciences are still predominantly areas for the cottage industry—i.e., inexpensive small-scale production involving little or no staff or equipment or logistical support. This may be the chief reason why interdisciplinary research often seems so problematic in the humanities and social sciences: it is problematic where the organization of research, the mode of production, makes it so.

The many specialties in the various social science disciplines are all trying to produce information relevant to the understanding of concrete social phenomena—and they do not always fail. But separately they at best elucidate a part or side or aspect or feature of some element of the social world, and it is not hard to see why a student of society would aspire to a better understanding of society than can be got by work within a single specialty. “There is scarcely an individual phenomenon or event in society with which we can deal adequately without knowing a great deal of several disciplines...” (Hayek, 1956, p. 464). Understanding social reality requires crossing or ignoring disciplinary boundaries. The problem is that the number of specialties contributing relevant information is likely to be very large, and the quantity of information provided far beyond the capacity of any individual to absorb and use—in a word, overload. Staying within disciplinary boundaries means giving up trying to understand concrete phenomena; not giving up means facing intractable overload. Compromise is unavoidable and may easily recede from consciousness; Hayek (1956) suggested that: “We are probably so used to this impossibility of knowing what we ideally ought to know that we are rarely fully aware of the magnitude of our shortcomings” (p. 464).

Cultural studies are in a similar position, as David Damrosch (1995) illustrates:

I spent twenty years, beginning in college, trying to learn everything I needed to know to work on the things I wished to study. The problem was that I was loyal to too many interests, in several ancient and modern literatures, in literary theory, in biblical studies, in history, archaeology, anthropology, and art history. A reasonable enough
constellation of interests, but in the advanced state of modern scholar-
ship it is inherently unmanageable, if one wants to be seriously 
engaged with scholarly work...I have learned that I do, sometimes, 
need to sleep. Worse, my memory simply isn’t good enough to hold 
in mind everything that would be necessary for full-scale 
multidisciplinary work. (pp. 15-16)

Damrosch found that he had set himself too ambitious a task. Overload 
did turn out to be an insurmountable problem.

The obvious fact that there are limits to an individual’s capacity to 
utilize information does not, however, imply that interdisciplinarity is ruled 
out for the solo practitioner. Even though individual capacity is limited, 
no scholar or scientist need stick to just one specialty, but rather they may 
simultaneously work in two or more (and of course may move from one 
to another—i.e., a serial specialist). There is no standard size of specialty 
(for that matter, there is no agreed way of identifying and distinguishing 
specialties), and a person may be perfectly capable of maintaining expert-
tise in more than one though not in dozens. Is there reason to think that 
it is harder to maintain currency in two specialties if they are in different 
disciplines than if they are in the same discipline? Would it be harder to 
keep up with streams of literature, one in sociology and one in political 
science, than to keep up with two streams of literature within sociology? 
There is no obvious reason to think so. It may be harder to attain expert-
tise in a new specialty if it is in a new discipline (new to the learner). 
However, given that one has somehow attained expertise in specialties in 
different disciplines, the fact that they are in different disciplines does 
not itself imply anything about how hard it will be to keep up. In any 
given case, overload may be a problem, but then the same may be true 
for maintaining currency in multiple specialties (or even a single spe-
cialty) within a single discipline.

So overload does not rule out the kind of solo interdisciplinary re-
search that requires expertise in at least two specialties in different disci-
plines, if we consider only the case of the research worker who has some-
where and somehow already achieved expertise in the different special-
ties and consider only the problem of keeping up (task overload can arise 
anywhere). But it is different when we consider the worker who proposes 
to enter interdisciplinary work, say in mid-career, by acquiring expertise 
in a new specialty in another discipline and using it in conjunction with 
already acquired knowledge. People do change disciplines in mid-career 
and, if one can change disciplines, one can add them too. This is not a 
quick and easy task; entry into a specialty is harder than keeping up in it 
once one has entered, and entry into a specialty in a new discipline is 
likely to be very much harder than adding a specialty in one’s home disci-
pline. It will also take time—from months to several years (see Ziman, 
1987, for relevant information on this and closely related matters). Still,
it is certainly not out of the question, and so it is worth considering what makes it more or less difficult to do.

**ENTRY BARRIERS**

There are some obvious features that affect ease of entry into a specialty (remember that we are still thinking of the attainment of expertise as it would be judged by already established practitioners). First is the extent of the prerequisites for gaining competence in the new specialty—the background knowledge needed by any competent worker in the new specialty and the tools to be acquired elsewhere and brought to work in the specialty. If one does not already satisfy the prerequisites, entry may be almost out of the question—e.g., if work in the specialty assumes scholarly knowledge of several ancient languages, those without prior knowledge will usually find entry too costly. (Mathematics can serve as a similar impassable barrier; this is one reason it is generally easier to move from a hard to a soft specialty than vice versa.) But not every specialty has demanding prerequisites.

Other factors influencing an individual's entry into a new specialty are the age and size of the literature of the field. The entrant has to catch up not only with the current practitioners of the specialty but also with the literature, and that will be easier if the specialty is new and has practically no literature yet. (The physicist Eugene Wigner [1950] wrote that: "Today, we are neglecting the theory of solids in which a student has to study perhaps six hundred papers before he reaches the frontiers and can do research on his own; we concentrate instead on quantum electrodynamics in which he has to study six papers" [p. 423].) Menard (1971) discusses at some length the barriers to entry into new and old fields in terms of the size of the literature to be worked through. Next is the sheer intellectual difficulty or complexity of the new specialty itself; it may be, as a critic said of research in diffusion of innovations, a mile wide and an inch deep, or it may be subtle and intellectually dense, requiring huge investments of time for mastery. (Ian Stewart [1992] is critical of applied mathematicians in perturbation theory for not adopting a technique developed in mathematical logic but then notes that the new technique requires "a distinctly different cast of mind, a new style of thinking that takes several years to get used to" [p. 114]. Little wonder they are not rushing to adopt it.) A further feature is the degree of codification of the field—i.e., whether text books and serious expositions of an agreed body of knowledge will bring one up reasonably close to the research front, or whether one has to organize knowledge for oneself on the basis of the original literature of the field. Given that work at the front is disorganized in all fields (Cole, 1992), the codified field (roughly, the hard as opposed to the soft field, often but not always the natural and formal science as opposed to the social science and humanities field) offers less of a burden to overcome.
All of these are features of the new specialty that affect the likelihood that overload will prevent entry. This is task overload; performing the task is, of course, at the same time investing in new intellectual capital, and the size of the task is a measure of the size of the investment. If one will have to spend a great deal of time acquiring prerequisite competencies—i.e., acquiring a new style of thought, organizing the content of the specialty for oneself, and/or catching up with a huge literature—the chances are good that one will consider alternatives to the acquisition of a new area of expertise. Uphill work like this would require special inducements; the natural gradient or direction of movement will be toward new fields without heavy prerequisites (or with prerequisites already met) that are relatively easily detached from other specialties in their discipline. But if what one wants is to work in a specialty that unfortunately has a big disorganized literature, heavy prerequisites, and so on, all is not lost, for there are alternatives—many of them—to an attempt to gain full expertise. One alternative is collaboration. Damrosch (1995) devotes a volume to arguing the merits of collaboration in the humanities and social sciences in the face of an “archaic hyperindividualism” (p. 7), an entrenched prejudice against anything except lonely research. Collaboration produces a small team and has the expected effect of reducing the pressure of overload and increasing the size of the field that can be worked. But there are still numerous alternatives for the soloist. One of these is ad hoc interdisciplinary specialties.

**AD HOC INTERDISCIPLINARY SPECIALTIES**

Rather than attempt to become an expert in an established specialty in another discipline (as expertise would be judged by the practitioners already in the field), one can try something else. One can design a new ad hoc idiosyncratic interdisciplinary specialty, with a specially delimited subject matter and specially formulated conceptual and theoretical basis, research questions to be pursued, techniques and methods to be employed, type and style of result to be aimed at. In practice, one is perhaps more likely to develop such a specialty piecemeal and instinctively rather than as a result of deliberate planning, but it is the sort of thing that could be planned. The new specialty may incorporate fragments or major fractions of existing specialties but need not correspond to anybody’s understanding of a pre-existing specialty. So, for example, one could be “drawing on work in psychology, cognitive science and history of science as well as epistemology and philosophy of science” (Solomon, 1992, p. 453, describing her own work). Some of the prerequisites associated with preexisting “outside” specialties may be skirted and simply worked around by deliberately setting out to do what can be done with big gaps in knowledge. (One of Bazerman’s subjects [Bazerman, 1988, p. 244] says that his field is so interdisciplinary that he inevitably must live with
vast areas of "relevant ignorance," and this may be accepted as the price one pays for easier and cheaper employment of a specialty.)

The full design specifications of the new specialty would include a policy on information use covering types of data to be used as evidence and bodies of already existing literature to be relied upon. The policy might direct one to discard or ignore much of what has already been done in one or more of the fields from which the new specialty is constructed. Large literatures may be cut down drastically: one may ignore the past, ignore "foreign" contributions, ignore contributions from identifiable schools and traditions of thought (e.g., no Marxists, no deconstructionists, no positivists, etc.), ignore work done with certain techniques or in particular styles or with particular approaches. Creation of a new ad hoc specialty may be the occasion for an idiosyncratic definition of "what is living and what is dead" in the specialties involved.

Whether creation of such an ad hoc idiosyncratic specialty is likely to be acceptable to others or even possible at all clearly depends on the intellectual environment. If it requires resources under others' control (e.g., money, research facilities), it will not be possible at all unless those others are persuaded that it is more desirable than alternative uses of the resources. This is one basis of social control on knowledge production. Even where resources are no impediment, intellectual acceptance may be; editors must be persuaded to publish, reviewers must not denounce the results. Acceptance may be denied to work perceived as heterodox or nonstandard—not just of poor quality, but of the wrong sort entirely—a second basis of social control. Both bases of control are generally stronger in the natural sciences than in the social sciences and humanities: research in the former is more dependent on expensive facilities and equipment, and agreement about what counts as acceptable work is generally greater. Stephen Fuchs (1992, 1993) argues plausibly that, in weakly controlled fields of inquiry, it is particularly easy to create new specialties; such fields tend to be fragmented, and further fragmentation is not resisted. As it happens, the weak fields he is thinking of are the social science and humanities fields where soloists predominate. If this is right, creation of ad hoc interdisciplinary fields is easiest exactly where it is most wanted to satisfy the soloist.

Even if social controls permit creation of such new idiosyncratic specialties, work in any particular new specialty may be rejected by others as a caricature or desecration, as involving distortions or misunderstandings of ill-assimilated specialized work, and so on (compare Klein, 1990, p. 88 on standard criticisms of borrowing), or the new specialty may turn out to be widely appreciated but essentially inimitable, remaining a unique soloist style, or it may actually attract imitators and grow into a new establishment.

Such specialty creation is not as radical as it may sound. Indeed, the world of research may actually be filled with unrecognized or unacknowledged idiosyncratic specialties, developed quite unintentionally in the
course of accumulating whatever special knowledge and skills seem to be needed to do the job one has undertaken. And an ad hoc interdisciplinary specialty will differ only in degree from a single-discipline specialty modified by the import of concepts, tools, methods from outside, or partly transformed by outside influence. Modification of research practice by import and under outside influence goes on all the time in research; it might even seem that every specialist would constantly be open to influence from outside and eager to import useful tools. But specialists differ enormously in their interest in, and openness to, influences from other specialties in the same or in different disciplines, and their practices will reflect such differences. In fact, we can imagine—and find—specialists who practice what we can call informationally closed specialization—i.e., ignoring everything done outside the specialty itself, confining one’s information intake to that produced by fellow specialists. The very idea of such an informationally closed practice may seem perverse, but we have no reason to think that it cannot exist and yield valuable results (for a different view, see Wilson, 1996). Microanalysis of the information use component of research practices would reveal a continuum of types of solo practice ranging from the narrowest informationally closed specialization to the full interdisciplinary practice based on expert knowledge of specialties in two or more disciplines, with a huge range of intermediate types representing greater or lesser isolation from, or involvement with, other specialties and other disciplines. This may look like a source of wild variation in an otherwise standardized and stabilized world of specialties, but the standardization and stability are mirages. While specialties no doubt differ in this regard, any specialist is likely to be more concerned with some parts of his specialty than others, more interested in some techniques and concepts than others, more convinced about some outcomes of research than colleagues are, and so on. And each specialist will bring to the work a unique repertory of intellectual resources (Ghiselin, 1989). We should expect to find that the practitioners of a single specialty all define their specialty somewhat differently and practice it somewhat differently. Just as each individual’s language constitutes an idiolect slightly different from everyone else’s, so each specialist’s expertise constitutes a research idiolect slightly different from everyone else’s. As for stability, John Ziman (1985) has emphasized that “at the subfield level, there are no really stable specialties at all...all is in flux” (p. 12).

The Soloist and Knowledge Policy

With all the variety of practice, the crucial fact remains that the soloist is limited—whether practicing within the boundaries of established specialties or working across boundaries—by what single individuals can manage. The simple desire to do interdisciplinary research does nothing to increase one’s capacity to utilize information or to lessen the burden
of overload. Research whose success requires the application of multiple specialized bodies of knowledge and skill and the utilization of vast quantities of information simply has to be done by teams, not by soloists. Serious large-scale interdisciplinary work is not for the soloist.

Still one could ask whether, as a matter of social policy on knowledge production, a soloist's effort to do interdisciplinary work is always to be encouraged over work within the limits of a single specialty. Perhaps single specialists should always join teams, and solo practice be reserved for interdisciplinary workers. (Granted that there is no such thing as an articulated social policy on knowledge production, there certainly could be; science policy is not an unfamiliar idea, and the social policy in question would be a generalization beyond science narrowly construed. See Kitcher, 1993, especially chapter 8, "The Organization of Cognitive Labor," and Fuller, 1993.) Is small-scale interdisciplinary work, of the size of which the soloist is capable, to be socially encouraged? Is full expertise-based interdisciplinary work to be considered more valuable than informationally closed work? And is this work more valuable than the other varieties of practice we have roughly sketched? Should solo interdisciplinary work be encouraged as a matter of policy by those in a position to affect the career choices of students and beginning researchers? Should educational institutions, foundations, and professional societies do what they can to encourage interdisciplinary work and discourage informationally closed solo practice? It is clear, for instance, that if such work is to be encouraged, students must be urged to start early, for we have seen how difficult it can be to add a new specialty in mid-career. A real social preference for interdisciplinary work could lead to a real policy with clear consequences for action.

But a real social preference for interdisciplinary work might instead lead to the end of private practice in research and the institution of teamwork everywhere. If one takes seriously that putative requirement of rationality for the use of all available relevant information, teamwork becomes unavoidable, for individuals cannot meet the requirement. (As far as the individual is concerned, it cannot actually be a requirement—one cannot require the impossible—but at most an unrealizable ideal, a "regulative ideal" of the sort proposed by Immanuel Kant that, though unrealizable, still provides an orientation for practice [Emmet, 1994, pp. 16-17].) Rather than encouraging soloists to do interdisciplinary work, we would urge them to join teams, contributing whatever knowledge and skill they happen to have to joint projects.

As we cannot realistically expect such a drastic reorganization of research in the social sciences and humanities, might we not still argue in favor of a general preference for interdisciplinary work by soloists on the grounds that it goes in the right direction—i.e., toward increasing utilization of relevant information and other cognitive resources—even
when it fails to go all the way, as it always must if done by a soloist? But "going in the right direction" may not be the best plan; success may call for indirection. The great successes of the natural sciences have been based not on scrupulous utilization of all available relevant information about natural phenomena but on systematic simplification, idealization, abstraction, approximation, and the concomitant ignoring of very large quantities of admittedly relevant information (Wilson, 1995 and works cited there). One may well want to reply that what counts as success in the humanities and in at least parts of the social sciences is so different from what counts as success in natural science and engineering that strategies of inquiry successful in the latter cannot guide the former. This might not be enough to warrant making the encouragement of maximum solo interdisciplinary work a social policy. Even if we praised solo interdisciplinary work for having its heart in the right place, we might hope for greater success from a system of inquiry in which individual workers narrowed their scope while contributing to a collaborative result beyond the capacity of any of them singly.

That sort of system is, in any case, the actual, the unavoidable one; we have been arguing at the margin over a little more or a little less. The gross disparity between individual and collective scope in research is nothing special but simply another manifestation of the general situation of the individual in the face of the collective cultural product, much emphasized long ago by the sociologist-philosopher Georg Simmel. Simmel noted that: "No cultural policy can eliminate the tragic discrepancy between objective culture, with its unlimited capacity for growth, and subjective culture, which can grow only slowly" (Simmel, 1976, p. 251) and described the "typical problematic situation of modern man" as that of "the feeling of being overwhelmed by this immense quantity of culture, which he can neither inwardly assimilate nor simply reject, since it all belongs potentially to his cultural sphere" (Simmel, 1976, p. 254). That is essentially the situation of the individual research worker in the world of research.

ACKNOWLEDGMENT

I am grateful to Michael Buckland for comments on a draft of this essay.

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Patterns of Knowledge Communities in the Social Sciences

ROBERT PAHRE

ABSTRACT

THE STUDY OF SCIENCE AND SCIENTIFIC COMMUNITIES is dominated by philosophies and sociologists. These disciplines naturally take different approaches to the subject, the one epistemological and the other sociological. While recognizing the role of society in shaping science, this article emphasizes the way that the epistemology of science influences scientific society. The epistemological status of various scientific discourses also shapes scientific communities. Discourses about methods have different effects on communities than discourses about theories; positivist discourses and nonpositivist discourses also shape communities differently. The best way to think about science and scientific communities is a dialogue between two hybrid approaches—i.e., a social epistemology and an epistemological sociology. Each presents some challenges to information science.

INTRODUCTION

Knowledge is found in communities built by individuals. Our efforts to systematize, categorize, or reorganize that knowledge must consider not only the individual knower but also the knowledge communities. In other words, studying knowledge presents a sociological problem in addition to an intellectual or philosophical one. For this reason, most contemporary studies of science treat science purely as a sociological issue.

In contrast to this literature, it will be argued here that knowledge communities present not just a sociological problem. The substance of science, and what is labeled here as the “epistemology” of science, affects the pattern by which scientific knowledge is organized. In particular, the epistemological status of a scientific discourse shapes the sociological struc-
ture of a scientific community. To understand knowledge communities, then, we need an epistemological sociology (ES) of science. This approach joins both the social and intellectual reasons why knowledge communities look the way they do.

While a polemical argument is made for such a sociology elsewhere (Pahre, 1995), this article will evaluate both the sociological and the epistemological reasons for the pattern of scientific organization, generally with reference to the social sciences. Four perspectives toward the problem of understanding disciplines and cross disciplinary research are discussed: (1) a purely epistemological approach, (2) a purely sociological approach, (3) a social epistemology, and (4) an epistemological sociology. These perspectives are lenses through which we can see different aspects of the organization of knowledge. Because neither of the two pure approaches is adequate for understanding how knowledge is organized, our studies of disciplines must be interdisciplinary.

Within this general project, special attention will be given to the twin issues of boundaries and boundary crossing. After all, being a community entails having boundaries of some sort, whether they take the form of walls or transitional zones between one community and another. Information science must deal with both intraboundary and interboundary communities. For instance, cataloging is an attempt to get the boundaries right, while reference librarianship must inevitably confront boundaries that are useful for one purpose and yet hinder the information search at hand. This is especially important because innovative knowledges are most likely in exactly those areas that are most difficult to classify and organize (Dogan & Pahre, 1990).

Like other contributors to this issue (see Dogan’s and Klein’s articles in this issue of Library Trends), the goal here is to describe patterns of knowledge creation today and not to propose how information science can meet the needs of the knowledge creators (for a discussion of this topic, see Palmer’s and Searing’s articles in this issue of Library Trends). Simultaneously, the pattern of knowledge creation and organization has implications for information science that will be touched upon throughout this article. Where there are epistemological reasons for a given pattern of scientific organization, then these presumably provide us with good reasons for organizing information services around them. Where scientific communities are organized for (nonepistemological) sociological reasons, the solution to problems of information will be less clear cut because intellectual and social principles of organization do not coincide.3

A PURELY EPistemOLOGICAL APPROACH TO KNOWLEDGE COMMUNITIES

For the most part, university curricula and administrative divisions assume the existence of coherent fields of knowledge and groups of fields within identifiable boundaries. The naïve view is that these fields and the
boundaries around them are found in nature: the objects of natural science are distinct from those of social science, pure science is epistemologically distinct from applied science, and scientific knowledge is distinct from nonscientific knowledge. These are “epistemological” claims about scientific communities since the alleged division between pure science and applied science rests on the difference between an epistemology appropriate to the search of knowledge for its own sake as opposed to an epistemology for seeking knowledge as a means to another end.

The existence of epistemological distinctions between kinds of knowledge or between the disciplines also finds more sophisticated expression among philosophers. For instance, Steve Fuller (1988) argues that disciplines are bounded by their procedures for adjudicating rival knowledge claims (p. 191). In particular, a discipline’s argumentation format restricts word usage, whether justification may rely on reason alone or must use technically aided perception and so on. Presumably, different procedures cluster into disciplines, providing an epistemological explanation for the pattern of disciplinary organization. This is essentially Julie Thompson Klein’s (1990) definition of a discipline: “[T]he tools, methods, procedures, exempla, concepts, and theories that account coherently for a set of objects or subjects” (p. 104).

Still, many have rightfully asked whether the alleged boundaries between science and nonscience, pure science and applied science, or natural science and social science, can be philosophically justified. The boundary between science and pseudoscience, for instance, does not rest on the normal demarcation criteria that many scientists believe it does. Paranormal research programs present models with testable hypotheses, for instance, while those who accuse such research programs of fraud do not themselves meet the traditional standards of “science” (Collins & Pinch, 1979; Pinch, 1979). It is also notoriously difficult to distinguish pure and applied science because: “The intellectual procedures adopted in pure and applied research are frequently indistinguishable and the scientific results often identical” (Mulkay, 1977, p. 95). As for the natural and social sciences, I cannot imagine criteria that would classify, for example, Jane Goodall as a natural scientist studying unknowing objects and quantitative economists as social scientists studying knowing objects.4

There are good reasons why such attempts to define boundaries should fail. These attempts are a variation of foundationalism within philosophy more generally, and analogous to the search for first principles on which to ground a (normative) philosophy of science. The trend of twentieth-century philosophy has, of course, been away from foundationalism. Among those reasons relevant here is that foundationalist philosophies of science unavoidably rest on empirical claims and prelogical judgments in order to justify their prescriptions for how scientists should engage in science (e.g., see Giere, 1985). For in-
stance, crude empirical claims about the “success” of physics in explaining the world have had an enormous effect on notions of what a normative philosophy of science must allow (or prescribe). Judging by past efforts, a philosophy absent from some such nonphilosophical foundations is impossible.

As an empirical matter, foundational explanations would expect a relatively static organization of scientific disciplines, since the justifications for dividing the disciplines are, by definition, unchanging. This is very much at odds with reality, where interdisciplinary centers, institutes, programs, and even colleges and universities abound (Dogan & Pahre, 1990; Klein, 1990). Pure philosophy would reject such an empirical test as illegitimate, of course. Yet, if some empirical claims inevitably lie behind any philosophy, then alternative empirical claims about the nature of disciplines do present a legitimate criticism of even the purest prescriptive philosophy of science.

While we should be suspicious of claims that disciplinary divisions exist in nature, they certainly do seem to influence the definition of disciplines. Divisions between “pure” and “applied” fields are ubiquitous in the physical sciences (science versus engineering), biological sciences (biology versus medicine), and social sciences (economics/business administration, sociology/social work, political science/policy studies). One reason these divisions exist is that asserting epistemological divisions is an important part of scientists’ “boundary work” (Gieryn, 1983). Thus, it is not too surprising that this apparently “intellectual” division probably makes more sense sociologically. Pure scientists produce for an audience of other researchers and are supposed to choose topics based on scientific “significance” (however defined). Applied researchers produce for a nonresearcher audience things of practical usefulness (or things that a nonresearcher audience is willing to fund as if practically useful).

These audience effects shape the communities and their boundaries. This sociological reality of science presents a serious challenge to any purely epistemological attempt to understand disciplines and other forms of knowledge communities (e.g., see Becher, 1990; Campbell, 1979; Gieryn, 1983; Huber, 1990; Pinch, 1990).

A Purely Sociological Approach to Knowledge Communities

If epistemology cannot explain them, then perhaps a sociological approach is the best way to understand knowledge communities. Unfortunately, the classical sociology of science was more a sociology of scientists than a field which problematizes knowledge. For Robert Merton and his disciples (i.e., Merton, 1973; Ben-David, 1973; Zuckerman, 1977), science is a particular form of social activity, where (in a Parsonian way) existing norms structure the roles filled by individual scientists coming from a variety of social backgrounds and forming various kinds of
networks. The internal allocation of rewards in science exerts a powerful influence on scientific recruitment, socialization, and knowledge production, as do professional networks, hybrid fields and scholars, journals, reading and citation patterns, or the (dis)integration of scientific specialties (i.e., Crane, 1972; Mullins, 1973; Chubin, 1976; Mulkay, 1977; Dogan & Pahre, 1990). External belief systems, such as Puritanism or democracy, might also help or hinder the spread of science by supporting certain norms (Merton, 1938/1970, 1973).

This approach usually does not seek to explain the substance of science, generally assuming that science progresses, and that each generation provides a successively better account of reality. Their inattention to the substance of science stems in large part from a belief that "true" scientific beliefs are best explained by their truth; only "false" beliefs need sociological explanation. Laudan (1977) calls this the arationality assumption, by which he means that "the sociology of knowledge may step in to explain beliefs if and only if those beliefs cannot be explained in terms of their rational merits" (p. 202). This is a profoundly ahistorical assumption, for it means that any 1950s-era sociology of knowledge would have been precluded from studying contemporary geology, while those writing after the tectonic revolution can provide a sociological account of geology as it was in the 1950s. Now, of course, those in the sociology of knowledge field are (temporarily) prohibited from studying scientists who believe in plate tectonics. Given such problems, this author rejects the claim that only false beliefs need explanation. In any case, it is more interesting to study the sociological conditions for "true" claims and the conditions affecting the variation between truth and falsity in knowledge claims.

While interesting, it is not immediately obvious why a sociology of "true" belief systems is possible. There are two major reasons why a sociology of knowledge is both possible and interesting—one epistemological and the other sociological. The epistemological reason is the Duhem-Quine thesis that scientific theories are underdetermined by the evidence because more than one theory fits any given set of evidence. "Facts," too, are equivocal, embedded in a particular research program or paradigm. No apparent anomaly can destroy a scientific research program since scientists may make the anomaly disappear by distrusting scientific instruments, restricting the domains of theories, and so on (Kuhn, 1962; Lakatos, 1970). This thesis implies that factors other than evidence—presumably including social factors—determine the content of scientific theories.

Karl Mannheim (1936) first noticed the sociological reason why a sociology of knowledge is interesting. He indicated that granting the truth of any knowledge claim benefits some people at the expense of others. Since any epistemic claim benefits some at the expense of others, the process of epistemic justification is really just another way of distributing power. This is especially clear when we consider how certain do-
mains of socially important knowledge, such as law or medicine, have been delegated to experts (Fuller, 1987). The creation of disciplines, too, served various social interests at particular moments in time (see Wallerstein, 1991). These disciplines and professions are far from epistemically "efficient"; after all, if one could start over and design intellectual boundaries for the current corpus of knowledge, surely one would not choose precisely the set of boundaries that we have today (Fuller, 1988, pp. 195-97; Whitley, 1986).

Where Mannheim (and his followers) erred was in assuming that, because someone benefits from the acceptance of any knowledge claim, this distribution of power is sufficient to explain why a knowledge claim is accepted. They do not consider the possibility that there are different kinds of interests in a given knowledge claim: the material interest of, for example, capitalists on the one hand, but on the other hand the contending professional interests of scientists who have staked positions on opposite sides of a particular knowledge claim. Similarly, disciplines persist independent of the "external" society’s class interest, in part because they engender material and professional interests in their continued survival—a fact evident whenever a university tries to abolish, for example, its geography department.

Even if we grant these weaknesses in the sociologists’ interpretation, scientific claims to a monopoly over certain truths cry out for challenge. The sociology of science has met this challenge, providing a thorough critique of the "myth" of scientific rationality, technical competence, and social authority. Ethnographic studies of science (see Knorr-Cetina & Mulkay, 1983 for an overview) have demystified the process by which scientists construct their knowledge claims by watching scientists create, construct, or find evidence and then seeing how they choose among alternative explanations for the evidence they have. What matters, they argue, is not the relation between science and external reality, but the process of reflexive fabrication that yields science (Knorr-Cetina, 1983, pp. 118-19).

Such work has produced a new approach, a constructivist sociology (CS) of science. Scientific beliefs are socially constructed, and changes in scientific beliefs arise from social and social psychological factors—they do not reflect successively better models of "reality." CS has dominated recent contributions to the sociology of science (i.e., Knorr, 1981; Knorr-Cetina & Mulkay, 1983; Latour & Woolgar, 1979; Mulkay, 1979; Woolgar, 1981). Even Mertonians now find parts of the constructivist position persuasive (i.e., Cole, 1992).

Constructivists argue that the boundaries between disciplines are important as the objects of political conflict, broadly defined. It is not by accident that physicians defend schools of medicine from schools of public health, that physicists look down on engineers and economists, or that
national academies of science are reluctant to admit social scientists. In the academic context, boundary struggles decide who controls the structure of the curriculum, dissertation writing, tenure and promotion decisions, journals, university presses, and external funding sources (see Klein in this issue of *Library Trends*). There are economic, political, and professional motives for all these boundaries.\(^{10}\)

Boundaries between academic divisions also make sociological sense. For instance, Pierre Bourdieu (1975) argues that the division between the natural sciences and the social sciences may be the natural outgrowth of class (or elite) domination:

> whereas the dominant class grants the natural sciences an autonomy corresponding to the interest it finds in the economic applications of scientific techniques . . . the dominant class has no reason to expect anything from the social sciences—beyond, at best, a particularly valuable contribution to the legitimation of the established order and a strengthening of the arsenal of symbolic instruments of domination. (p. 36)

Thus, the divisions must be understood in terms of their social purposes and not as the result of epistemological differences.

For all its insight, constructivist sociology is not without its problems. To begin, we note that, because multiple constructions are possible and the ultimate construction is socially determined, constructivism “is based upon a relativist epistemological position and the argument that nature has very little, if any, influence on the development of the content of science” (Cole, 1992, p. ix). Karin Knorr-Cetina (1983), a leading proponent of CS, bluntly claims that the scientific laboratory is “not an establishment designed to mimic nature” (p. 135). Harry Collins (1981) agrees that “the natural world has a small or non-existent role in the construction of scientific knowledge” (p. 3). Going further, it does not matter whether reality exists, for reality does not constrain our accounts of it (Woolgar, 1983).

Some will find this relativism objectionable on its face, but let us limit ourselves to those objections relevant to the sociology of science. First, the claims of constructivist sociology become more difficult to defend when we look at knowledge claims accepted across many cultures or time periods. There is every reason to believe, then, that CS and all sociological approaches exaggerate the social explanation for scientific beliefs held in many places and at many times. One such belief is that science naturally falls into recognizable fields or disciplines. Because there is a justifiable foundation for this belief, certain principles of disciplinary organization and patterns of cross disciplinary organization make sense on epistemological grounds.

Epistemology constrains cross disciplinary synthesis, a topic that constructivist sociology has not yet examined (Goldman, 1995). Like
most sociologies of knowledge, CS examines the construction of scientific fields or continued knowledge production within boundaries. Yet these are exactly those cases where sociological variables are most important, because knowledge production in a given scientific field takes place within an established social structure. Inside a discipline, existing administration, professional associations, professional socialization, and gatekeeping by the powerful all affect knowledge production.

Since they have studied disciplinary knowledge, it is not surprising that contemporary sociologists have taken a skeptical view of science. Their conclusions might be different if they were to study the destruction of scientific fields, or processes such as boundary crossing, the migration of subfields, the reorganization of knowledge, or the partial destruction of two fields that later merge and create a new hybrid body of knowledge. Reality seems to play an important role in these cases.

Another weakness of the constructivists is that constructivist sociology cannot explain why anyone takes science seriously. Fairness requires that we grant our subjects at least as much understanding of their interests as we claim for observers such as us. If sociologists can see that reality does not constrain scientific narratives, then the producers and consumers of those narratives should realize the same thing. This insight may not stop cynical knowledge producers from producing science that they know to be unconstrained by reality, but it should prevent governments, foundations, and other scientists from believing any of the accounts thus produced.

As this point suggests, constructivist sociology must deny the norms and belief systems of science. This is odd for a relativist position, which is value neutral with respect to every other kind of belief (Pahre, 1995). This denial can even help interrogate constructivism, for CS cannot explain its own efforts to develop a “true” account of how science is constructed. If reality does not constrain scientists’ accounts of reality, then so too science must not constrain sociologists’ accounts of science. If this is true, then why do constructivist ethnographers study real scientists in Jonas Salk’s lab?

Finally, and most relevant for the subject of this issue, constructivism makes a mockery of information science. First, following constructivist sociology would require information providers to achieve a heroic level of cynicism. It asks them to provide information with which scientists can construct accounts of reality while also asking them to believe that this information will not constrain scientists’ accounts of reality. Second, CS implies that there will be no systematic relationship between patterns of information organization and patterns of scientific organization (since scientific organization is not predicated on reality or evidence about reality).

There is, of course, a middle ground position that allows for a meaningful constructivist sociology, though it is different from existing versions.
Goldman (1987) argues that "while students of science and culture may properly abstract from the truth of the ideational contents they study, they do not and should not extrude the question of truth from their own propositions about the growth, prevalence, and extinction of people’s ideational contents" (p. 126). In other words, CS should admit that it seeks “true” knowledge claims about knowledge, and that real knowledge communities do play some role in the construction of knowledge about knowledge. When we grant this, then CS must also allow for the possibility that reality exists and affects scientists’ accounts of it—i.e., science is not purely a social construction. At the same time, society does shape science. This brings us to our next question: Given that society constrains our accounts of reality, how do we ever produce true knowledge?

**A SOCIAL EPISTEMOLOGY**

The previous section argued that sociologists must take note of the role that reality plays in shaping scientific narratives. Yet, as the first section argued, reality and other epistemic concerns do not, by themselves, explain knowledge and knowledge communities. Social forces, too, shape our accounts of reality. Social epistemology examines this problem, analyzing those social structures that are more (or less) likely to encourage conversion to “true” scientific beliefs than are other social structures. This project only makes sense if there is a (partially) knowable reality against which to evaluate knowledge claims. Since the social epistemology project is in part empirical, it is no surprise that it is grounded in something other than a classical epistemology. A “naturalized philosophy” (Quine, 1969; Giere, 1985) or an “evolutionary epistemology” (Campbell & Paller, 1989) are common starting points.

While a social epistemology does not seek to explain the shape of knowledge communities, it does highlight certain patterns or biases in the knowledge held by communities; an epistemological sociology can then show how these patterns help shape the community. To the extent that scientists find themselves in communities that foster the pursuit of true beliefs, we should see an explosion of knowledge. The epistemological characteristics of this knowledge should affect the form scientific communities take. To the extent that scientists are in communities whose organization hinders the pursuit of true knowledge, epistemology will play less of a role in shaping communities. Presumably, social factors will be more important.

The problem of nonmainstream research is a straightforward example of how this might work. Peer review authorities seem to be systematically biased against nonmainstream work in general and academic whistle-blowing in particular (see Moran & Mallory, 1991). This conflicts with scientific norms and biases knowledge production. This bias, in turn, makes it look as if mainstream approaches are better explanations of the world
than they really are. This apparent "success" of the mainstream gives greater intellectual authority to powerful scientists in the mainstream, helping them retain control of gatekeeping roles such as peer review authorities. Mainstream science advances within these limits but is inevitably incomplete.

Another example is the existence of disciplinary boundaries. To defend boundaries, scientists highlight certain claims while obscuring others. For instance, a cultural anthropologist studying reciprocal gift giving will tend to downplay forces of supply and demand influencing the relative value of different goods in order to emphasize the social positions of the two participants; an economist studying the same phenomenon will downplay or ignore the social position of the people involved and highlight the relative prices of the goods.

In such cases, what one discipline ignores are exactly those processes that are part of other disciplines, a process known as "ontological gerrymandering" (Pawluch & Woolgar, 1985; Fuller, 1988, p. 197). One example of how boundaries exclude extradisciplinary factors is the sociology of science itself (compare Delamont, 1987). Mertonian sociology, following Parsons sociology, showed a concern for norms, socialization, and social structure as influences on science. Challenges to this position became increasingly important with the work of Thomas Kuhn (1962), a physicist turned historian of science, whose researches fall outside sociology proper. Ethnomethodology, a sociological field with roots outside the discipline (Mullins, 1973), also became an important source of new approaches to the sociology of science and a major influence on constructivist sociology. One effect of these new approaches was that the sociology of science excluded normative research, leaving that to the philosophers. The philosophers, for their part, had turned away from a concern with real knowledge communities. In short, "[a]n implicit agreement seems to have been made to let the sociologists concern themselves only with what actually passes as knowledge in particular cases, while the epistemologists take care of what ought to pass as knowledge in general" (Fuller, 1988, p. 263).

A second example of interest here is gerrymandering in the study of academic information retrieval and exchange (Stoan, 1991). While sociologists study informal methods of research, such as "invisible colleges," librarians study researchers' use of formal research methods such as bibliographies, indexes, and abstracts. Neither type of study alone can explain why younger scholars rely more heavily on formal research sources yet make less use of formal sources as their careers progress. A unified approach could explain this, arguing that scholars are less closely tied to informal networks early in their careers and therefore are forced to rely more on formal sources of information. We do not have such an approach because of where the academic boundary is drawn.
Crossing these gerrymandered boundaries can play an important positive role in knowledge production. As scientists move outside their original scientific communities, social pressures are less constraining. This leaves scientists more open to conversion. While such conversion is not necessarily a sign of having adopted “true” beliefs, conversion that cuts across social pressures is better evidence of persuasiveness than conversion stemming from socialization within a particular discipline.

Similarly, informed observers in a different community are a useful judge of the likely validity of some set of scientific statements. Campbell (1994) gives the example of applied plant and animal breeders and doctors assembling family histories of specific disorders, both of whom were important for Mendelian genetics: “Because of their lack of prior commitment and lack of membership in partisan thought collectives, these groups have less social influence on them against adopting the new paradigm” (p. xviii). Similar kinds of arguments are to be found in more philosophical approaches, where the clash of rival paradigms or research programs (Kuhn, 1962; Lakatos, 1970) leads more or less to survival of the fittest. The argument is directly analogous to Mills’s belief in the free exchange of ideas.

Such arguments might lead one to conclude that crossing boundaries always makes innovative knowledges more likely (Dogan & Pahre, 1990), while remaining within boundaries always risks producing nontruthful knowledges. Alas, life is never so simple. Women’s studies is a good illustration of some tensions evident in boundary crossing and in the cross-validation of multiple communities. Prior to the development of women’s studies, existing academic organizations often excluded women and many issues important to feminists. Social factors such as sexism clearly played a role in shaping existing disciplines and in excluding research by, for, and about women. Just as clearly, scholarship responding to feminist challenges makes some knowledge claims that are clearly “more true” than the previous knowledge claims.

For these reasons, women’s studies intentionally challenged existing organizational forms, though it was far from clear what the organizational solution was (for brief histories see Boxer, 1982; Klein, 1990, pp. 95-98; Sheridan, 1990). Should feminist scholars build women’s studies as an interdisciplinary field or should they work to transform existing disciplines from within? Either choice entailed boundaries and thus the implicit exclusion of something (Gunew, 1990, pp. 25-31). Each choice also has implications for scholars outside the boundaries—if women’s studies became a separate department, other departments in the university might well remain unchanged by feminist scholarship.

As these examples show, even “interdisciplinary” fields have boundaries that are constructed and defended in some way. While they can transform knowledge, interdisciplinarity offers only temporary emanci-
pation from boundaries. Understanding knowledge communities requires studying both the social forces behind boundaries and the truth-seeking efforts to transform them. This dynamic interaction between social constraint and truth seeking is central to the next section.

AN EPISTEMOLOGICAL SOCIOLOGY

Scientists are positivist, realist, and empiricist, and they believe that we can construct narratives that reflect objective reality. They believe that the purpose of science is to collect data, test hypotheses, and construct theories about the real world. Because scientific beliefs reflect reality, and scientific methods and theories help science better comprehend reality, these beliefs, methods, and theories must affect both scientific behavior and social organization. This claim is central to this author's epistemological sociology (Pahre, 1996) and Schmaus, Segerstrale, and Jesseph's (1992) "Hard Program in the Sociology of Scientific Knowledge" (see also Fuller, 1988, pp. 263-75).

Of course, social factors both internal and external to science also affect these communities, so this approach is not simply yet another example of a (discredited) normative sociology (see Collins, 1992). To see how this works, consider a commonly cited example—multidisciplinary teams doing "problem-focused research." This is (applied) research on a particular problem, usually a social problem of some sort. Understanding where these problems originate requires some sociological understanding of researchers' connections to the outside world. Yet the justification for multidisciplinary teams is epistemological, an argument that we cannot solve problems that straddle several disciplines without seeking true information from each (Ben-David, 1973; de Bie, 1970; Heckhausen, 1972). This is especially true, the argument runs, for clinical care (Klein, 1990, pp. 140-55). The social need for a certain kind of knowledge, combined with the "epistemological" rules for pursuing this kind of multidisciplinary knowledge, combine to produce a particular form of knowledge community, the multidisciplinary team.

Next we will turn to an extended example of where the epistemological sociology approach can take us. We will begin with the claim that disciplines are organized according to their dependent variables, which make up the facts with which their discipline is concerned. This is true (1) for social reasons, because society wants certain sets of problems solved or facts explained; and (2) for epistemological reasons, because scientific norms lead scientists to explain facts, where they know the facts in advance but not the explanations. Once organized into disciplinary communities, scientists develop hypotheses and theories to explain the facts that their community studies.

Given this construction of disciplines, any theory claiming to be useful to a discipline must be *germane* to that discipline—i.e., it must explain
some subset of the new discipline's existing set of data. Sociologists will not borrow the apparently true statements of quantum mechanics from physics unless these statements say something about sociological data. Social forces arise to defend boundaries, so “facts” will persist longer within a knowledge community than either “hypotheses” or “theories” (compare Campbell & Paller, 1989, p. 242)—facts are more essential to the maintenance of these boundaries.

There arise, then, multiple scientific communities, each seeking hypotheses and theories to explain the facts in their disciplines. Some of these sets are likely to overlap for two reasons. First, any system of classifying facts is a social construction. One good example is the different taxonomies found in Western science and among the Karam aborigines (Barnes, 1983). The West classifies bats as mammals and cassowaries as birds; Karam classifies (flightless) cassowaries as animals and (flying) bats as birds. Karam makes the “flying” characteristic central to its schema, while the West classifies according to genetic or evolutionary relationships. Both taxonomies are equally logical, so social needs decide which taxonomy governs—genetic relationships being most important to the West, behavioral characteristics to the Karam. Because classification schemata are (epistemologically) arbitrary, there is no reason why a given object need belong exclusively to a single discipline. For these reasons, we find many dependent variables to be germane in more than one discipline. Klein, in this issue of Library Trends, gives examples of crime (economics, sociology, political science, and others), poverty (economics, sociology, political science, women’s studies), and disease (medicine, public health).

A second reason several disciplines explain some of the same facts is that any fact is open to multiple interpretations by the Duhem-Quine thesis. Multiple explanations of the same fact are ubiquitous in science—for instance, the choice between two or more plausible explanations is at the heart of most scientific controversies. It is less frequently remembered that there can be not only multiple interpretations of the same facts, but multiple consistent logical systems—such as non-Euclidian geometries—each incompatible with the other. Scientific controversies need not end with one interpretation victorious but may produce two or more internally consistent bodies of theory.

The appearance of the same “fact” in more than one discipline is an obvious inducement to interaction between fields. Let us consider two forms of interaction: (1) the exchange of data detached from theory, and (2) the exchange of hypotheses designed to explain some data.

As epistemological sociology would expect, the epistemological difference between data and hypothesis leads to different kinds of community. Borrowing data, for instance, does nothing to create community between disciplines. The same data can appear in multiple fields without changing them at all, no matter where the data came from. The com-
mon use of economic data does not create a community between political scientists and economists or between sociologists and economists.

The exchange of hypotheses, on the other hand, can create community. Because the sets of objects studied by different disciplines overlap, scientists always have an inducement to exchange hypotheses. This follows directly from scientists' beliefs about what they are doing and can take several different forms. First, one discipline might borrow another discipline’s hypotheses and use them to explain some data in the borrower discipline not found in the lender discipline. For instance, in the 1950s and 1960s, many anthropologists and political scientists found Parsonian sociology useful and borrowed this theory for their own purposes. Second, any lender discipline that observes this borrowing might find the borrower discipline’s facts interesting and might simply incorporate any data into its own field that these hypotheses explained in the borrower field. For instance, there are now economic explanations of family structure so the discipline of economics now includes data about families and society without such data being excluded from sociology.

This appropriation of data might make part of the borrower field appear as an outgrowth of the lender field. When this occurs, observers will describe an “imperialist” discipline that enters the subject matter of neighboring fields. Political economy is a good example, driven by the theoretical imperialism of economics (Hirshleifer, 1985). A sizable economic literature now explains economic regulation, a topic originally germane to political science. By this process of incorporation, economic policies have become part of the explanandum of economics, which has expanded to include them. Economic fields such as the “economics of regulation” or “endogenous tariff theory” now explain politics in economic terms.

Because facts define a scientific field and hypotheses are tightly linked to facts, borrowing results can also lead directly to the creation of a new scientific field. There are two possibilities here: the two fields may merge entirely, as did botany and zoology in 1945-1955, or the exchange of results may lead to the creation of a new hybrid field that defines itself by the facts at the interstices of the parent disciplines.

Perhaps the largest hybrid field is historical sociology, where sociology and history interact to produce results that are useful to the other (see Dogan & Pahre, 1990, pp. 187-201). The community is so large that there exists subcommunities depending on different kinds of ties to the outside. For instance, the school of the Annales pursues multidisciplinary studies of the long durée. Grounded in communities of historians, this school attempts to use social scientific and natural scientific results as part of the reconstruction of particular historical social structures.

It is easy to multiply such examples because the exchange of hypotheses is a bread-and-butter form of interaction across scientific boundaries
It changes the boundaries of existing fields and may lead one field to subsume another or two fields to merge into a hybrid. Though closely tied to data, this is very different from the mere exchange of data, with different implications for community. The exchange makes perfect sense in terms of scientific beliefs in positivism and realism, according to which scientists seek explanations of reality in a variety of places.

There are also borrowings entirely divorced from data. For instance, it is possible to borrow assumptions and deductions derived from them completely detached from facts. A borrowing detached from facts is especially evident when the theory is couched in mathematical terms and a field borrows only the mathematical terms (see also Pahre, 1996). An interesting example is the borrowing of Newton's inverse-square law by international trade theorists in economics. Jan Tinbergen (1962) and Pentti Pöyhönen (1963) saw this as a useful way to estimate trade volumes between countries. Their initial insight was to relabel the algebra and create a "gravity model" of international trade in which force is reinterpreted as bilateral trade volume, mass becomes the GNP of any two countries, and the distance between these countries has an inverse-square effect on trade. These "gravity models" describe trade flows better than any other theory we know, despite having no connection at all to economic theories of international trade (see Leamer & Stern, 1970, chap. 6; Deardorff, 1984).

Such borrowings rest on the language of metaphor. Metaphorical communities may emerge, but successful innovation in a metaphorical community is a less predictable matter. Certainly physicists and economists will not find any ground for a community in the above example. The difficulty of forming metaphorical communities is inexplicable in terms of constructivist sociology but makes sense for epistemological sociology because it relies on distinctions among data, hypothesis, and mathematical language that are important to scientific epistemology.

The exchange of research methods also does little to create community. Statistical methods are a good example. Any concept or method from the field of statistics—i.e., the description of a Gaussian distribution, sampling rules, Bayesian inferences, and hundreds more—is substantively empty; it matters not whether one is counting gold mine production, deaths in war, or quasar emissions. In other words, such methods are not at all linked to facts. Yet such concepts, and the methods for applying or manipulating them, are enormously useful and have spread from discipline to discipline. Despite their importance, they do not create communities or disciplines, which are always organized around dependent variables.

Let us conclude this section by contemplating some implications of epistemological sociology for information science. Facts are stable and
central to the construction of disciplinary boundaries. Designing information systems that respect these disciplinary boundaries makes sense. Still, information systems are themselves social constructions and help strengthen these boundaries, not challenge them.

Facilitating the exchange of hypotheses is a matter of helping communication among "neighbors." While there are likely to be many problems in practice, in principle it is easy to see that monetary policy will interest economists and political scientists, peasant villages will interest anthropologists and sociologists, and speech recognition will interest linguists and psychologists. The relevant communities can help information providers recognize these needs; though research in psycholinguistics might be classified as part of either psychology or linguistics, researchers need hardly be told to look in both places for recent contributions to the field.

The primary obstacles to information science's efforts to cultivate the exchange of hypotheses are likely to be social. Hybrid fields conflict with socially constructed boundaries that are embedded in fiscal constraints, administrative divisions, and academic politics (see Searing's article in this issue of *Library Trends*). When forced to choose between allocating resources to facilitate research at the interstices of disciplines or giving resources to support research at the discipline's core, most administrators will emphasize the core.

In contrast, the major obstacles to metaphorical communities are epistemological. We are not very used to thinking about them, and it is hard to imagine how information science might facilitate exchange in this area. Complexity theory, also known as chaos theory (see Gleick, 1987), is a good example of these difficulties. The core of this cluster of theories is the methodological principle that apparently chaotic behavior can be patterned in complex ways, and that we should model this behavior from the "bottom up" and then look for patterns. For instance, some lines of computer code might simulate the rules guiding an ant, a migrating bird, nations at war, protein synthesis, or a weather system. The computer can then simulate how a large number of these units would behave in interaction with each other, and the scientist can scan this behavior for patterns such as flocking behavior in birds or the way that ants sort different kinds of trash.

What makes complexity theory a challenge is the diverse applications possible with this method (my seemingly random list above is taken from real research). A recent graduate course on complexity theory in my political science department had students from chemistry, computer science, mathematics, psychology, and political science; colleagues in this area interact with biologists, economists, sociologists, and many other disciplines. There is no obvious way to connect a would-be user in the study of war to information such as the Lorenz equations, originally written to simulate the behavior of a water wheel.
CONCLUSIONS: TOWARD AN EPISTEMOLOGICAL SOCIOLOGY RESEARCH PROGRAM

While there are many challenges for information science raised by the study of crossdisciplinary communication, this discussion will conclude with what this author sees as the research program facing those doing epistemological sociology. After some years of research, we should then be in a much better position to think normatively about issues of concern to universities, science policy makers, and information service providers.

First, this research program needs a more fully developed epistemology. Institutional and social organization, social-psychological pressures, politics, and economic incentives all shape the pursuit of knowledge, and social epistemology is well poised to explain how such social processes help or hinder efforts to develop a better understanding of the real world. A foundationalist epistemology cannot explain changing constructions of truth-seeking disciplines and their boundaries in the same way that a social epistemology can. These changing constructions are, in turn, an important source of sociological change in an epistemological sociology.

The second task for epistemological sociology is to develop a large body of hypotheses about how epistemology shapes scientific organization. The ES reaction to constructivism risks making the following kind of argument: scientific norms matter, so if we observe scientists we should see them seeking truth in accordance with those norms. There are two problems here. First, the argument does not add any information to our understanding of science since we have assumed norms in order to explain norm-driven behavior. More seriously, any empirical study based on such an argument will likely be tautologous, deriving the norms only from the study of normative behavior and then using these derived norms from the very same behavior.

To avoid these problems, hypotheses are proposed here that connect norms with social organization, mostly about cross-boundary communities. These hypotheses should be compared to existing models of these communities, such as specialization-fragmentation-hybridization (Dogan & Pahre, 1990), or a spatial model of islands and archipelagoes (Berger, 1972; Garfield & Small, 1985). These models are not mutually exclusive, but we have not yet asked under what circumstances a particular model will fit one field or another. It is at least as important to start asking which models do not fit particular fields and which models do not seem to fit very many fields at all.

As this suggests, it is time for sociologists of science to buckle down and pit contending approaches against each other in empirical tests. Warren Schmaus et al. (1992; also compare Collins, 1992) note that "social students of science do not seem to think it necessary to eliminate alternative explanations and demonstrate the superiority of their own
explanation; they just argue their own specific case” (p. 249). For those of us who grant that theory testing is meaningful—as positivists or as social epistemologists—this lack of testing is an undesirable state of affairs. Because these tests should be comparative—that is, against a rival paradigm or research program (Kuhn, 1962; Lakatos, 1970)—it is helpful to pose epistemological sociology against the constructivist sociology of science.18

Another way to develop hypotheses is to treat norms not as a constant that structures society but as a variable that influences the structure of scientific society. For instance, scientific norms about the purpose of research are much stronger than norms about the purpose of making university appointments (where scientific ability and nonscientific norms such as teaching, mentoring, or diversity all play a role). We should also expect the effects of scientific norms to be more obvious in crossdisciplinary science. Very powerful social forces, crystallized as disciplinary boundaries, may well overwhelm these norms as an explanation of disciplinary and intradisciplinary organization.

Whatever the details, this is an exciting area of research. Looking at both the social constraints on knowledge and the way that knowledge transforms communities forces the scholar to be reflexive and self-critical. At the same time, this research also highlights the creative and transformative potential latent in existing social structures and communities.

NOTES

1 Similarly, connecting information to end-users is not just a technological problem but a sociological one. However, librarians typically think about meeting the needs of information users in terms of technological fixes—better abstracting, indexing, online search capabilities—instead of social solutions.

2 Throughout this paper I use “epistemology” as a shorthand that includes much that is not only epistemological but also ontological or hermeneutical. For instance, this “epistemology” also includes scientists’ ontological beliefs that reality exists and hermeneutical guidelines about uncovering the secrets of that reality. I also use the term to include the process of dividing the scientific toolkit into “data,” “methods,” “theory,” and other more-or-less exclusive categories.

3 Another implication of the sociological study of disciplines stems from the fact that members of the different divisions (engineering, humanities, natural sciences, social sciences) search for information in different ways. While all rely heavily on informal networks, bibliographic searches are much more important in the natural sciences, while library accession lists and publishers’ catalogs are much more important in the humanities (Stoan, 1991). Thus, studying scientific communities is important not only in order to understand the informal information sources that stand as alternatives to librarians’ formal sources, but also to understand the origins and likely persistence of the differences in the use of formal sources. These issues will not be addressed here.

4 For seven examples of failed foundationalist attempts to mark off the human sciences, see Fuller (1988, pp.197-201). For review of the argument distinguishing knowing from unknowing objects, see Harbers & de Vries, 1993 and Lynch, 1993.

5 Laudan’s (1977) critique of those who try to demarcate science from non-science is telling, for each philosopher tried to design criteria to exclude specific beliefs that he finds objectionable: Aristotle excluded Hippocratic medicine, Carnap ruled out Bergsonian metaphysics, and Popper put Freud and Marx beyond the Pale.
Fuller (1988), too, notes that "history tells against the systematic approach" to organizing disciplines (p. 196).

For an example of how a highly critical external audience shapes research in the humanities, see Messer-Davidow (forthcoming).

We must also consider the interests of "users" (Fuller, 1987, pp. 157-58), such as those who accept (use) claims about materials, forces, and stress in order to assert claims about architecture. It is impossible to explain the persistence of knowledge claims in the face of social change without considering a broad range of such "interests."

Numerous variations exist within this general position, including constructivists (Knorr-Cetina, 1983), discourse analysts (Mulkay et al., 1983), ethnomethodologists (Lynch et al. 1983), postmodernists, and the like. I take this term to include a large cluster of postmodern, post-structuralist, ethnomethodological, deconstructing, and discourse-oriented perspectives, despite the myriad differences among these sects (see Knorr-Cetina & Mulkay, 1983).

For nonconstructivist discussions of the social nature of disciplines, see, among others, Bauer (1990), Becher (1990, 1994), Campbell (1979), Pinch (1990).

Donald T. Campbell (1969, 1986, 1989, 1994) calls this project a "Sociology of Scientific Validity" (SSV), while Goldman uses the term "veritism" for the evaluation of social practices according to their production of true beliefs. The project is also central to the journal Social Epistemology and editor Steve Fuller’s (1988) book of the same name, and I have followed the nomenclature of that community here.

It might also be interesting to think about the political aims of the sociology of science: (1) to debunk the achievements of the natural sciences in order to make the natural sciences resemble the social sciences, who would then share in the higher prestige of the natural sciences; (2) to buttress the position of sociology as a discipline capable of understanding “reality” objectively, and thus something different than the less prestigious subjective disciplines of the humanities.

Social epistemology need not be this panglossian, of course. Compare Fuller’s (1988) statement of the task: “[M]ost of the cognitive utopias of the philosophers involve activities such as inspecting the logical structure of arguments and replicating the experiments of one’s colleagues, which are simply impossible to enforce on a systematic basis in the world of Big Science” (p. 268). Thus, understanding the social constraints on replication is a necessary condition for a normative epistemology.

For a trite example, consider those newer truth claims in medical studies that are drawn from the population of both women and men. These are an advance on pre-existing studies, which generally excluded women from the sample even for studying medical problems suffered mostly by women.

Throughout this essay I will treat “facts,” data, and objects as unproblematic and as somehow prior to theory. This is a simplification, to say the least. Someone “discovers” certain facts for certain purposes and not some other imaginable facts, and we describe these facts in one language and not another.

If internally consistent, each must be incomplete, by Gödel’s Theorem.

For a different kind of example, in which the interaction of truth-seeking and citation maximization goals produce particular patterns of replication in high and low status journals, see Feigenbaum and Levy (1993).

This is not quite a fair test because constructivists reject the positivist project of theory testing.

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Disciplinary Structures on the Internet

PATRICIA CLARK

ABSTRACT
EARLY UTILIZATION AND IMPLEMENTATION of the Arpanet/Internet hinged largely on problem-centered research endeavors among established academic and scientific communities. Most of these early adopters had their roots in existing disciplinary structures. As a more diverse population gains access to the Internet, some of the underlying organizational devices used to structure discussion space have become increasingly flexible. In fact it might be described as a self-organizing system in some cases, imposing a more consensual definition of discipline to the discourse undertaken there.

INTRODUCTION
This study samples several threads from Internet discussion groups and attempts to inductively identify the disciplinary structures which provide the framework for the identity of the participants. Approaches to indexing and information organization strategies which can be employed to take advantage of the structures identified are offered.

In order to make sense of information, human beings exercise a variety of strategies. Librarians have always had a special interest in the categorization and classification of information. Those in the library profession who have made some of the most lasting reputations are those who have contributed significant advances in this area—e.g., Dewey, Bliss, and Sears. Central to the established methods of classification is the idea that knowledge can be divided into broad subject areas. These broad subject areas have been treated primarily in a hierarchical fashion ruled by the hegemony of disciplines.
If it can be assumed that, as Dogan and Pahre (1990) and a growing body of other scholars have suggested, knowledge is expanding at the interstices of the disciplines, the library profession must anticipate some changes in their traditional hierarchies of classification. If the vast literature on interdisciplinarity that has appeared in the last decade or two has not been a powerful enough indicator of change, the expansion of digital information on the Internet and other electronic media provides an even more undeniable sign.

This study examines changes in disciplinary identity demonstrated in the discourse of several usenet discussion groups and offers some suggestions for rethinking the way librarians approach the organization and classification of digital information.

**The Culture of Discipline**

The organization of knowledge by discipline has never been static. From the time of the early classicists, disciplinary structures can be observed. Aristotle, for example, reflects the disciplinary divisions of logic, physics, ethics, and rhetoric. Subsequent disciplinary structures reflect changes in the organization of the historical academy. Those structures are influenced by social and political change as well as by shifts in scientific and popular interest (Klein, 1990).

Contemporary academic disciplines are not so much a function of academic organizational structure as they are of the economics of funding (Dogan & Pahre, 1990). Knowledge and funding, however, do not necessarily vary in direct proportion. According to Boyer (1990), "what we have, on many campuses, is a climate that restricts creativity rather than sustains it" (p. xii).

Disciplinary work can be defined in other than economic terms, of course. Academic journals provide structure to traditional disciplinary work through an expectation of rigor, adherence to methodological standards, and application of the peer review process. Disciplinary structure provided by academic journals can reflect the identification of contributors more strongly than membership in a particular academic department in some cases.

The pursuit of knowledge, however, often leads across disciplinary boundaries. "The nature of [an interdisciplinary field] must be determined in the context of the questions and problems which give rise to that field" (Dogan & Pahre, 1990, p. 117). The opposite also applies; ways in which the global questions are constructed can provide the framework for the discipline. It has been noted earlier that disciplinary boundaries have never been static. A point is sometimes reached in which work across formerly recognizable disciplinary boundaries becomes institutionalized. Such shifts substitute the old canon with a new one (Lombardo, 1992). Freitas (1992) despair of the viability of interdisciplinarity and
dynamic collaboration as the old canon becomes the new. She complains of “too much specialization, too much compartmentalization, not enough local collaboration” (p. 98) and cites overspecialization and the competition for funding as impediments to a wider, more creative, cultural experience and exchange.

Institutional barriers may not be the primary impediments to interdisciplinary initiatives. “The practitioners of the various disciplines show stereotypical differences over many things: lecturing style, design of curriculum, role of graduate students, and also political, social, and religious affiliations and beliefs” (Bauer, 1990, p. 105). Bauer highlights culture and the norms which govern the culture of discipline. These factors, once they become assimilated by a discipline, are indicators of an inevitable cultural shift—i.e., the movement from the old canon to the new. Connell and Franklin (1994) discuss the educational issues generated by the Internet as a learning environment in terms similar to Bauer: changing roles, unequal access, changes in curricula, and the need for improved learning tools.

THE CULTURE OF THE INTERNET

The culture of “discipline” varies notably from what might be called the culture of the Internet. The roots of the Internet are in a U. S. Department of Defense project called Arpanet. The underlying idea for Arpanet was to implement a communication network with so much redundancy that it could not be put out of commission by any kind of enemy strike. As this network grew, the people using it developed an enormous variety of both practical and pleasurable tasks for its use. Examples include the World Wide Web, electronic mail, Gopher, usenet, and, of course, online games. Most of the early expansion of the Internet was effected at federal and state agencies. Much of the early culture of the Internet had as its basis the background of people working in universities and government agencies. This being the case, even a cursory observation reveals some overlap in the cultures of discipline and of the Internet.

The utility of a large interconnected communication network is apparent to many, and businesses inevitably wanted to connect their machines to the network. Numerous service providers now offer access to general individual users as well. As the demographic profile of Internet users changes, the culture of the Internet will also change. Usage has shifted from primarily research toward a balance between serious and recreational use.

There is evidence that the scholarly community detects qualitative differences among some of the services available on the Internet. For example, usenet and listserv are both services supporting topic-focused discussions, but their cultural differences may be related to their origins. The origins of listserv were on the academic bitnet network and it is still
perceived as more scholarly in nature (Cline, 1994). Part of the reason for this perception may be that listserv is offered as a service through a user-initiated request. In order to join the discussion, one must be aware of its existence. Specific groups of users may be targeted and invited to join such discussions. Sometimes subscriptions are restricted to this group, and messages sent to the group are screened by a moderator. Listserv postings are delivered directly into a subscriber's electronic mailbox.

Hahn and Stout (1994) define usenet as a large collection of topic-centered discussion groups involving millions of people from all over the world, but usenet has unique qualities which distinguish the delivery of the postings to interested participants. Message threads for all discussions are relayed to a central location where messages are available for browsing instead of on a subscription and individual delivery basis. This structure enables the casual reader to scan messages in any discussion group without making the same kind of commitment to the topic as is required by the listserv structure. Usenet discussions are structured into hierarchies identified through naming conventions that help identify the topical nature of the content in each of its over 5,000 groups. The most significant hierarchies and their broad topic coverage are listed in Figure 1.

<table>
<thead>
<tr>
<th>NAME ELEMENT</th>
<th>COVERAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>alt</td>
<td>alternative discussion topics</td>
</tr>
<tr>
<td>bionet</td>
<td>biological topics</td>
</tr>
<tr>
<td>bit</td>
<td>topics collected from various bitnet mailing lists</td>
</tr>
<tr>
<td>comp</td>
<td>computer topics</td>
</tr>
<tr>
<td>k12</td>
<td>elementary and secondary school issues</td>
</tr>
<tr>
<td>misc</td>
<td>miscellaneous topics</td>
</tr>
<tr>
<td>news</td>
<td>usenet in general</td>
</tr>
<tr>
<td>rec</td>
<td>recreational topics</td>
</tr>
<tr>
<td>sci</td>
<td>science topics</td>
</tr>
<tr>
<td>soc</td>
<td>discussion of social issues</td>
</tr>
<tr>
<td>talk</td>
<td>various controversial topics</td>
</tr>
</tbody>
</table>

Figure 1. Selection of Broad Usenet Hierarchies

The main difference between listserv and usenet is that usenet newsreaders allow users to scan the entire list of discussion topics and participate in any of them without becoming a permanent member of the discussion group. All users select the discussions in which they wish to participate. If there is no discussion group that is focused on a desired topic, a procedure exists for starting a new one. A typical listing of usenet discussion groups is provided in Figure 2. This becomes a kind of self-organizing system in which participants self-select the groups with which they most strongly identify based on their observation of what is discussed.
Group Selection

17 6174  comp.internet.net-happenings  Announcements of network happenings
18 bit.listserv.varie-l  RLG Ariel Document Transmission
19 bit.listserv.asis-l  American Society of Information
20 bit.listserv.gutnberg  GUTNBERG Discussion List. (Mode
21 87  bit.listserv.novell  Novell LAN Interest Group.
22 956  bit.listserv.pacs-l  Public-Access Computer System F
23 3272  alt.tarot  Your destiny is in the cards.
24 102  alt.winsock.trumpet
25 729  comp.os.ms-windows.win95.setup  Setup and Configuration of Wind
26 6  misc.news.internet.announce  News bulletins from the Internet.
27  sci.med.prostate.cancer  Prostate cancer.
28  bionet.ecology.physiology  The practice of obstetrics by m
29  sci.med.midwifery  Science of rivers and lakes.
30  sci.geo.rivers+lakes  Any type of interest in any for
31 4  rec.autos.sport.rally  People of mixed "culture", "eth
32  soc.culture.intercultural

Figure 2: Sample of groups as viewed through the tin newsreader.

One of the primary ways that people are assimilated into a culture of any kind is through the medium of language. The Internet has developed a metalanguage of its own which is characterized by certain conventions and a large number of acronyms as shorthand for commonly used phrases (e.g., IMHO for "in my humble opinion" and ROTFL for "rolling on the floor laughing"). It can be disconcerting to newcomers to encounter such language until they have become acclimated. Different discussion groups may vary in the use of certain conventions and may contain some that are unique. They may contain references to shared past events. Signatures containing a favorite quote or a disclaimer are sometimes utilized to elucidate a writer's individual identity or their identity within the culture of a group.

Metalanguage also permeates the culture of discipline (Dogan & Pahre, 1990). One of Klein's (1990) central concerns for interdisciplinary
work is the problem of language. If a "metadiscourse" or a "rhetoric of inquiry" is lacking, effective communication is not possible. If the assumption can be made that the cultures of discipline, of interdiscipline, and of the Internet all strive to advance problem-focused, or at least topic-focused, discourse, a core body of shared terms within those cultures is essential.

**Method**

The sample for this study was drawn from eight usenet discussion groups. Not all hierarchies were sampled, only those that: (1) were likely to contain sustained topical discourse, (2) were likely to reflect an interdisciplinary approach to the exchanges, and (3) were not likely to be recreational in nature. The hierarchies alt, misc, news, and rec were intentionally deselected for these reasons (Figure 1). The bit hierarchy was not selected with the intention of preserving the distinction between usenet and listserv discussed earlier. The hierarchies selected for use were: bionet, talk, sci, and soc. Groups used from these hierarchies and the number of messages in each are described in Figure 3.

Within the hierarchies, specific discussions were selected if they suggested that the discourse would lend itself to interdisciplinary topic-centered discussion. Bionet provides some outstanding examples of discussion groups that contain key terms that are linked in ways that do not reflect traditional institutional department names—e.g., bionet.agroforestry, bionet.parasitology, bionet.cellbiol.cytomet, and bionet.biophysics.

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>sci.geo.rivers+lakes</td>
<td>10</td>
</tr>
<tr>
<td>sci.med.midwifery</td>
<td>3</td>
</tr>
<tr>
<td>bionet.ecology.physiology</td>
<td>3</td>
</tr>
<tr>
<td>sci.med.prostate.cancer</td>
<td>3</td>
</tr>
<tr>
<td>soc.culture.intercultural</td>
<td>31</td>
</tr>
<tr>
<td>talk.philosophy.misc</td>
<td>16</td>
</tr>
<tr>
<td>soc.culture.native</td>
<td>50</td>
</tr>
<tr>
<td>bionet.agroforestry</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 3: Instances from selected usenet discussions. N=118

All messages posted to the selected groups during the week of February 11, 1996 were included in the sample. The total number in the sample was 118. The textual and message heading information was analyzed. Where excerpts of text have been used, the group name is appended in parentheses.

**Analysis of the Text**

Each computer directly attached to the Internet is assigned a domain name by Internic, the Internet Network Information Center. A domain
name usually has four segments which are separated by dots. The final element of the domain name reflects the organizational affiliation of the machine. Educational institutions, for example, contain the element “edu” in the final segment; “com” is the designation for commercial providers. Thus it is possible to determine the machine from which any given piece of information originates.

Of the total of 118 messages examined, 31.4 percent originated from edu domains and 68.6 percent originated from other sources. These numbers demonstrate the shift in demographic participation within usenet. Distributions of domains are shown in Figure 4.

<table>
<thead>
<tr>
<th>Domain</th>
<th>Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>edu</td>
<td>37</td>
</tr>
<tr>
<td>se</td>
<td>1</td>
</tr>
<tr>
<td>us</td>
<td>1</td>
</tr>
<tr>
<td>com</td>
<td>46</td>
</tr>
<tr>
<td>org</td>
<td>1</td>
</tr>
<tr>
<td>uk</td>
<td>2</td>
</tr>
<tr>
<td>net</td>
<td>12</td>
</tr>
<tr>
<td>ca</td>
<td>11</td>
</tr>
<tr>
<td>au</td>
<td>3</td>
</tr>
<tr>
<td>fr</td>
<td>2</td>
</tr>
<tr>
<td>gov</td>
<td>1</td>
</tr>
<tr>
<td>th</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 4. Number of messages by domain

In order to inductively discern trends within discourse, the content must be examined closely. The usenet texts reveal strong support for three separate findings. The first finding relates to the request for “expert” information from group participants. The occurrence of such requests is demonstrated in the following excerpts from unedited discussion postings. Much of the discourse on usenet centers on the give and take of such expert information. There is often a core group of experts who watch the discussion with interest and are generous in offering responses. The experts do not always concur with each other and heated conflict can ensue. The disparate positions of experts provide less knowledgeable members of the group with the opportunity to draw their own conclusions. Three of the requests sent during this period received responses during the same week the sample was taken. The other excerpts represent queries from postings made during the sample period for which no responses had yet been received.

I am looking for literature and Internet sources on stream foam. Searches in Georef, a geological literature database and in w.w.w. by Alta Vista gave very little more than a hint that the phenomenon may be dealt with by hydrobiologists.
The foam I am interested in is dense, firm, it persists for days, piles up to several tens of centimetres in height and it supports "cappings" of clay and fine organic debris. It occurs in pristine mountain streams in an area with low level of pollution in the atmosphere, in watersheds lying completely within a national park.

I have recently seen a foam like this in a film on Travel channel in cable TV. The film told the story of an expedition to the elevated rocky "mesas" in Venezuela. The text was in Italian; I understood only that the expedition sampled the foam for a laboratory study.

> B) Exactly how much expertise is required to give these injections?  
> It sounds like a major intervention, (but I agree, probably not  
> so much as an epidural)

I gave the injections myself and from the conference, a physician (from Vancouver B.C.-teaching hospital) said that he and the nurses on the OB unit gave them. Realize that the amount of sterile water is only 0.1 ml injected subdermally (like a PPD). It is quite easy to give the injections and nothing as involved as an epidural. I don't think of this as a "major intervention" but as another option. I see it as a very viable option when there is intense back labor, a woman screaming for relief and a fetal heart tracing that is worrisome. I am not saying that everyone with back labor should have this but it's there if needed. It does have a very remarkable but brief period of intense sting. But...there is relief from back pain. Has anyone else heard of this method or have tried it?

I am seeking information that will help me with my research project. At this stage I am intending to study characteristics of leaf area, leaf dimensions, leaf inclination, and canopy architecture and hoping to find functional relationships to the growth/biomass of 16 cabinet wood trees being grown in a mixed species agroforestry plantation. The species are 5 years old and for unapparent reasons have shown differential growth. If anyone can help or knows where I can get Info I would Much appreciate it.

I'm looking for some experimental data on the hemoglobin-bound oxygen reaction:

\[ k^+ [Hb] + [O2] \longrightarrow [HbO2] \]

\[ k^- \] (bionet.ecology.physiology)

I am a journalism student at Ohio University and I am interested in finding any information available on any aspect of tropical rivers. I am specifically researching the broad scope of effects (social, environmental, ecological, economic and cultural) that humankind has had on the Amazon River region in the 20th century. Any information pertaining to any of these topics is greatly appreciated.

How many trees would have to be destroyed to produce 563,000 sheets of copy paper? This question was presented in our employee
newsletter by our director... who by the way does not recycle... hopefully the answer will shock him into changing his ways. (bionet.agroforestry)

> What is a PSA test? What do the results mean? Please, will some- one respond? I'm not a medical professional but I understand that the PSA threshold of concern increases with age. So a person at 65 with a PSA of 4.5 might be fine but a person aged 45 with that PSA reading should be concerned. (sci.med.prostate.cancer)

Can anyone tell me the history of this sign as it relates to the Native American? How about some research direction so that I can find out myself? This symbol appeared on an Old Town canoe from the 1920s. I believe it is a Native American good luck symbol, perhaps Penobscot, but I'm trying to find more information than that before I put the photograph on my web site (along with the 50+ other Old Town designs that are already there).

I know it's controversial, but I would like to include it for historical correctness, and fully explain the origin if I can. (soc.culture.native)

The second finding demonstrated in the sample is the use of the discussion group to announce an event or to extend an invitation for participation at an event. This type of posting is sometimes in the form of an electronic newsletter. Because of this characteristic, usenet discussion groups are also sometimes known as newsgroups. The excerpts that follow demonstrate the perception of posters that they are targeting people with a focus on a particular topical interest or expertise.

Economic Development for Canadian Aboriginal Women (EDCAW) announces its upcoming National Symposium:
"Forging New Linkages"
Aboriginal Women and Business
March 19-21, 1996
Delta Chelsea Inn, Toronto, Canada (soc.culture.native)

WHO: The Totem Pole Group (The first Native Am. AA group in Seattle.)
WHAT: 28th Anniversary Celebration (The group began in March 1968.)
WHERE: Pilgrim's Congregational Church, 509 10th Avenue E.
(Broadway & Republican)**

WHEN: March 16th, 1996 from 12 noon to 12 midnight.
HOW: Bingo, Giveaway, AA Mtgs, Honoring Ceremony, Potluck, Door prizes, & Laughter. (soc.culture.native)
Master's programme in Applied Environmental Measurement Techniques Chalmers University of Technology will give an international MSc programme in Applied Environmental Measurement Techniques. The programme starts in September 1996 and ends in May 1997. A thesis that will take about 3-4 months to accomplish follows. The whole programme will be given in English using the method PBL, Problem-Based Learning. At least 15 of the 30 students should be from foreign countries. The four main themes are 1. Aquatic Environment 2. Geohydrology and Geochemistry 3. Air quality and 4. Global Environmental problems and Biogeochemical Cycles. Three additional themes will be integrated into the main themes: Environmental Statistics, Environmental Databases and Environmental Legislation. (sci.geo.rivers+lakes)

Am inviting all to visit the following web site:
http://www.pobox.com/~jsd/index.html
so as to review and comment on a Narragansett History presently in progress. (soc.culture.native)

University of Pennsylvania offers several summer study programs in Europe and Asia
1) Penn-in-Prague, Czech Republic (July 8-Aug. 16)
   Courses in Czech language and civilization, political science and Jewish studies. Some internships can be arranged.
2) Penn-in-London, England (June 29-Aug. 2)
   Courses in literature and theater
3) Penn-in-Bordeaux, France (June 17-July 4)
   Anthropology course on human origins
4) Penn-in-Compiègne, France (May 28-July 4 or May 28-July 20)
   Courses in business French and European economics, family stays, possibility of internships
5) Penn-in-Tours, France (May 27-July 10)
   Courses in language, civilization and art history. Family stays.
6) Penn-in-Freiburg, Germany (July 15-Aug. 21)
   Course in Intermediate German
7) Penn-in-India (June 28-Aug. 9)
   Courses in religion, music, economics, art, history and ayurvedic medicine. Instruction in major languages available. Family stays, community projects, some internships
8) Penn/Bryn Mawr-in-Florence, Italy (June 3-July 12)
   Courses in language, civilization, literature and art history
9) Penn-in-Seoul, Korea (June 14-Aug. 17)
   Courses in economics and history. Internships with Korean and American firms.
10) Penn-in-Warsaw, Poland (June 21-July 30)
    Courses in political science, economics and survival Polish. Internships with American businesses
11) Penn-in-Alicante, Spain (June 25-July 26)
    Courses in language, literature, civilization. Family stays.
    (soc.culture.intercultural)

The third finding of this study reveals a large number of texts in which questions are referred out of the discussion to another resource as
shown in the following excerpts. Libraries and printed texts are often mentioned as sources of further information or as more authoritative sources. Experts with complementary viewpoints can identify one another through the process of discourse. Offers of collaboration on formal publication projects can sometimes result.

Look in the scientific literature under Rich Merritt or check your library for books on the subject of using dead bacteria to kill black-flies. (sci.geo.rivers+lakes)

[To find other articles about this issue, go to the Apache Survival Coalition’s Home Page at URL:http://www.teleport.com/~amt/planetpeace/]

(soc.culture.native)

It’s nice to know that you’re still out there! I was wondering if you might be interested in working together on a journal article for one of the anthropology/sociology/criminology/native studies/journals? I was impressed with your discussion in the past. My time is a bit limited as I’m trying to finish my dissertation, teach an undergraduate class, write a paper for a conference in two weeks, BUT I would be able to contribute something in the near future. Take Care.

(soc.culture.native)

As far as I can tell the people reading this would also be ones that practice responsible techniques where and when ever possible. So who are these people that keep posting reasons why an agricultural crop that was grown up until the 1920’s (and temporarily re-instated during times of war) couldn’t be grown now? (If you want to look up the history of Hemp—All you people who keep writing “Where did these facts come from?” can go to the library and find out that Farmers in Canada are now growing it again because agriculture Canada is interested in it’s potential. I suggest getting to a good library and check out HISTORY and AGRICULTURE not HEMP. If you look up hemp as a topic all you get is the drug mumbo-jumbo and nothing about the industrial crop. Once you have found stuff like the wartime movie put out by the US gov’t called “Hemp for Victory” (encouraging American farmers to grow hemp) you can post back on here and let us all in on where you got your info. (bionet.agroforestry)

this foam may be analogous to the sea surface microlayer, which was the (focus of a fair amount of research in the 70’s and 80’s. a lot of the work was done at the university of Rhode island. there was a review article in scientific American by ferrin macintyre (sp?). this layer (sci.geo.rivers+lakes)

DISCUSSION AND SUGGESTIONS FOR FUTURE STUDY

The three findings from this selected set of texts yields several insights into ways in which the culture of the Internet is challenging epistemological tenets. Knowledge is requested and negotiated over networks without regard to educational credentials, formal or physical settings, or disciplinary affiliation. The nature of the discussions, while not necessarily
scholarly, is often supported in rhetorically credible ways through the citation of authoritative sources. The study of electronic discourse is a valid method for research if it yields understanding of the ways in which knowledge can potentially be generated and shared.

Traditional disciplinary structures do not have the flexibility to address information needs in exactly the same way. Interdisciplinary frameworks within traditional academic architecture have tried to address some of the deficits but, as they have matured, they have become part of the new canon that has been growing since the time of Aristotle. The structures of such factors as economics, time, and place conspire to impede access to knowledge in this model. Even the evolution of the framework of disciplinary structures addresses neither the creative nor information needs of large groups of people. Large numbers of individuals have made the effort to understand the culture and avail themselves of the opportunities they have found in Internet discussion groups.

If the assumption can be made that valuable dialectical exchanges are made in the discourse of the Internet, the questions of storing and retrieving this knowledge are implicit. This is the work for which librarians have been trained. Historians have long been cognizant of the problems inherent in analyzing vast amounts of written and oral texts, time and place as organizing principles, and relating concrete data with generalization and interpretation (McCrank, 1992). Raitt (1994) believes the library community is asking the wrong questions when they worry about the future of libraries and the profession. The findings of this study support his position. He asks:

Does one ask the same question about schools and teachers? Will teachers still be around in thirty years? There are now all kinds of new educational technologies—distance learning, educational games, and interactive learning—and all kinds of teach yourself this or that on CDROM or diskette or tape. But I haven't come across many debates about whether all schools should be closed and whether there is a need for teachers because of it. (p. 275)

New electronic arenas for the generation of information increase the need for meaningful access to that information—increase the need for information professionals and retrieval systems. When the Bibliographic Classification by Bliss was first published in the United States, it was “a time when real doubt and some severe disillusionment concerning classification systems was evident” (Maltby & Gill, 1979, p. 11). Librarians seem to be reliving the same experience of doubt today as they face the complexities of organizing digital information sources, perhaps with some underlying legitimacy. A study of indexing adequacy and interdisciplinary journals (Gerhard et al., 1993) demonstrates that current practices are inadequate in 60 percent of the cases examined.

Several scholars have suggested possible approaches and argued over the desirability of links, indexes, and classification systems (Marchionini, 1994; Liebscher, 1994). Digital information raises questions about more
than just the scenario of online discourse. Images, hypertext, audio, and video texts raise complex issues of storage and retrieval. Keister (1994) has done interesting work on image retrieval utilizing the analysis of user queries. Marchionini (1994) suggests an interdisciplinary approach which involves system designers, indexers, and information scientists. The object-oriented model for networked information (Tsai, 1995; Heaney, 1995) also promises to yield new advances in the organization and retrieval of digital information.

The complexities of digital storage and retrieval problems offer the opportunity for interdisciplinary collaboration. Librarians, information scientists, computer programmers, and other specialists have not been able to offer the solutions independently, but perhaps we can all work together to develop the tools needed to organize and more fully realize the potential of the new knowledge being born in the delivery rooms of the Internet.

REFERENCES


Literature Retrieval for Interdisciplinary Syntheses

HOWARD D. WHITE

ABSTRACT

THIS ARTICLE CONTAINS SUGGESTIONS for retrieval of bibliographic data: (1) by those interested in revealing interdisciplinarity, and (2) by those interested in being interdisciplinary. It is the latter who are most likely to produce interdisciplinary syntheses. Retrieval depends on bibliographic markers of various kinds, some of which divide disciplines. A major bibliographic indicator of interdisciplinarity is occurrence of the same marker on both sides of a disciplinary divide. Bibliographic markers, however, are not reliable for distinguishing lesser kinds of syntheses from high-level integrations of substance. Dialog's RANK command is demonstrated as a means of revealing interdisciplinarity in any field, using various search terms as starting points in LC MARC-Books and the citation databases of the Institute for Scientific Information (ISI). Next discussed are retrieval techniques for persons who are interested in synthesizing work from their own discipline (e.g., library and information science) with work from another discipline. Searchers can begin with authors or subjects from outside their own field and learn how these have been used within it, or they can begin with authors or subjects from within their own field and learn how these have been used outside it. Examples are given for all retrieval techniques. Interspersed are discussions of creativity, the connection of hitherto unconnected literatures, the retrieval and assessment of syntheses, and the nature of library browsing.
INTRODUCTION

A few years ago, in The Handbook of Research Synthesis, this author wrote about retrieving literature for a certain kind of review—the meta-analytic in which the aim is to collect all empirical studies on a topic (even unpublished ones), so that the statistical effects reported in them can be compared and, through new statistical operations, integrated (White, 1994). While demanding of skill and effort, such meta-analyses are not necessarily interdisciplinary in nature—in fact, most probably occur within a single specialty or sub-specialty, in which different researchers have measured similar things again and again. Given the theme of this issue of Library Trends, this discussion will turn to interdisciplinary syntheses, leaving meta-analytic reviews to the earlier piece and to Smith's article in this issue.

Using current online technology, I shall offer some suggestions for retrieval of bibliographic data with two groups in mind: those interested in revealing interdisciplinary—i.e., in tracking and studying it as it already exists—and those interested in creating interdisciplinary—i.e., in incorporating matter from different areas of knowledge in new works of their own. While either group may contain authors doing original work, and either may be served by retrieval specialists such as librarians, the two groups plainly differ. The first take interdisciplinary as the subject of their inquiries (as it is, archetypally, for Klein, 1990) and use bibliographic data as evidence for claims about the nature of interdisciplinary in some particular case. The second group, in contrast, may take anything under the sun as their subject matter; they are simply being interdisciplinary by drawing on authorities from more than one field. For them, bibliographic data are adduced to support claims about the world, in the general scholarly style, rather than serving as evidence of interdisciplinary per se. Their work might be considered as raw data by the first group, who stand in a “meta” relation to them.

Properly speaking, interdisciplinary syntheses are a product of this second group. Although hard to define, such syntheses are easy enough to recognize. An interdisciplinary synthesis might use concepts from one field to describe or explain things of central importance in another (e.g., Harter, 1992; Sandstrom, 1994). Or it might unite parallel but hitherto separate concepts within a new superordinate scheme (e.g., Robertson, 1971). At its best, it might blend concepts from different disciplines so subtly that no mechanistic formula could describe it; it would simply represent a unique fusion of the author's wide-ranging knowledge (e.g., Koestler, 1964; Gardner, 1985; Lakoff, 1987). Whatever the case, it would involve a creative transfer not merely of vocabulary but of a whole frame of mind, so that the subject matter being fused took on a new kind of meaning. Ideally, it would convince the reader that the field providing the frame of mind could not be easily replaced by another one.

Such writings are clearly at the high end of a continuum of integration. Many other writings exhibit certain features of interdisciplinary
without being syntheses in the strong sense just described. To pursue this matter, however, we need a sketch of what constitutes objective evidence of interdisciplinarity in authors' *œuvres* or disciplinary literatures.

**MARKERS OF INTERDISCIPLINARITY**

Literatures are bodies of writings by different authors whose common features are shown by explicit markers. Markers are character strings—usually words, phrases, and numerals—whose meanings, established by convention, are more or less stable over time. Markers may appear in the full texts of writings or in verbal models of writings—that is, in bibliographies, interpreting this term broadly. They include such well-known types as descriptors, subject headings, and keyword noun phrases from natural language.

Disciplinary markers, an important subset, identify writings by the discipline (or field) in which they originate. The names of abstracting and indexing services do this for the articles and papers they cover. Library of Congress or Dewey classification codes, properly interpreted, do it for monographs and serials. Other sets of markers, such as journal titles, article titles, and descriptors, often imply a writing's disciplinary origin without stating it explicitly.

Within this world of literatures and markers, claims about linkages between disciplines—about interdisciplinarity—can be operationally defined. That is, they can be made in such a way that different observers can gather the same evidence on them in the form of classifiable and countable observations. The major indicators of interdisciplinarity along this line are occurrences of the same markers on both sides of a disciplinary divide—especially when these recur and pile up. Such co-occurrences link the disciplines. Crude measures of interdisciplinarity are simply frequency counts of these co-occurrences.

Classification codes do not occur in this way since they are disciplinary divisions—mutually exclusive by design—but other markers do—e.g., authors' names. As one indicator of interdisciplinarity in individual authors, we might note whether any books they have published are classified outside their primary disciplinary fields. Thus, a contributor to this issue of *Library Trends* has published books classified in library and information science, his primary field, and in philosophy, a field in which he was trained. His name is a marker that links their LC classification codes:

```
Z BD
Patrick Wilson Patrick Wilson
```

This could be read as evidence either of Wilson's own interdisciplinarity or, more abstractly, of some degree of commingling of information science
and sociology of knowledge (Wilson, 1977, 1983). Other authors associated with the Z classification who have published books classified in other fields include William S. Cooper (1978) in the P classification and Gerard Salton (1988) in the QA classification. Of course, to establish the extent to which authors are actually commingling fields, we must examine their books. While Wilson, Cooper, and Salton qualify as interdisciplinary synthesizers, not all variegated authors do qualify as such; they may simply be exhibiting diverse interests at different times. The bibliometrician S. C. Bradford published his well-known book on documentation (1948) after one on roses (1946) without synthesizing information science and horticulture.

Possibly the most important interdisciplinary markers are those in which an author in one field cites the work of an author in another, thereby bringing a marker of that work across a disciplinary divide. Porter and Chubin (1985) call these “citations outside category” (COGs). They distinguish two sorts:

1. breadth of citation BY a given article (or journal or research category);
2. breadth of citation TO a given article (or journal or research category).

These may be designated as outgoing and incoming citations respectively. Assume that article $XYZ$ is assigned to a subject category—e.g., economics. It may well cite other works. If so, one may ask, Are any outgoing citations made to works classified in some other discipline—across the border, so to speak? Similarly, one can ask whether any citations incoming to article $XYZ$ are from disciplines outside economics. Instances of either sort are COGs and are explicit indicators of interdisciplinary ties. Explicit interconnections among literatures are strong evidence for the state of interdisciplinarity at any given time. The patterns in which markers co-occur between disciplines are the key (their failure to co-occur may also be meaningful; see Swanson, 1987, 1989).

In the following schema, one can see the play of the markers around article $XYZ$, which is taken as central. The marker for article $ABC$ appears on both sides of a disciplinary divide as an outgoing citation from article $XYZ$. The latter's marker then appears on both sides of a divide as an incoming citation from article $MNO$.

<table>
<thead>
<tr>
<th>Sociology</th>
<th>Economics</th>
<th>Information Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Article $ABC$</td>
<td>Article $XYZ$</td>
<td>Article $MNO$</td>
</tr>
<tr>
<td>$cites$</td>
<td>$cites$</td>
<td>$cites$</td>
</tr>
</tbody>
</table>

Article $ABC$ cites Article $XYZ$.

By declaring some (operationally defined) category as central and then aggregating “citations outside category” across many writings, one can
determine what fields a given literature draws upon and what fields it contributes to—and in what proportions. (Porter and Chubin’s “breadth” adds a rough measure of intellectual distance between fields, such that economics would be further from, for example, chemistry than it is from another social science like sociology.) Over the years, a fair number of authors in information science (e.g., Earle & Vickery, 1969; Nicholas & Ritchie, 1978; Hurd, 1992) have tabulated outgoing and incoming citations to reveal broad patterns of intellectual indebtedness within literatures. Counts of outgoing citations show that some fields (such as economics) draw relatively little on other fields; others draw much. Counts of incoming citations show that some fields (such as library and information science) contribute relatively little to other fields; others contribute much.

Such counts may now be quite easy to obtain—for example, through Dialog’s RANK command—as will be demonstrated below. However, even when interdisciplinary citations are plentiful, they do not necessarily represent integration in the strong sense. One must still inquire into the quality of the interdisciplinarity attained, and it could turn out to be relatively superficial. Some citations might merely be rhetorical grace notes, as when someone in, for example, library and information science (LIS) alludes briefly to ideas of the mathematician Kurt Godel or the philosopher Karl Popper. Some might refer to material from other fields that is used simply as illustration (e.g., the case histories throughout Klein, 1990) or as raw data (e.g., the studies in LIS that treat as data the literatures of other fields such as McCain & Whitney, 1994). Still others might indicate integration only at the level of methodology (e.g., models borrowed from statistics or mathematics) rather than main substance (Meadows [1976] calls such borrowing transdisciplinary as opposed to interdisciplinarity). Since interdisciplinarity admits degrees, the term synthesis will be reserved here for those writings that integrate fields in the strong sense—i.e., at the level of main substance.

Unfortunately, synthesis in this sense is a difficult concept to operationalize through markers. Since all learned writings synthesize to some extent, the relevant task is determining whether the author is working in one disciplinary tradition or more than one. But this is often a complex and subtle matter in which different judges may well reach different conclusions. Occasionally, a work is explicitly revealed as an interdisciplinary synthesis through its title or subtitle (e.g., Koopman & Hunt, 1988), its table of contents, or the blurb on its jacket, but it must often be the case that syntheses that are in fact interdisciplinary are not marked as such in any readily discoverable way, short of reading them (book reviews sometimes reveal it).

Moreover, there seems to be no algorithmic way of differentiating a true interdisciplinary synthesis from a work that is only superficially interdisciplinary, if one uses as markers solely what it cites; the same set of outgoing citations could appear with either. As a result, apparently, one
cannot create a search strategy that reliably breaks out syntheses from nonsyntheses in the citation databases of the Institute for Scientific Information (ISI). One can break out reviews of the literature in these databases by asking for them as a document type (Select DT=Reviews) or by taking them from a publication known to publish reviews. But that is not quite the same thing, since many true syntheses would not be considered reviews by their authors or labeled as such when they appeared. We shall grapple a bit more with this problem in the discussion of retrieval techniques below.

A separate problem, even when a true interdisciplinary synthesis is found, is the degree to which it succeeds. Two major reasons for criticism are: (1) attempting to unite the wrong things, and (2) failing to unite the right things. An example of the first is Heilprin (1989) which, in this author’s opinion, prematurely tries to ground information science in physical systems theory. As an example of the second, failing to unite the right things, Swales (1986) comes to mind. A plausible effort to unite discourse analysis—Swales’s field—with citation analysis nevertheless manages to omit most of the major works in the latter, such as the entire writings of Henry Small. Indeed, a common negative reaction to an attempted synthesis must be that the writer has failed to search the literature adequately or to learn of highly relevant work that should have been taken into account. Probably many people would regard the book Relevance (Sperber & Wilson, 1986) as a successful interdisciplinary synthesis, but Wilks (1982) is frankly contemptuous of an earlier presentation (Sperber & Wilson, 1982) because the authors neglect, in his view, the relevant literature from his field, artificial intelligence (AI). Schank (1995) is another AI researcher’s dismissal of another well-reviewed synthesis, The Emperor’s New Mind (Penrose, 1989).

Since intellectuals read what they want to read and cite what they want to cite, no moralizing about how they ought to have searched the literature is likely to change behavior. But ISI-style citation retrieval may be of help to some in that it may lead to useful criticism of the attempted synthesis. It may also help assess the impact of syntheses already published, as will be shown.

**Revealing Interdisciplinarity**

The motive in revealing interdisciplinarity (as opposed to creating it) is that one is simply trying to learn the degree to which some complex of fields have made use of each other. Typically, one would be studying fields other than one’s own, although that, too, could be studied in this objective way. But, as noted above, one would not be trying to effect a synthesis between one’s own field and others; the fields of interest would be used mainly as data rather than substantively.

There are now several labor-intensive bibliometric analyses scattered through the literature that meet this description. While the genre will continue to attract ambitious scholars (e.g., Neeley, 1981; Rogers & Ander-
son, 1993; McCain, 1994), information specialists and end-users should be aware that there is an easier way to gather intelligence on interdisciplinarity—one that may help both groups "make effective, fast, and light-handed use of unwieldy instruments" (White et al., 1992, p. 246).

In the United States, this way makes use of the software of major online database vendors—i.e., Dialog's RANK command or Orbit's GET command (European vendors have similar commands). In Dialog and Orbit databases, it is now possible to form a set of documents with one kind of indexing term (such as a descriptor or a natural language phrase) and then, through RANK or GET, to display the indexing terms that co-occur with the input term in every record of the retrieved set. At the searcher's option, these co-occurring terms may be the same kind as the input term or a different kind. Depending on the database, they may be descriptors, identifiers, concept codes, LC subject headings, LC classification codes, journal titles, authors' names, and so on—a variety of bibliographic markers. By default they are displayed high to low in order of frequency of co-occurrence; they may also be requested in alphabetical order.

This interconvertibility of terms, discussed in White and McCain (1989, pp. 124-28), has always been possible, but with manual methods it is prohibitively slow in large files. GET- or RANK-type software is a fairly recent innovation in the United States that gives searchers considerable new powers (White, 1990; Snow, 1993). The significance of fast interconvertibility in the present context is that, if one has a term expressing the name of a discipline or a specialty, one can use it to form a set of documents online, display the co-occurring terms, and see which, if any, of them cross disciplinary divides. Large-scale profiles of connections between disciplines and specialties are now perfectly feasible.

To demonstrate, Dialog's RANK command, dating from early 1992, will be featured with a variety of bibliographic markers (Readers will be presumed to know the basics of Dialog retrieval. Dialog outputs used as examples are real but edited). The first example shows a capability that probably has not been much exploited by librarians, to say nothing of end-users. That is to convert one kind of marker, LC classification codes, into another, their associated LC subject headings, in the LC MARC-Books database, which covers books cataloged by the Library of Congress since 1968.

The classification code chosen is GN 365.9, which stands for "Biological determinism. Sociobiology." Sociobiology is itself usually considered an interdisciplinary field. In the following presentation we can see something of its components and also its ties (as perceived by subject catalogers) with fields beyond its usual range of connotation. 2

First we select all documents posted to the classification code (CA). A space is necessary between 365 and .9, and a final truncator (?) is used to eliminate the Cutter numbers of the individual titles:

? SELECT CA=GN 365 .9?
The computer returns in Set 1 the 108 documents that meet this description:

\[ \text{S1 108 CA=GN 365 .9?} \]

We then ask RANK to display the LC subject headings assigned to this set in order of their frequency. The standard Dialog code for subject headings is DE (for "descriptors"), and we ask that they be displayed "continuously" (CONT), one of the available options:

\[ \text{? RANK DE CONT} \]

In the resulting list, "Sociobiology" appears as a subject heading in 104 of the 108 records retrieved; "Social Evolution" occurs in 21, and so on:

<table>
<thead>
<tr>
<th>Rank No.</th>
<th>No. Items</th>
<th>Ranked Term</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>104</td>
<td>1</td>
<td>SOCIOBIOLOGY</td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>2</td>
<td>SOCIAL EVOLUTION</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>3</td>
<td>HUMAN EVOLUTION</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>4</td>
<td>HUMAN BEHAVIOR</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>5</td>
<td>NATURE AND NURTURE</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>6</td>
<td>PHILOSOPHY</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>7</td>
<td>SOCIAL ASPECTS</td>
</tr>
<tr>
<td>8</td>
<td>7</td>
<td>8</td>
<td>SOCIAL BEHAVIOR IN ANIMALS</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
<td>9</td>
<td>CONGRESSES</td>
</tr>
<tr>
<td>10</td>
<td>6</td>
<td>10</td>
<td>MAN</td>
</tr>
<tr>
<td>11</td>
<td>5</td>
<td>11</td>
<td>BEHAVIOR</td>
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<tr>
<td>12</td>
<td>5</td>
<td>12</td>
<td>BEHAVIOR EVOLUTION</td>
</tr>
<tr>
<td>13</td>
<td>5</td>
<td>13</td>
<td>HUMAN BIOLOGY</td>
</tr>
<tr>
<td>14</td>
<td>5</td>
<td>14</td>
<td>PRIMATES</td>
</tr>
<tr>
<td>15</td>
<td>5</td>
<td>15</td>
<td>SOCIAL DARWINISM</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>16</td>
<td>ADDRESSES, ESSAYS, LECTURES</td>
</tr>
<tr>
<td>17</td>
<td>4</td>
<td>17</td>
<td>BIOLOGY</td>
</tr>
<tr>
<td>18</td>
<td>4</td>
<td>18</td>
<td>CULTURE</td>
</tr>
<tr>
<td>19</td>
<td>4</td>
<td>19</td>
<td>EVOLUTION</td>
</tr>
<tr>
<td>20</td>
<td>4</td>
<td>20</td>
<td>GENETIC PSYCHOLOGY</td>
</tr>
<tr>
<td>21</td>
<td>4</td>
<td>21</td>
<td>SOCIAL POLICY</td>
</tr>
<tr>
<td>22</td>
<td>4</td>
<td>22</td>
<td>SOCIAL STRUCTURE</td>
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<tr>
<td>23</td>
<td>3</td>
<td>23</td>
<td>ANIMAL NATURE</td>
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<tr>
<td>24</td>
<td>3</td>
<td>24</td>
<td>ANTHROPOLOGY</td>
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<tr>
<td>25</td>
<td>3</td>
<td>25</td>
<td>BRAIN</td>
</tr>
<tr>
<td>26</td>
<td>3</td>
<td>26</td>
<td>COGNITION AND CULTURE</td>
</tr>
<tr>
<td>27</td>
<td>3</td>
<td>27</td>
<td>OPTIMISM</td>
</tr>
<tr>
<td>28</td>
<td>3</td>
<td>28</td>
<td>POWER (SOCIAL SCIENCES)</td>
</tr>
<tr>
<td>29</td>
<td>3</td>
<td>29</td>
<td>PSYCHOLOGY, COMPARATIVE</td>
</tr>
<tr>
<td>30</td>
<td>3</td>
<td>30</td>
<td>SOCIAL SCIENCES</td>
</tr>
<tr>
<td>31</td>
<td>2</td>
<td>31</td>
<td>EQUALITY</td>
</tr>
<tr>
<td>32</td>
<td>2</td>
<td>32</td>
<td>HUMAN POPULATION GENETICS</td>
</tr>
<tr>
<td>33</td>
<td>2</td>
<td>33</td>
<td>NATURE AND NURTURE</td>
</tr>
<tr>
<td>34</td>
<td>2</td>
<td>34</td>
<td>PHILOSOPHICAL ANTHROPOLOGY</td>
</tr>
<tr>
<td>35</td>
<td>2</td>
<td>35</td>
<td>RACE</td>
</tr>
<tr>
<td>36</td>
<td>2</td>
<td>36</td>
<td>SCIENCE</td>
</tr>
<tr>
<td>37</td>
<td>2</td>
<td>37</td>
<td>SEX</td>
</tr>
<tr>
<td>38</td>
<td>2</td>
<td>38</td>
<td>SEX DIFFERENCES</td>
</tr>
<tr>
<td>39</td>
<td>2</td>
<td>39</td>
<td>SOCIAL PSYCHOLOGY</td>
</tr>
<tr>
<td>40</td>
<td>2</td>
<td>40</td>
<td>SOCIAL VALUES</td>
</tr>
<tr>
<td>41</td>
<td>2</td>
<td>41</td>
<td>SOCIOLOGY</td>
</tr>
</tbody>
</table>
The process of generating such lists from an input term vaguely resembles breaking forms of radiation into spectra, though these "literature spectra" change over time, unlike those in nature. Once they are more or less settled, however, they are both distinctive and informative.

The lists can be hundreds of items long, especially if one includes the items that occur only once. Therefore, the one above has been limited to subject headings that appear in at least two records. There are slight distractions: "Nature and Nurture" is ranked in two places because of a typo, and some terms, such as "Social Aspects" and "Congresses," are not subject headings but "dash-on" subdivisions. Nevertheless, the list clearly gives leads for tracking different manifestations of subjects within class GN 365.9. For example, one can distinguish writings on human beings and on other animals. One can infer different specialty shadings within sociobiology such as "Brain" or "Sex Differences." And one can look for interdisciplinary crossings of interest, such as the four titles linked to "Genetic Psychology" or the three titles linked to "Anthropology."

The software permits one to save all connections by their rank numbers. However, when they reappear as sets in their own right, they are no longer combined with (ANDed with) the input term. Thus, if one wanted to retrieve the 12 titles linking GN 365.9 with "Philosophy," the simplest way would be to enter:

SELECT CA=365.9? AND DE=PHILOSOPHY

and then display the titles in the resulting set. Whether one would get high-level syntheses in this retrieval is uncertain, of course, but at least one would have a plausible group of works to browse.

In LC MARC-Books, it is also possible to run the above operation in reverse—that is, to start with an LC subject heading (DE) and then to rank all the LC classification and Dewey codes (CA) that co-occur with it:

? SELECT SOCIOBIOLOGY/DE  
S2 285 SOCIOBIOLOGY/DE  
? RANK CA CONT

The ten most frequently occurring class codes follow. Note that LC and Dewey class codes are mixed in the ranking.

<table>
<thead>
<tr>
<th>Rank No.</th>
<th>No. Items Ranked</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>104</td>
<td>GN 365</td>
</tr>
<tr>
<td>2</td>
<td>103</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>87</td>
<td>304</td>
</tr>
<tr>
<td>4</td>
<td>77</td>
<td>304.5</td>
</tr>
<tr>
<td>5</td>
<td>22</td>
<td>306</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
<td>301</td>
</tr>
<tr>
<td>7</td>
<td>15</td>
<td>155</td>
</tr>
<tr>
<td>8</td>
<td>14</td>
<td>HM 106</td>
</tr>
<tr>
<td>9</td>
<td>14</td>
<td>301.2</td>
</tr>
<tr>
<td>10</td>
<td>14</td>
<td>305</td>
</tr>
</tbody>
</table>
Starting from class numbers (or ranges) or subject headings, librarians could use these capabilities to analyze interdisciplinary aspects of their collections. They could also employ the same means to help end-users find interdisciplinary monographs.

LC MARC-Books is a very valuable database for investigations of this kind because of its universal coverage of subject matter. Comparably valuable for the journal literature are the citation databases of the Institute for Scientific Information. In the next example, ISI's Social Scisearch is used to analyze the subject areas penetrated by articles in behavioral ecology. The input terms were:

\texttt{SELECT BEHAVIORAL(W)ECOLOGY OR BEHAVIOURAL(W)ECOLOGY OR BEHAVIOR?(2N)ECOLOG?}

This produced a retrieval of 295 articles after duplicates were removed. These were ranked by their subject categories (SC) using the "Continuous" option:

\texttt{RANK SC CONT}

The result is a very clear display of the interdisciplinary nature of behavioral ecology. The ranked subject codes are actually applied by ISI to the journals in which the articles appear. Anthropological journals top the list, but articles in psychology journals are in fact more numerous if all types of psychology are considered. As noted above, RANK can present listings alphabetically if that is needed to make subjects easier to find. And, again, sets may be saved by their rank numbers for further processing.

<table>
<thead>
<tr>
<th>Rank No.</th>
<th>No. Items Ranked</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
<td>ANTHROPOLOGY</td>
</tr>
<tr>
<td>2</td>
<td>49</td>
<td>PSYCHOLOGY</td>
</tr>
<tr>
<td>3</td>
<td>47</td>
<td>ZOOLOGY</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>BEHAVIORAL SCIENCES</td>
</tr>
<tr>
<td>5</td>
<td>33</td>
<td>BIOLOGY, MISCELLANEOUS</td>
</tr>
<tr>
<td>6</td>
<td>17</td>
<td>SOCIOLOGY</td>
</tr>
<tr>
<td>7</td>
<td>16</td>
<td>MULTIDISCIPLINARY SCIENCES</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>ENVIRONMENTAL STUDIES</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>PSYCHOLOGY, CLINICAL</td>
</tr>
<tr>
<td>10</td>
<td>9</td>
<td>ECOLOGY</td>
</tr>
<tr>
<td>11</td>
<td>9</td>
<td>SOCIAL SCIENCES, BIOMEDICAL</td>
</tr>
<tr>
<td>12</td>
<td>7</td>
<td>PSYCHOLOGY, EDUCATIONAL</td>
</tr>
<tr>
<td>13</td>
<td>7</td>
<td>PSYCHOLOGY, EXPERIMENTAL</td>
</tr>
<tr>
<td>14</td>
<td>7</td>
<td>PSYCHOLOGY, SOCIAL</td>
</tr>
<tr>
<td>15</td>
<td>6</td>
<td>ARTS &amp; HUMANITIES, GENERAL</td>
</tr>
<tr>
<td>16</td>
<td>6</td>
<td>GENETICS &amp; HEREDITY</td>
</tr>
<tr>
<td>17</td>
<td>6</td>
<td>PSYCHOLOGY, DEVELOPMENTAL</td>
</tr>
<tr>
<td>18</td>
<td>6</td>
<td>PUBLIC HEALTH</td>
</tr>
<tr>
<td>19</td>
<td>5</td>
<td>DEMOGRAPHY</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>PSYCHIATRY</td>
</tr>
<tr>
<td>21</td>
<td>5</td>
<td>SOCIAL SCIENCES, INTERDISCIPLINARY</td>
</tr>
<tr>
<td>22</td>
<td>4</td>
<td>ARCHAEOLOGY</td>
</tr>
</tbody>
</table>
The same set of 295 articles can be analyzed on the basis of journals in which they appear. To produce the following list we simply ask for the journal names (JN):

? RANK JN CONT

Out of 170 journals, only those containing at least three articles are shown. The diversity of fields is still clearly evident:

<table>
<thead>
<tr>
<th>Rank</th>
<th>No.</th>
<th>No. Items</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>ANIMAL BEHAVIOUR</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>AMERICAN ANTHROPOLOGIST</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>CONTEMPORARY PSYCHOLOGY</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>ETHOLOGY AND SOCIOBIOLOGY</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>JOURNAL OF HUMAN EVOLUTION</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>HOMO</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>ETHOLOGY</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>JOURNAL OF SCHOOL PSYCHOLOGY</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>TRENDS IN ECOLOGY &amp; EVOLUTION</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>BEHAVIORAL AND BRAIN SCIENCES</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>HUMAN ECOLOGY</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>3</td>
<td>JOURNAL OF ANTHROPOLOGICAL RESEARCH</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>3</td>
<td>JOURNAL OF ENVIRONMENTAL PSYCHOLOGY</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>3</td>
<td>NATURE</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>3</td>
<td>POLITICS AND THE LIFE SCIENCES</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>3</td>
<td>PSYCHOLOGICAL RECORD</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>3</td>
<td>SCIENCE</td>
<td></td>
</tr>
</tbody>
</table>
The point in producing this latter list is that, in some cases, a librarian or end-user might be interested not only in interdisciplinary linkages but also in the particular journal in which a linkage manifests itself. To such a person, a lead to, for example, the *Journal of School Psychology* might be more useful in deciding whether to pursue a retrieval than a broad subject category like "Psychology, Educational."

Thus far, the input terms have named broad fields of learning—sociobiology and behavioral ecology. But more specialized areas of research can also be analyzed with the RANK command. The next analysis, conducted a few years ago in Medline (File 155), began with the formation of a set of writings on pregnancy, schizophrenia, and low birth weight:

? SELECT PREGNANCY AND SCHIZOPHRENIA AND WEIGHT

Forty records were retrieved and their descriptors ranked. Only terms occurring at least five times in the set are listed below. As an idiosyncrasy of Medline, the abbreviations for standard descriptor subdivisions (such as GE for "Genetics" and CO for "Complications") show up as separate terms; they may be disregarded. Of primary interest are the pointers to different disciplinary components of this literature. The medical, the genetic, the psychological, and the epidemiological are all represented for retrieval:

<table>
<thead>
<tr>
<th>Rank No.</th>
<th>No. Items Ranked</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>36</td>
<td>PREGNANCY</td>
</tr>
<tr>
<td>2</td>
<td>34</td>
<td>SCHIZOPHRENIA</td>
</tr>
<tr>
<td>3</td>
<td>27</td>
<td>BIRTH WEIGHT</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td>GE</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>GENETICS</td>
</tr>
<tr>
<td>6</td>
<td>21</td>
<td>INFANT, NEWBORN</td>
</tr>
<tr>
<td>7</td>
<td>21</td>
<td>SCHIZOPHRENIA-GENETICS-GE</td>
</tr>
<tr>
<td>8</td>
<td>20</td>
<td>ADULT</td>
</tr>
<tr>
<td>9</td>
<td>18</td>
<td>PREGNANCY COMPLICATIONS</td>
</tr>
<tr>
<td>10</td>
<td>16</td>
<td>ET</td>
</tr>
<tr>
<td>11</td>
<td>16</td>
<td>ETIOLOGY</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>CO</td>
</tr>
<tr>
<td>13</td>
<td>12</td>
<td>COMPLICATIONS</td>
</tr>
<tr>
<td>14</td>
<td>12</td>
<td>LABOR COMPLICATIONS</td>
</tr>
<tr>
<td>15</td>
<td>11</td>
<td>ADOLESCENCE</td>
</tr>
<tr>
<td>16</td>
<td>11</td>
<td>DISEASES IN TWINS</td>
</tr>
<tr>
<td>17</td>
<td>11</td>
<td>SCHIZOPHRENIA-ETIOLOGY-ET</td>
</tr>
<tr>
<td>18</td>
<td>11</td>
<td>SCHIZOPHRENIC PSYCHOLOGY</td>
</tr>
<tr>
<td>19</td>
<td>9</td>
<td>CHILD</td>
</tr>
<tr>
<td>20</td>
<td>8</td>
<td>DI</td>
</tr>
<tr>
<td>21</td>
<td>8</td>
<td>DIAGNOSIS</td>
</tr>
<tr>
<td>22</td>
<td>8</td>
<td>INFANT</td>
</tr>
<tr>
<td>23</td>
<td>8</td>
<td>PSYCHOLOGY</td>
</tr>
<tr>
<td>24</td>
<td>8</td>
<td>PX</td>
</tr>
<tr>
<td>25</td>
<td>7</td>
<td>CHILD DEVELOPMENT</td>
</tr>
<tr>
<td>26</td>
<td>7</td>
<td>SCHIZOPHRENIA-DIAGNOSIS-DI</td>
</tr>
<tr>
<td>27</td>
<td>6</td>
<td>INFANT, LOW BIRTH WEIGHT</td>
</tr>
</tbody>
</table>
At this point someone might wonder why searchers would not simply "cut to the chase" with terms stating what they want rather than exploring term co-occurrences with RANK. The answer is that, while it is relatively hard to think of—or look up in thesauri—the various terms in which one might need to express an interest, it is relatively easy to recognize terms once one sees them in displays like those shown above. What one sees, moreover, is the correct form of a term for searching as opposed to plausible variants of it (e.g., "Schizophrenia, Childhood," rather than, say, "Schizophrenia in Children"). One can also make use of their associated postings counts in deciding on next steps. In effect, the RANK command presents one with a customized guide to terms—a product all the more valuable because it is based not on the meanings and paradigmatic relationships of the terms as found in thesauri but on their syntagmatic connections in the literature. Those connections assure one that there are writings on the connected topics to be retrieved, even if their worth is still uncertain.

As a final example, consider the following guide to terms for an applied field that is highly interdisciplinary—human-computer interaction (HCI). This field was not defined by a single descriptor or natural-language phrase. Instead, it was defined as consisting of the literature in seven journals. The seven were chosen by a Drexel colleague, Gary W. Strong, who, under National Science Foundation sponsorship, had both teaching and research interests in HCI. In December 1993, we retrieved all the articles in these journals covered in the INSPEC database. The counts are as follows:

<table>
<thead>
<tr>
<th>No. of Articles</th>
<th>Journal Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,081</td>
<td>INTERNATIONAL JOURNAL OF MAN-MACHINE STUDIES</td>
</tr>
<tr>
<td>347</td>
<td>BEHAVIOUR AND INFORMATION TECHNOLOGY</td>
</tr>
<tr>
<td>64</td>
<td>HUMAN-COMPUTER INTERACTIONS</td>
</tr>
<tr>
<td>104</td>
<td>INTERACTING WITH COMPUTERS</td>
</tr>
<tr>
<td>71</td>
<td>ACM TRANSACTIONS ON INFORMATION SYSTEMS</td>
</tr>
<tr>
<td>245</td>
<td>HUMAN FACTORS</td>
</tr>
<tr>
<td>428</td>
<td>ACM SIGCHI BULLETIN</td>
</tr>
<tr>
<td>2,340</td>
<td></td>
</tr>
</tbody>
</table>

We then rank-ordered the descriptors in the 2,340-article set by frequency of occurrence. There were 698 different descriptors—far too
many to present here. The top twenty-five are given so as to indicate major ramifications of the field. They are a mixture of disciplines, specialties, and applications, exhibiting considerable diversity (ironically, a National Science Foundation official who saw the top 100 found them *not* diverse enough, but then he wanted to expand the empire for HCI studies).

<table>
<thead>
<tr>
<th>Rank No.</th>
<th>No. Items Ranked</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>768</td>
<td>USER INTERFACES</td>
</tr>
<tr>
<td>2</td>
<td>756</td>
<td>HUMAN FACTORS</td>
</tr>
<tr>
<td>3</td>
<td>226</td>
<td>INTERACTIVE SYSTEMS</td>
</tr>
<tr>
<td>4</td>
<td>218</td>
<td>MAN-MACHINE SYSTEMS</td>
</tr>
<tr>
<td>5</td>
<td>157</td>
<td>EXPERT SYSTEMS</td>
</tr>
<tr>
<td>6</td>
<td>125</td>
<td>PSYCHOLOGY</td>
</tr>
<tr>
<td>7</td>
<td>114</td>
<td>COMPUTER GRAPHICS</td>
</tr>
<tr>
<td>8</td>
<td>95</td>
<td>COMPUTER AIDED INSTRUCTION</td>
</tr>
<tr>
<td>9</td>
<td>95</td>
<td>SYSTEMS ANALYSIS</td>
</tr>
<tr>
<td>10</td>
<td>94</td>
<td>ARTIFICIAL INTELLIGENCE</td>
</tr>
<tr>
<td>11</td>
<td>82</td>
<td>KNOWLEDGE ENGINEERING</td>
</tr>
<tr>
<td>12</td>
<td>79</td>
<td>KNOWLEDGE BASED SYSTEMS</td>
</tr>
<tr>
<td>13</td>
<td>75</td>
<td>HYPERMEDIA</td>
</tr>
<tr>
<td>14</td>
<td>75</td>
<td>SOFTWARE ENGINEERING</td>
</tr>
<tr>
<td>15</td>
<td>73</td>
<td>INFORMATION RETRIEVAL</td>
</tr>
<tr>
<td>16</td>
<td>71</td>
<td>NATURAL LANGUAGES</td>
</tr>
<tr>
<td>17</td>
<td>70</td>
<td>SOCIAL ASPECTS OF AUTOMATION</td>
</tr>
<tr>
<td>18</td>
<td>70</td>
<td>TRAINING</td>
</tr>
<tr>
<td>19</td>
<td>68</td>
<td>PROGRAMMING</td>
</tr>
<tr>
<td>20</td>
<td>66</td>
<td>ERGONOMICS</td>
</tr>
<tr>
<td>21</td>
<td>61</td>
<td>BEHAVIOURAL SCIENCES</td>
</tr>
<tr>
<td>22</td>
<td>61</td>
<td>WORD PROCESSING</td>
</tr>
<tr>
<td>23</td>
<td>56</td>
<td>COMPUTER SCIENCE EDUCATION</td>
</tr>
<tr>
<td>24</td>
<td>55</td>
<td>KNOWLEDGE ACQUISITION</td>
</tr>
<tr>
<td>25</td>
<td>54</td>
<td>DATABASE MANAGEMENT SYSTEMS</td>
</tr>
</tbody>
</table>

In bibliometrics, the next step in understanding human-computer interaction might be to map it in two or more dimensions based on co-occurrence data for each of these terms with every other term on the list. This is now a specialty at several institutions (White & McCain, 1989), but it is still labor-intensive. If the HCI data were partitioned by, for example, five-year periods, it would be possible to track changes in the field over time.

**Creating Interdisciplinarity**

All the techniques someone might use to reveal interdisciplinarity can also be used by someone who wants to create it. The main difference is that the latter searcher will include his or her own discipline in the synthesis. Probably few readers of *Library Trends* are trained in the fields used in the illustrations above (except, perhaps, human-computer interaction). Nor is this author so trained, but that did not prevent me from rapidly gathering data on them, and it would not prevent others, whatever their backgrounds, from doing the same. However, in the illustra-
tions to come, it will be assumed that the substantive field I share with most readers of *Library Trends* is library and information science. The LIS literature is home ground, in other words, and our interest lies in assimilating relevant work from other disciplines (we can reveal, but scarcely influence, other disciplines' use of LIS). Moreover, the center for investigations of this kind is not merely a home discipline but one's own reading and thought—a set of specific ideas on what may be synthesized—and that should help to narrow the focus of online inquiries.

Until those ideas are present, of course, there is little firm advice on retrieval to give. To meta-analysts of the sort discussed in White (1994), one can say, *Increase recall*, on the hunch—probably justified—that their means for doing so are not yet exhausted. But to the researcher who would be interdisciplinary, one can say only, *Read outside your field and make connections*, which leaves open so many possibilities as to be inane. One is really saying, *Be creative*—advice that the creative do not need and the uncreative cannot take. The essence of individual creativity lies in what Arthur Koestler (1964) called “bisociation,” the productive association of ideas hitherto unconnected, and that “Eureka” experience is precisely what no adviser can guarantee.

This uncertainty extends to the disciplinary provenance of the ideas. From any disciplinary vantage point, some fields are always easier to connect than others (LIS and text linguistics, yes; LIS and cosmology, no). But the creative rarely begin by wanting to integrate specific fields as a main object; they are simply struck by something usable from another literature—perhaps one they have already read. From there, if they want to go beyond writings immediately at hand, they can simply follow leads through the usual strategies—i.e., consultation of other people, searching in subject indexes, forward or backward citation chasing, or browsing (Wilson, 1992b, White, 1994). Whether their subsequent reading stays within or crosses disciplinary lines is usually of little concern. Also of little concern are what lines they cross as long as they keep up their intellectual momentum.

Whatever the scope of their search, however, they must have some sense of what they are looking for. Even if merely browsing, they must be able to recognize clues, and this presupposes a definite, but highly individualized, motive that shapes their powers of recognition. Creativity in connecting ideas cannot be divorced from personal emotions. Feelings like love or rivalry or fear of pain, arising from very specific circumstances, are needed to teach the mind what to seek.

These forces may be seen at their most dramatic in the movie *Lorenzo's Oil*, where the incurable illness of a beloved child leads his parents, Augusto and Michaela Odone, not only to medical writings they would otherwise never have known, but also to a scientific breakthrough, a dietary therapy, based on a kind of oil, for adrenoleukodystrophy (Odone
et al., 1994). Biographical detail is lacking, but they may also underlie Don R. Swanson's series of breakthroughs in connecting hitherto unconnected medical literatures for therapeutic ends (Swanson, 1990) (by odd coincidence, the first of Swanson's therapies also involves dietary use of an oil, in this case a fish oil, to treat Raynaud's syndrome). While knowing something of online searching, this author could never have made the discoveries that the Odones or Swanson made, because nothing in my own situation would have led to seeing what they saw in various scientific literatures even if I had looked where they looked. Only persons schooled by a specific problem, it seems, are sufficiently motivated to distinguish and interpret clues at the forefront of knowledge, and such fortunate conjunctions of persons and clues are rare. This implies that creativity, whether disciplinary or interdisciplinary, cannot be reduced to algorithms that anyone can carry out, despite impressive recent work in that direction (Swanson, 1993; Beghtol, 1995; Gordon & Lindsay, 1996). The literatures are always there to connect, the fruitful linkages always potentially exist, but the persons who can actually make the connections, even with computer assistance, are not interchangeable, though there may be more than one.

The point needs emphasis because, as we have seen, present online technology allows us to reveal interdisciplinarity—to examine its components or to track its development—as never before. Researchers who want to measure it objectively may now be able to support their claims with bibliographic data both specific and broad-based, and they can reduce the necessary data-gathering steps to something like algorithms. But that is not the same as a technology that allows one to be interdisciplinary in the sense of successfully synthesizing ideas from different literatures. At most, the technology now available for studying the interdisciplinarity of any field can also be marshaled on the prospective synthesist's own behalf, perhaps to test whether any other writer has thought in a similar vein.

To answer questions like, *Have any of my ideas been anticipated? Is there any predecessor on whose work I can build?* the best resources are the citation databases of ISI. Not only do these databases cover the full range of learning, enabling one to branch out in multidisciplinary fashion; they also allow one to check the citation records of particular authors and works. The latter helps those who are prompted to synthesis by works they already know—those who have already attained a certain level of cross-disciplinary literacy.

Many creative persons, of course, care little about reading in other disciplines; they may regard literature searches in general as roadblocks to the flow of their ideas (if necessary, they will put in the citations to others after their own work is written). But assuming one is engaged by an author from another field and wants to move toward synthesis, the
fundamental literature-searching operation in the ISI databases is to declare one's own field with a subject category (SC) label and then to see whether the author of interest has been cited within it. The object is to discover colleagues in one's own field who may have already used this author, because their work, too, should be considered for incorporation. They are the ones who may have already laid claim to ideas or upon whose work one should build. They and other disciplinary colleagues are also likely to be the synthesist's most critical readers.

Finding Writings in LIS

One's ideas begin to show in picking the cited author (CA). (In LC MARC-Books, CA has a different meaning—LC and Dewey classification codes.) Take, for example, a search in Social Scisearch:

? SELECT SC=LIBRARY AND CA=PHILLIPS M

The full SC alluded to is "Information Science and Library Science," but "Library" or "Info?" is sufficient. With "CA=Phillips M" I am asking for all articles in Social Scisearch that cite anyone named Phillips whose first initial is M (ISI allows only surnames and initials in searching). With the ANDed combination, I am asking for any writings in LIS that cite anything by Martin Phillips, a British text linguist, whose work I found through browsing. Phillips (1985) used the computer to map words that co-occur in "text windows" in the chapters of books of various kinds, including scientific textbooks, and his revelation of hidden structure seems obviously relevant to segments of LIS such as co-word analysis and automatic indexing. The search is rather imprecise and produces some false drops, because more than one "M Phillips" is cited even in a relatively small field like LIS. But it does show that Phillips (1985) has been incorporated into LIS research by R. M. Losee and S. W. Haas at the University of North Carolina. A similar search on another British text linguist, Michael Hoey, shows that his book, too (Hoey, 1983) has been used by researchers in LIS, notably by Timothy Craven at the University of Western Ontario.

For precision's sake, it would have been better in these two cases to search on cited works (CW) rather than cited authors (CA). However, to do that kind of search properly, one must know not only the titles of the cited works but also the ways in which the titles are abbreviated by ISI. In the case of Phillips (1985), one would enter:

? SELECT SC=LIBRARY AND CW=ASPECTS TEXT STRUCTU

Often a given work has more than one abbreviation in the ISI databases, and so it is wise to consult the CW index (with an Expand command) before forming sets. If one lacks the title (or the patience to track it down), a cruder search by cited author's name, like those above, may be
the only recourse. Searches by author bring up the citation record of a total *oeuvre* as opposed to that of a particular work.

The most valuable index for this type of investigation may be the one that gives cited references (CR) in full:

\[ \text{EXPAND CR = some work} \]

The CR index allows one to check for different forms of cited authors’ names, different forms of the title of cited works (including journal titles), erroneous entries, and so on. But one must browse this index for quite some time to learn its structure. The inconsistent practices of academic citers and ISI data entry persons give it a number of idiosyncrasies that affect searching. To examine the citations to Hoey (1983), one might enter:

\[ \text{EXPAND CR=HOEY M, 1983} \]

Its ISI-abbreviated title as a cited work is “Surface Discourse,” but one would very likely not know that in advance.

In examining various online indexes, such as those for cited authors, cited works, and cited references, it is usually desirable to combine ISI databases through Dialog’s OneSearch capability. This makes use of ISI’s full multidisciplinary potential. Essentially, one wants to see citations to authors in various journals. But the journals of a discipline may be split between ISI databases. For example, Social Scisearch covers most of the journals in LIS, but some are covered only by Scisearch. The latter will be left out of a search that does not combine both databases (when journals are covered by both, duplicate retrievals can be eliminated with Dialog’s Remove Duplicates command). And even when the journals of a field are not split between ISI databases, an author’s citation record may span more than one database. Nonduplicate citations to some authors appear in all three of ISI’s databases—Scisearch, Social Scisearch, and Arts & Humanities Search. Noam Chomsky would be a notable example.

As a potential synthesist, I am interested mainly in the citation records of some authors in linguistics and cognitive science. These fields are generally thought to overlap with LIS, and so the chances that one will find connections are not remote. One might believe, for example, that work by cognitive theorists such as Eleanor Rosch, George Lakoff, Paul Grice, Teun A. van Dijk, or Dan Sperber and Deirdre Wilson can shed light on certain parts of LIS. The goal thus becomes to learn the uses to which their writings have been put. More than once I have used the strategies given here to discover the impact of these authors. They have in fact been cited in various LIS journals, but one cannot point to much in the way of genuine synthesis. An exception is Harter (1992), which
brings Sperber and Wilson's (1986) relevance theory into LIS for discussion and debate.

This is to approach interdisciplinarity through known authors and works. A variant strategy for those who know authors is cocited author retrieval (White, 1986). The names Eleanor Rosch and George Lakoff, for example, jointly imply work on human categorization, especially prototype theory. To seek writings in LIS that cite them jointly, enter:

? SELECT SC=LIBRARY AND CA=ROSCHE AND CA=LAKOFF

One can also confine the search to particular cocited works—for example, to anything that cited both Sperber and Wilson (1986) and Harter (1992).

To connote a complex subject area, multiple pairings of cocited authors or cocited works can be used. This seems a possible approach to the problem, mentioned earlier, of retrieving syntheses algorithmically. Recall that, although reviews can be broken out in ISI databases by selecting them as a document type:

? SELECT DT=REVIEWS

there is no corresponding way to break out syntheses. However, if one created a profile of authors or works from different disciplines and then retrieved documents in which those authors or works were multiply cocited, that might occasionally turn up syntheses. This strategy is discussed as “combination of all possible pairs” in White (1986, pp. 95-96).

Those in LIS not attracted to these fancier strategies should recall that they can explore interdisciplinarity through ordinary subject searching. For example, some years ago a follow-up on the use of the word “Categorization” in LIS produced sixteen documents in Social Scisearch:

? SELECT CATEGORIZATION AND SC=LIBRARY

whereas a similar search on “Prototype(w)Theory” produced nothing, suggesting that prototype theory had not penetrated LIS at that time.

Again, after the union of “Text(w)Linguistics” with “Discourse(w)Analysis” produced a 284-document set in Social Scisearch, the command

? RANK SC CONT DETAIL

resulted in the following list, in which the top fifteen ranks are shown. Note that “Detail” in the command causes fuller data to be presented: the total number of items in the file with the various SC codes, and the percentage of ranked items, out of 284, that would be retrieved if a particular SC were ANDeed into the set.
At Rank 11, we see that seven articles linked to text linguistics or discourse analysis would be retrieved from LIS journals.

**Finding Writings Outside LIS**

In the previous section, the examples were aimed at helping one learn the extent to which writings associated with other disciplines have been used within LIS. In language introduced earlier, we have been looking for LIS writings that send outgoing citations to other fields. We know the identities of these other fields in advance; we can characterize them by authors, works, or subject terms. It is the LIS writings that are unknown but desired, and the examples show different ways of calling them up.

This is not to imply that the synthesist will want to call up only these writings; obviously that could be foolishly parochial. Useful writings are useful writings, whatever field they come from. But someone in LIS would not want to miss LIS writings, even if only to reject them as being off target.

The other fundamental operation for literature synthesists is to start with a known work or subject term or author's oeuvre in the home discipline, here LIS, and then to learn the extent to which it has penetrated other fields. Technically, this means looking for incoming citations to LIS. However, it may be clearer to say that it is now the writings outside LIS that are unknown but desired.

In Scisearch (alone among ISI databases) there is a relatively new means of using known authors or works to search outside one’s field. That is the use of research fronts (RF). They appear in Scisearch as one of the indexing fields on a full bibliographic record and may be thought of as a special kind of subject indexing. Following is a research front from LIS, taken from the record for Richards (1984), which, of course, must already have been retrieved:

Research Fronts: 85-0608 004  (INFORMATION RETRIEVAL SYSTEMS AND USE OF CITATION ANALYSIS TO ASSESS THE IMPACT OF JOURNALS AND RESEARCH)
This means that Richards cites into a cluster of documents numbered 85-0608 and labeled (or subject-indexed) as shown by ISI. The clusters comprise earlier documents that have been repeatedly cocited (above some threshold) by later documents—evidence that both groups are related in subject matter. The "004" means that Richards actually cites four documents in the cluster. The identity of the cited documents in RF clusters is not revealed by ISI, but all the citing documents that create the cluster—the so-called "research front"—can be retrieved. For example:

\[ \text{SELECT RF=85-0608} \]

would retrieve all the articles citing at least one document in that cluster. Since this often leads to a somewhat miscellaneous assortment of articles, it is definitely a way to transcend disciplinary lines, and it may bring serendipitous retrievals.

If the research-front method of searching seems too indirect, one can be more straightforward. Suppose one wants to know how Don R. Swanson's work has been used outside LIS. He is indeed cited in medical and pharmaceutical journals, but most of those journals are covered only in Scisearch. Thus, to explore interdisciplinarity in his case, one should combine Social Scisearch, where much of his citation record will appear, with Scisearch, which may contain the most important information for a synthesis.

A further complication in this case is that more than one "Swanson DR" is cited in learned journals, and so one must try to extract citations to the "right" Swanson, the information scientist at the University of Chicago, by building up sets from the Cited Reference index (this is also a problem with many other authors having non-unique surnames and initials—e.g., William S. Cooper or Howard D. White). I cannot guarantee I have formed exactly the right final set, but, such as it is, it contains 390 citations (CRs), from journals whose Subject Categories (SCs) appear as follows when ranked (the top eight only are given):

<table>
<thead>
<tr>
<th>Rank</th>
<th>No. Items</th>
<th>Ranked Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>249</td>
<td>INFORMATION SCIENCE &amp; LIBRARY SCIENCE</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>PSYCHIATRY</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
<td>COMPUTER APPLICATIONS &amp; CYBERNETICS</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>CARDIOVASCULAR SYSTEM</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>PHARMACOLOGY &amp; PHARMACY</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>MEDICINE, GENERAL &amp; INTERNAL</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>NEUROSCIENCES</td>
</tr>
<tr>
<td>8</td>
<td>7</td>
<td>MEDICINE, RESEARCH &amp; EXPERIMENTAL</td>
</tr>
</tbody>
</table>

Swanson's record of acknowledgment outside LIS is extraordinary, and of course it is precisely the articles from medical literatures implied by this list that one would want to retrieve and consider for a synthesis. A
synthesist might also be interested in ranking other data from the 390-item set—the authors who cite Swanson, their journals, and so on. Naturally, the simplest way to get the full range of articles citing Swanson would be simply to print out their bibliographic records, but RANK provides a way of quickly displaying their features in informative "views." Occasionally, such a capability might prompt one to focus on subsets of the total set that would otherwise be overlooked.

It should be clear by now that we have a fairly reliable means of learning the impact of a particular author or work on other fields. As a general means of evaluating an author or work, citation counts are well known and widely used. But current online technology also allows us to count "citations outside category" more readily than Porter and Chubin could in 1985. This opens interesting possibilities for evaluation of syntheses. For example, Sandstrom (1994), an LIS author, creates links between contributors to the LIS literature and contributors to the optimal foraging literature. Over the next decade, one will be able to observe the impact of Sandstrom's ideas. It will be easy to get a total citation count for her article, but one can also report, by using the technique just illustrated with Swanson, whether the citations she receives are solely from LIS or from other fields as well, such as anthropology or cognitive psychology. Put another way, Sandstrom is a new synthesis that cocites many authors who have never been cocited before; her article gives each pair, such as Paul B. Kantor from LIS and Bruce Winterhalder from behavioral ecology, a cocitation count of 1. Now, assume that at least some of those cocitation counts grow. Who will be doing the incrementing, people from LIS or people from some branch of optimal foraging theory? Given the relative isolation of LIS from other fields, it would be remarkable if theorists on optimal foraging were to follow Sandstrom in including scholarly communication behavior in their explanatory design, but it could happen, depending on where those theorists forage themselves. It seems most likely, of course, that the counts will be incremented by Sandstrom and others in LIS.

This suggests a specific way of assessing interdisciplinary syntheses: are they cited outside the author's home field? The answer bears on their success, a matter raised earlier. No one would claim that citation outside the author's home field—or inside it, for that matter—is the sole criterion by which a synthesis should be judged. But it is one criterion: a synthesis that is well cited can be called influential, and if a fair number of positive citations come from disciplines other than the author's, so much the better (consider whether a professor going up for tenure would rather have those citations or not).

Earlier I was somewhat critical of two syntheses—i.e., Swales (1986) and Heilprin (1989). Despite my reservations, both are valuable pieces of work, well worth having. However, their success as cited influences can be qualified in quite specific terms. A check in Scisearch and Social
Scisearch (March 1996) shows that Swales (1986) has been cited five times in his own field (twice by Swales himself) and five times outside it. All but one of the latter citations are by M. H. MacRoberts and B. R. MacRoberts in their controversial critiques of citation analysis. Heilprin (1989) has been cited six times in LIS (once by Heilprin himself). These findings strengthen me in my reservations, in that the citation-analytic techniques displayed earlier will reveal other syntheses to have had greater influence both inside and outside their own disciplines.

CONCLUSION: HUMAN MARKERS

Most of the operations described earlier are intended to provide, through online retrieval, a set of novel bibliographic records that is small enough to browse. Usually, browsing of this kind takes place at the computer screen or with printouts on paper; it requires little physical movement. But browsing in libraries does involve movement; we must transport ourselves to various parts of the stacks. That is because, in the time-honored system, the subject-classification space of books and serials has been made to coincide with the space in which we live rather than being tucked into some fold of cyberspace. Thus, in Dewey- or LC-classified stacks, the markers that may appear on both sides of a disciplinary divide are ourselves in person rather than symbols representing us. Needless to say, our appearances are not simultaneous; anything from a few seconds to years may elapse between them. But these mark an aspect of our nature as walking bundles of subject interests. And if those interests were trained in a particular discipline or specialty, we generally can find one or more corresponding literatures in the stacks, the writings on which our disciplinary identities rest.

In environments where people with disciplinary identities are the rule, it is possible to study whether those who browse do so only in the part of the stacks that is their disciplinary home or go to parts corresponding to other disciplines. Browsing, of course, usually leaves little or no trace, but when people borrow items as a result of their stack visits, we can learn from circulation records the classification codes of what they borrow and note the range of disciplines represented. By cross-tabulating what they borrow with their own disciplinary IDs, we can report the patterns of interdisciplinarity for each discipline in a particular locale, as Metz (1983) did for Virginia Polytechnic Institute. But this kind of study, though based on behavior in libraries rather than on bibliographic connections, once again simply reveals interdisciplinarity in others, including many with whose work one has no particular ties. It is not grounded in the interdisciplinary relations of one's own field, nor is it likely to help one effect a new synthesis.

In contrast, if we identify library and information science as our home field, we have the Z classification as our stacks; as long as we browse there, we are on our own intellectual turf. We can, if we choose, work toward
syntheses of writings we find there, or we can move out to other fields. The question then becomes, Where do we browse when *we* are being interdisciplinary? The question at this point can only be answered on an individual basis, so I will speak for myself. In the stacks, it is not just symbol strings like "Patrick Wilson" that link the Z classification with the BD classification; it is also me, walking between them, visiting them on winter nights, pulling down books in both places. More plausibly, I link the Z classification with certain sections of the BF classifications and P classifications, where I have not merely interests but some coalescing ideas. I may also be seen browsing elsewhere, but there is next to no chance that a synthesis will result: wrong person.

Most readers can replace these autobiographical notes with equivalents of their own, and that, of course, is the point: we know where *we* start from. But there are other big questions: Who from other disciplines is coming to join *us*? Who is entering the Z classification from other directions? And do those strangers have ideas for connecting LIS with something else? Is there an interdisciplinary synthesist in the house?

**Notes**

1. It would be a service if someone reviewed the bibliometric studies of interdisciplinarity, which extend beyond those scattered through the Klein (1990) bibliography. Katherine W. McCain allowed me to use her personal collection of these studies, which greatly assisted the writing of this article.

2. I am indebted to Pamela E. Sandstrom for motivating the analyses of terms in sociobiology and behavioral ecology that are used in this article. They were performed in January 1996 as exploratory follow-ups to Sandstrom (1994).

3. Since form subdivisions such as "Congresses" and "Addresses, Essays, Lectures" are searchable, one might use them to break out collections of works by different authors in the hope of finding multidisciplinary points of view, and perhaps symposia, in a given subject.

4. The method just shown can be used with individual authors. To see a single multidisciplinary genius portrayed in subject headings, invoke Dialog's BOOKS databases through OneSearch, form a set on "Morris, William," and then enter

```
? RANK DE CONT
```

5. If *bundles* of terms are saved using their rank numbers, they must all be ANDed with the input term to reproduce the set sizes in the ranked display. There is more than one way to do this.

6. RANK displays the after-decimal numbers of the Dewey codes correctly, but, by a design flaw, it breaks off the after-decimal numbers of the LC codes from their root numbers—for example, the 103 "9's" in second place actually belong with the 104 occurrences of "GN 365" as GN 365.9. This problem does not affect retrieval: that is, the LC root numbers have the proper decimals attached when the bibliographic records are printed out. LC class codes without decimal subdivisions are, of course, unaffected.

```
? EXPAND SC=some field
```

7. To see full SC labels, which allow one to capture the literatures of disciplines and specialties as defined by ISI, enter:

```
? SELECT RF=85-0608 004
```
REFERENCES


Meta-Analysis: The Librarian as a Member of an Interdisciplinary Research Team

JACK T. SMITH, JR.

ABSTRACT
META-ANALYSIS IS A quantitative statistical tool for combining research studies with a small study population to achieve a larger effect in size. It combines the talents of subject experts, statisticians, meta-analytic specialists, information management professionals, and librarians, creating a multidisciplinary team. This article will explore the interdisciplinary nature of interdisciplinary research, provide a brief explanation of the Integrative Review of Research (IRR) of which meta-analysis can be a part, and describe the librarian’s role or roles in the various stages of the project. Finally, a look at developing trends or issues in the area will be discussed.

THE INTERDISCIPLINARY NATURE OF INTERDISCIPLINARY RESEARCH
Julie Thompson Klein’s paper in this issue of Library Trends sets the stage for a discussion of the impact that interdisciplinary research has on researchers, the library and its staff, academic departments, and their parent institutions. Academic administrators are grappling with the reality of shrinking state funds and are applying pressure on researchers to be totally self-sustaining. Researchers seeking federal support for their projects are finding dwindling funding sources which means that the competition for grant support is more competitive than ever before. One way to gain an advantage is to submit a grant proposal that crosses disciplines.

Klein describes the interdisciplinary approach evidenced in several broad disciplines. More specifically, the area of health sciences research is undergoing this same phenomenon. A perusal of the titles of projects
funded by the Department of Health and Human Services, Public Health Service, illustrates this fact. The following three exemplars were chosen from a list produced from a search of the CRISP database as mounted on the World Wide Web (gopher://gopher.nih.gov) site at the National Institutes of Health.

1. "CNS Effects of Alcohol—Cellular Neurobiology" has a stated purpose "to continue its long term, cooperative, interdisciplinary research." One of its subthemes is "the molecular and cellular mechanisms of short term ethanol intoxication, and its endocrine, metabolic and behavioral concomitants" which demonstrates the variety of disciplines that are involved.

2. Christine Cassel was awarded a Geriatric Leadership Academic Award. This award "will assist her in expanding interdisciplinary research in aging at the University of Chicago and in the broader academic community throughout this city." Cassel will deal with a new basic science research facility, a new Department of Health study, as well as foster "collaborative aging research in the social and biomedical sciences." A prime example of one researcher blending several disciplines into a research project.

3. Finally, the Western Consortium for Public Health submitted a project entitled "Meta-Analysis—Social Relationships and Drinking Outcome." The consortium "proposed to determine the association between social relationship factor and alcoholism treatment drinking outcomes." Among the areas that the study will address are alcoholism, alcoholism therapy, psychosocial rehabilitation, and quality of life.

If researchers are to conduct interdisciplinary projects, they must have appropriate outlets for dissemination. Evidence of opportunities for publication of multidisciplinary research in the health sciences may be gleaned from the List of Serials Indexed for Online Users (National Library of Medicine, 1996). Such titles as Cardiovascular and Interventional Radiology, Health and Social Work, and Social Science and Medicine demonstrate the kind of breadth to be found.

In Medical Subject Headings, the National Library of Medicine (NLM) (1989) defines meta-analysis as "a quantitative method of combining the results of independent studies (usually drawn from the published literature) and synthesizing summaries and conclusions which may be used to evaluate therapeutic effectiveness, plan new studies, etc., with application chiefly in the areas of research and medicine" (pp. 1-40). Meta-analysis began to be used as an index term that year. However, Gene V. Glass (1976) had begun using the term in 1976 (p. 3). The use of statistical techniques to combine research results might go back to Legendre in 1805 and his development of least squares (Cook et al., 1992, p. 6). In combining the results of individual agricultural experiments, two differ-
ent approaches were taken. One tested for statistical significance of the combined results. The other relied "on estimating treatment effects across studies" (Hedges & Olkin, 1985, p. 1). By the 1930s, meta-analysis research began to appear in the social sciences (Cook et al., 1992, p. 6). It was not until the late 1970s that meta-analysis began to appear in the medical literature (Schell & Rathe, 1992, p. 219).

After Glass's 1976 article, other researchers also began to refine meta-analysis procedures and publish their results (Hedges & Olkin, 1985; Rosenthal, 1984; Wolf, 1986; Cooper, 1979). The medical community was still hesitant to accept meta-analysis studies and to believe in the validity of the results. A group at Oxford University in the 1980s began to change this. This group "took the approach of gathering all studies, published and unpublished, and excluding those that used different endpoints" (Schell & Rathe, 1992, p. 219). Using studies on therapeutic issues, the British called their research "overviews" and they recommended that their conclusions be used in clinical trials for a further check of the validity of their results (Yusuf, Collins, et al., 1985; Yusuf, Petro, et al., 1985).

**INTEGRATIVE REVIEW OF RESEARCH**

Cooper introduced procedures for doing an Integrative Review of Research in 1982. He described it as the application of the research process to a collection of studies (Cooper, 1982). To achieve reliable results, there must be rigorous adherence to the rules of scientific inquiry with special attention to threats to validity. Meta-analysis is contained within the scope of an Integrative Review of Research (Smith, 1991, p. 48). Cooper (1984) detailed a five-stage process for conducting an IRR. These stages are: (1) problem formulation, (2) data collection, (3) data evaluation, (4) analysis and interpretation, and (5) public presentation (Cooper cited in Smith et al., 1991, p. 48). The librarian or information professional can be involved in any or all stages.

**THE ROLE OF THE LIBRARIAN**

The literature on what the role of the librarian should be in a meta-analysis project is scant. The Committee on National Statistics (CNSTAT) of the National Research Council held a workshop on the future of meta-analysis in 1986 (Wachter & Straf, 1990). The goal "was to assess the role actually played by meta-analytic methodologies in current practice" (p. xiii), identify strengths and limitations, and suggest priorities for future research. The major players in meta-analysis, Harris Cooper, Robert Rosenthal, Larry Hedges, and Ingram Olkin, made presentations at this workshop. For the purposes of this article, the relevant sections are those concerning the literature review. One group actually performed a meta-analysis on treatment of aphasia specifically for this workshop (Wachter & Straf, 1990, pp. 29-46). In their concluding paragraph to the section
on researching the literature, they acknowledge that this retrieval process is “the most critical phase in a quantitative literature review” (Wachter & Straf, 1990, p. 34). Their next sentence provides an insight into how the entire meta-analysis process is perceived by the subject expert. “It became obvious that this phase [literature review] could be completed only by a subject matter specialist, that is, a person knowledgeable about aphasia, in our case Dr. Fromm. She felt, however, that a measure of reliability would have been added to the project by having two subject experts, rather than one, involved in this stage” (Wachter & Straf, 1990, p. 34).

In her reaction to this study, Nan Laird recognized the importance and the enormity of the task for the meta-analysis researcher in undertaking a comprehensive literature review (Wachter & Straf, 1990, p. 48). All contributors to this monograph agreed with Harris Cooper’s statement: “Nobody’s out there searching forever. If they are, they’re certainly not the folks who are here. They’re still at the library and have never published” (Wachter & Straf, 1990, p. 169). Cooper went on to say that those who are conducting a search of the literature have an obligation to strive for comprehensiveness. That if researchers are going to say to a reader that they have examined the literature and can describe and summarize it, then the researcher should be cognizant of what is going, and has been going, on. Cooper also firmly believes that it is vital that the researcher be “incredibly explicit” about the process they use to retrieve the literature and the criteria used to determine what to cite (Wachter & Straf, 1990, pp. 168-69). What is noticeably absent in the monograph is the mention of any role for a librarian to play. A reading of the monograph suggests that the contributors performed their own searches, selected the databases or print indexes to be searched, and formulated their own strategies. An unstated question is, Would it have been beneficial if a librarian had been consulted regarding the search? The librarian would need to have experience in conducting an in-depth reference interview, training in online search techniques, and possess the requisite skill for online retrieval of literature. At the very least, the librarian’s search results could be checked against the researcher’s result for consistency.

Schell and Rathe (1992) provide a brief historical perspective on meta-analysis and its use in medicine. The librarian is seen as having a role in defining the inclusion parameters, data collection and bibliography, and summary of findings. The authors believe that a librarian who is knowledgeable in meta-analysis techniques will be able to choose the degree of involvement in a project. Because of the librarian’s training and experience in citation analysis and literature searching, they should play an important role in this type of research (Schell & Rathe, 1992, p. 221).

Smith, Smith, and Stullenbarger (1991) used Cooper’s (1991) five-stage process for conducting an integrative review of research to present a detailed explanation of the process so that librarians would have a bet-
ter understanding of the needs of the researcher and how these needs could best be served (Smith et al., 1991, pp. 47-72). As part of the presentation, they formulated flow charts to illustrate various decision points in the process. In each of Cooper’s five stages, Smith et al. discussed the specific needs the research members would have and how the librarian could address and meet those needs. Smith, Smith, Stullenbarger, and Foote (1994) followed up this theoretical article by taking an actual topic on head-injured adults and presented a practical application of the process (pp. 57-72). As in the earlier article, the specifics of the librarian’s role was discussed and illustrated by describing exactly what assistance should be given to the research team and at what point.

Mead and Richards (1995) describe the process used by The Center for the Evaluative Clinical Sciences (CECS) of Dartmouth Medical School. A typical meta-analysis research team is interdisciplinary and would be comprised of a team leader, statisticians, subject specialists, and grant source experts. The Technology Assessment Program is a unit within CECS with a librarian as an integral participant in their projects. The librarian is viewed as a valuable resource in the “selection of bibliographic databases and vendors, planning and testing of search strategies, and use of Medical Subject Heading (MESH) tools and other controlled vocabularies” (Mead & Richards, 1995, p. 462). Other areas in which the librarian provides assistance include suggesting alternatives for finding references, focusing discussions among team members, reviewing search results, and providing regular updates.

One of the more intriguing aspects Mead and Richards describe is the use of FileMaker-Pro for postprocessing of search results and networking the resulting database for the researchers to use in article selection. A template was designed so that the researchers can view the citations with the appropriate fields masked (i.e., authors and their affiliations). In reviewing the citations, all a researcher has to do is click on a button or box to indicate whether or not the article should be retrieved for further study. According to Mead and Richards (1995):

The benefits of this approach are many:
- It is not necessary to print thousands of references.
- The method is easy to use and support.
- The approach facilitates the recording of exclusion codes.
- The method simplifies and consolidates work effort.
- A single copy of the file can be networked.
- Articles not relevant are eliminated based on downloaded data instead of a hard copy, saving lots of trees and fees. (p. 463)

Mead and Richards (1995) see an expanded role for the librarian in this process. At a time when the role of the medical librarian is in transition, being a valued member in the meta-analysis process can assist in defining a new role. As an active participant, the librarian can enhance
and refine the literature analysis process and bring unique skills to the
task of improving health care (p. 463).

At the University of Alabama at Birmingham, an interdisciplinary
meta-analysis research team has been in place since the late 1980s. The
team consists of two meta-analysis experts, a statistician, and a health sci-
ences librarian. While working mostly with researchers in the health
sciences, the group is available to anyone on campus who wishes to inves-
tigate the possibility of conducting an integrative review of research. Sub-
ject areas which have been reviewed include oncology nursing re-
search; nursing research of the adult head injured, cited previously; and
quality of life of recovering cardiovascular patients. The group is cur-
tently working with the Alabama Board of Nursing evaluating the litera-
ture concerning continuing education. New territory is being explored
in this project. The research team is applying existing integrative review
of research processes to an entirely different arena—appellate case law.
The team is composed of nursing education experts, meta-analysis meth-
odologists, a statistician, and legal experts including an online research
analyst from the Alabama Supreme Court Library who is also a lawyer.
The methodology of this research as well as its findings will be published
at the conclusion of the project.

This "research in progress" is mentioned because there are two in-
formation professionals who are integral members of the research team.
Both have been involved from the beginning of the project, but their
roles and contributions are very different. The team drew on the Su-
preme Court librarian's expert knowledge of the court system, the law,
its terminology, and electronic legal databases. Because the group was
going into uncharted water, the librarian acts as a sounding board and
relevance check for ideas on procedure. The health sciences librarian
has contributed his skills in identifying the appropriate nonlegal data-
bases which contain information on how continuing education is discussed
and applied to regulated or licensed occupations or professions. He has
also had the opportunity to participate in coding the legal cases which
were selected for inclusion in this study. The other team members value
these contributions and view the librarian as having an integral role in
meta-analysis research.

An examination of Cooper's (1984, p. 12) five stages demonstrates the
role that the librarian can play in an integrative review of research or meta-
analysis project. Cooper's first stage is problem formulation. It is in this
stage that the actual question(s) to be researched is (are) constructed. Usu-
ally, the question has to do with a topic that has been discussed in the litera-
ture and that has had conflicting results associated with it. For example, a
medical researcher might want to cull the literature to investigate the effect
that a particular drug has on a certain disease. A social worker could investi-
gate what effect, if any, early intervention had on spousal abuse. For a true
multidisciplinary topic, any quality of life study could bring together subject experts on medicine, nursing, psychology, physical therapy, occupational therapy, social work, education, or the humanities.

Librarian involvement in this stage can take many forms. Naturally, it would be most helpful if the researcher would state the topic of interest and the fact that a meta-analysis on the topic is being considered. The librarian would then be presented with the opportunity to ask, during the reference interview, specific questions like What time period is needed? Are there specific aspects of a topic that should be present in each study? Is there a language restriction? Is there a country limitation as to publication or population? If the librarian is not familiar with the topic or a particular aspect of the topic, then a student-teacher atmosphere is needed with the librarian as student and the researcher as teacher. It is vital that the librarian gain an extraordinarily clear picture of what kind of information the researcher is requesting and at what breadth and depth and level.

A more realistic scenario is one in which the researcher comes to the library and asks for assistance in finding information on a certain topic. With this typical request, even a standard reference interview might not elicit the fact that the patron wishes to embark on an integrative review of research or a meta-analysis on that topic. Remember at this stage the researcher is doing a preliminary investigation of the literature to see if an in-depth review would be worthwhile. Perhaps the only clue the librarian would receive is if the patron asks for reviews, meta-analytic studies, integrative reviews, research synthesis, or other combinations of these words. The use of these phrases by the patron to describe the type of articles that would be useful alerts the librarian to the possibility that the patron might be considering a meta-analysis project. It might be prudent at this point to inquire if the patron is beginning an integrative literature review or meta-analysis. As a result, both patron and librarian will be on equal footing in their information quest.

Once the topic and its parameters have been discussed and agreed on, the next step is the selection of databases and formulating a search strategy that will elicit the desired results. At this point, the researcher does not need a thorough literature review. However, it is at this point that a decision is made by the researcher to continue or discontinue the project. For this reason, the researcher may augment the online search results with an issue-by-issue search of two or three top journals in the field. Granted, the researcher probably knows which titles these are, but the librarian may be asked if a standard list of journals in this area exists. This list would serve as a verification that the appropriate journals have been included in this manual search. The results of this search process serve to alert the researcher, as well as the librarian, to missed articles and to verify the validity of the online search. It is quite possible that the researcher has been keeping a reprint file on the topic and this file may
be culled for appropriate articles. All of these information sources serve to answer the question, "Should this project go forward?"

A number of other decisions must be made. One is, which meta-analysis approach to use for the project. The ones most frequently used are Cooper, Hedges and Olkin, Rosenthal, and Hunter and Schmidt. Briefly, the "Cooper and Hedges and Olkin approach asks if there is a difference between experimental and control groups as to effectiveness of treatment outcome. Rosenthal...asks if there is a relationship between treatment and outcome. Hunter and Schmidt account for artifacts, such as sampling errors, in primary studies and use Rosenthal's approach" (Smith et al., 1994, p. 61). This decision is made in conjunction with formulating the "problem question." It is in researching the answer to the problem question that the project is driven. The question must be carefully crafted so that it can be matched with the proper approach and in order for the results to be meaningful.

At this point, the researcher evaluates what resources are on hand. Are the appropriate subject/content experts available and willing to participate in the project? Are methodology experts knowledgeable in meta-analysis or integrative review of research available and willing? Is a librarian who has the proper information skills, training, and experience on board? Is a statistician present to run the appropriate statistical tests? If the team members have committed their time, and the proper expertise is represented on the team, the last question is one of funding. Will the project have the proper financial support to see it through to its conclusion? If all of these questions are answered in the affirmative, then the project may proceed.

Once the problem question is formulated and the proper resources are in place, then the team begins a discussion of the variables. Many of these variables are always included, such as date of publication or language, and are considered standard variables. Substantive variables are those items that are unique to the area being researched. For a study involving family violence, these variables might include family size, age of family members, and sex of family members. If teenage pregnancy is being studied, age of mother, the composition of the family unit, marital status of the mother, and age of the baby's father might be substantive variables.

When all the variables are identified, a coding form and a glossary are created. The coding form fits all of the variables, both standard and substantive, with a blank by each variable. The person filling in the coding form, the coder, reads each article or study and fills in the form appropriately. The variable may have a yes or no answer (e.g., is the mother married?), or it may have a list from which the coder chooses the appropriate answer (e.g., age at onset of condition 15-20, 21-25, 26-40). The glossary contains a definition of each term on the coding form. These
definitions should be decided upon by the team, and each definition must have a source from which the definition of the term was derived. The coder uses the glossary in conjunction with the coding form and its corresponding instructions to answer any questions about how any term or variable is being used or defined. There should be no doubt or ambiguity in the coder's mind concerning any variable on the coding form. The ideal situation is that a person with no knowledge or background of the subject area being investigated should be able to code accurately. In fact, many subject experts and methodologists are not allowed to be coders because they might bring a hidden bias to that part of the project which would adversely affect the validity of the results.

The librarian can play a role in this part by acting as an objective observer. Both the researchers as subject experts and the methodologists have unique points of view. The librarian can act as facilitator, keeping the discussion on-point and bringing an unbiased mind to the discussion. There is also a traditional role here—identifying dictionaries that the team might need in order to prepare the glossary. In addition to standard English language dictionaries, specialized subject dictionaries exist in many fields such as law, demography, ecology, and psychotherapy. It is important to the integrity of the entire project that the researchers be able to document a source for each piece of information, and the librarian can assist in identifying and obtaining these sources.

Cooper's second stage, data collection, is perhaps the most intensive for the librarian. It is during this stage that comprehensive searches are performed to retrieve as many relevant study articles and sources as possible. In many respects, the roles and actions of the researcher and the librarian discussed in stage one are repeated but with a clearer focus and at a comprehensive level. In 1985, Cooper did a survey to discover how investigators performing meta-analytic studies found the studies they used for their research (Cooper, 1985). The three most frequently used sources were: (1) "references in review papers written by others"; (2) "references in books written by others"; and (3) "communication with people who typically share information with you" (Cooper, 1985, p. 1268). An online search of the literature was fifth. Cooper does state that online searches "appear to be making significant inroads on reviewing practices, and reviewers who use computer searches find them extremely useful" (p. 1268).

Current meta-analysis studies present the results of the literature review. However, the details of the review consisting of what was searched, database selection, and search strategies are rarely included in the report. The researcher must keep a record of all online searches performed and their strategies, any manual searches that were done, whether in reprint files, files of colleagues, or issue-by-issue searches of personal or library journal collections, or any other searching techniques or sources that were used to identify studies for the project. This record serves two
important functions. First, if a reader wants more detailed information about the search and retrieval process, the researcher has that record at hand and can provide the information. The second function is for replication. If a future researcher wishes to replicate the study or perform a similar study, this record serves as a baseline from which to begin.

On a practical level, the librarian and the researcher examine the problem question and the variables identified for inclusion in the study. This information is used to review the initial search strategies and databases searched. As a result, the initial search parameters may be expanded or altered. To be as comprehensive as possible, many different publication types are now searched for possible studies. In addition to studies reported in the regular journal literature, basic literature reviews, conference proceedings, unpublished studies, government publications, monographs, and electronic journals and tables-of-contents may be searched (Smith et al., 1994, p. 63). Barbara Quint’s two-part series “Inside a Searcher’s Mind: The Seven Stages of an Online Search,” is an excellent and exhaustive presentation of the online search process (Quint, 1991a, 1991b). At the completion of the project, most, if not all, of Quint’s suggestions and ideas will have found a place in an online search of the literature. The librarian’s strengths are the knowledge of, and experience in dealing with, database construction, indexing practices, timeliness of the information added, update intervals, use of controlled vocabulary, full-text versus bibliographic databases, and how to refine and revise strategies once online.

These strengths will be needed in dealing with the newest source of information, the World Wide Web. Librarians are playing a key role in organizing this information. The researcher will need to be aware of this resource, both its richness and its limitations. The same rules apply to these “publications” as to any print publication. Does the study meet the inclusion criteria? Is the methodology sound? Has it been reviewed? Ferreting out information from the Web requires a knowledge of how the various search engines that search and index Web sites are designed. Yahoo, AltaVista, Lycos, and WebCrawler are just some of the search engines available. However new and exciting these Web search engines are, the librarian and researcher are still dealing with a database. It is a different kind of database, but the questions about its informational content are not different. They are just a variant of the information needed about bibliographic or full-text databases. Questions like What sites have been indexed? How are the results organized? and What are the search and retrieval options? need to be answered if this resource is to be used effectively.

Data evaluation is stage three of the meta-analysis process. Usually the librarian’s role in this stage is minimal. The researchers and methodologists refine the coding form and glossary and select the studies that will be included in the project. The studies that meet the criteria for
meta-analysis will be coded and given the appropriate statistical treatment. If the researcher so chooses, studies that do not meet the exacting standard for meta-analysis can be included in a descriptive statistical analysis.

During this time, the librarian should be reviewing and updating the actions taken during data collection. Was a database overlooked? Is there another method to obtain an elusive publication? Is there a librarian or information specialist colleague with a different subject speciality or background that can review the search strategies? Has information in the databases selected been updated so that the searches need to be performed again to retrieve new studies? Has a source been overlooked that might lead to the discovery of an unpublished study appropriate to the project? This is perhaps the biggest gap in the data collection and data evaluation stages. Unpublished studies are by nature elusive. They are often uncovered by checking bibliographies of other studies, word-of-mouth from a colleague or a subject expert, or just plain serendipidity. Of all the roles the librarian plays, tracking down unpublished studies is the most challenging. However, this constant checking and rechecking is imperative to the meta-analysis process. It is up to the librarian to keep the search and retrieval aspects of the project accurate, thorough, and current.

Stage four of the meta-analysis process is data analysis and interpretation. During this stage, subject, methodology, and statistical researchers begin the tedious process of reviewing the results of the statistical treatment performed on the studies selected in the data evaluation stage. While the librarian's interaction with the team is minimal, the librarian can perform a significant function. Because the librarian has distance from the project and a different perspective, the librarian can help to focus discussions and act as a facilitator when the entire team meets. It is also important for the librarian to look ahead to stage five—dissemination of results.

If they are to be useful to others, the results of research projects must be reported in the literature. The librarian may not be heavily involved in the actual writing of the research results but can help identify journal titles appropriate for dissemination. Most researchers know the journals in their major subject area and to which of those journals they wish to submit their article. However, given the multidisciplinary nature of many of these studies, the researcher may ask the librarian to assist in identifying major journals in other disciplines that might have an interest in this project. To continue with the family violence example, the social work researchers will know in which social work journal they wish to publish. But they might not know the legal, education, or psychological journal possibilities.

In addition to identifying journal titles, the librarian might raise the issue of publishing outside the major subject area. The researchers may be so focused on getting published in their subject area that they might
overlook other publishing opportunities. Also, while the results will be reported in the appropriate subject journal, there might be possibilities for reporting unique aspects of the methodology used or describing the process of performing this kind of research in the ancillary subject areas. The librarian also needs to address the aspect of electronic access to the publication. The research team needs to answer the question, “What electronic database would I use to search for articles on this topic?” or “What database(s) would the people that I want to read this article access if they want information on this topic?” Informing the research team of the various databases in which a journal is indexed is a major role for the librarian in this stage of the project.

The words interdisciplinary or multidisciplinary have not been frequently used during the discussion of the librarian’s role in a meta-analysis project. When dealing with a meta-analysis or integrative review of research, interdisciplinary is a given. Looking beyond the composition of the team, the area chosen for research will require an interdisciplinary approach. Even a problem question as innocuous sounding as Does early intervention by a social worker decrease violence directed by a parent toward a child? requires a broad approach. For example, how did the social worker become involved? If the police requested the social worker, then legal databases and informational sources must be searched. Did a teacher request intervention? Then education sources are needed. Did someone in the family seek counseling? Then psychological and psychiatric information is required. The range of possibilities is great and none of them must be overlooked. The search may find nothing useful, but the researcher must document that the appropriate sources were identified and searched and what resulted from this process. The librarian’s unique qualifications in this area are vital to the success of this stage of the research project.

As a conclusion to this section, Smith and Stullenbarger (1989) combined from several sources the following list of questions to be used as a suggested guideline for evaluating a meta-analysis or integrative review of a research project.

1. Are the purpose and problem questions specified?
2. Does a theoretical framework serve as the basis for coding, hypothesis testing, and interpretation of results?
3. Are descriptions provided to ensure representativeness of the sample?
4. Are decision rules made explicit at each step of the process?
5. Is there sufficient similarity among constructs, treatments, and control groups for study comparisons?
6. Is the unit of analysis consistent across studies?
7. Are checks for reliability and bias described at each step of the process?
8. Are outcomes related to study characteristics?
9. Are alternative explanations in the form of rival hypotheses provided?
10. Is generalizability restricted to the domain under study?
11. Is the report presented in sufficient detail for replication?
12. Are recommendations for the future specified? (pp. 114-15)

CONCLUSION

Procedures for conducting integrative reviews of research and meta-analyses are continuing to be refined. Joseph Lau et al. have developed a technique labeled cumulative meta-analyses. Using this approach, once a meta-analysis project has been conducted, every time a new study on this topic appears in the literature, the original meta-analysis is updated to include the new study. "These techniques make it possible to study trends in good and bad effects and to pinpoint the first time a difference in outcome between treatment and control groups becomes statistically significant at a chosen level" (Lau et al., 1992, p. 248). The implications of this technique on librarians working with interdisciplinary research teams are obvious. Continuous sweeps of the literature to identify newly published studies must be performed. Being alert to new databases, vocabulary changes in existing databases, new journals in the field, and the publication of dissertations or monographs on the area of study are just some of the other sources of studies that must be continuously investigated.

The growing prominence of the World Wide Web is another new potential source of studies. Numerous articles are appearing in the literature describing what Internet resources are available in various subject areas (Buhle et al., 1994; Huntley et al., 1996; Notess, 1996, 12ff; Felt, 1995). The current fluid nature of the World Wide Web makes it difficult at best to search for information and almost impossible to find consistency. An even greater problem is reliability. A librarian has the utmost confidence that Lau et al.'s article on cumulative meta-analyses will always be found in the New England Journal of Medicine, volume 327, 1992, page 248. However, there is no guarantee that the Web document discovered today will be at the same site or at the same place at a Web site tomorrow. Also Lau et al.'s article is printed on paper and published in its final state. Not so with Web publications. Documents can be revised daily, weekly, or whenever the author decides to revise it. This revision may delete previous information, add new information, or alter the meaning or interpretation of ideas previously presented. Even with all the problems and obstacles, the Web as an information resource cannot be overlooked.

The integrative reviews of research and meta-analysis are powerful tools for research. By understanding the process, librarians can provide the appropriate information in an efficient and timely manner. The
interdisciplinary composition of the research team as well as the interdisciplinary nature of research projects offers an opportunity for librarians to use all of their acquired knowledge, training, skills, and experience. Providing this kind of intensely focused service and continuing to gain recognition and inclusion as a team member on a project is a challenge to the individual librarian and the profession. Discovering, recognizing, and providing services to multidisciplinary subject areas presents a challenge to the libraries and institutions in this era of ever-shrinking financial resources. It is hoped that, by discussing these factors and the issues enumerated in this volume of Library Trends on interdisciplinary inquiry, librarians will have an understanding of, and an appreciation for, the intricacies of meta-analysis research across disciplines and the roles that they can play in this process.

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Bibliography as an Interdisciplinary Information Service

JOAN B. FISCHELLA

ABSTRACT
ALTHOUGH PUBLISHED SUBJECT BIBLIOGRAPHIES would seem to have lost their value due to the availability of electronic catalogs and indexes, they still play an important role in winnowing the vast amount of information derived from these resources. This article supports this claim through an examination of an information search of a study of the subjects of play and leisure. The complementary notions of bibliography drawn by Marcia Bates (1976) and Patrick Wilson (1992) show the continuing importance of well-conceived and carefully executed bibliographies for interdisciplinary areas.

INTRODUCTION
The wide availability of electronic access to published materials might suggest a decreasing importance of published bibliographies. Among the access tools in electronic form are catalogs (of print and nonprint materials); indexes and abstracts of periodic literature; and tables of contents of journals and books. Researchers using a personal computer and modem can search catalogs worldwide at their convenience. Moreover, keyword searching of catalogs and indexes can be done easily, thus freeing searchers from lengthy training and practice needed for highly structured organizational tools such as subject headings or thesauri. One argument against compiling subject bibliographies is that the researcher or the nonscholarly searcher can find extensive materials by using keyword searches in national or local catalogs and in subject indexes. Many catalogs are available through the Internet, and academic and public li-
Libraries are providing patron access to these through personal computers. Such ubiquitous availability means that even a lack of subject expertise is not a deterrent to finding at least some information on most topics. In any case, the bibliographic activity which leads to the selection and publication of lists and descriptions of articles or books on a topic takes time which would be better spent on other activities.

This argument is not self-evident, however, for it assumes that bibliographic activity serves only as a "gathering" activity, not a winnowing one. Further, it assumes that all topics for bibliography are congruent with the classification and organization of existing catalogs and indexes; it does not consider areas that are perhaps ripe for bibliography just because these are outside common intellectual organizational schemes. Interdisciplinary topics, for example, are areas in which straightforward searches of catalogs and indexes are of limited help because the work has indistinct boundaries.

The importance of bibliographies for interdisciplinary work can be seen by examining an interdisciplinary field of study. Play is illustrative of a field in which the activity of compiling bibliographies becomes problematic when dealing with electronic bibliographic tools commonly used today. The examination of these problems is preceded by a discussion of two notions of bibliography and a description of "play" and "leisure," two related concepts.

**BIBLIOGRAPHY**

A bibliography is a "list or sequence of descriptions of graphic materials on a given subject or area" (Bates, 1976, p. 9). In her 1976 article, Marcia Bates makes a strong case for the value of systematic or enumerative bibliography by providing a foundation for it in terms of both the practical utility of such bibliographies and the skills of "information seeking, selection, and organization" (p. 7) required by those compiling such bibliographies. Bibliographies are secondary sources of information, functioning as pointers to other materials (information recorded by human agency). Each item on the bibliographic list carries selected bits of information about an indicated work, such as author, title, publisher, and date; it may also carry a summary of the work, highlighting those particular aspects relevant to the subject area of the bibliography.

The value of a bibliography lies in its gathering and preliminary screening of information on a subject. It combines and organizes the information about materials from diverse resources, and it evaluates the materials. A good bibliography provides enough information about a set of materials to determine whether or not it is worth reading them. A bibliography performs this function because it is more than a listing of items. Rather, a bibliography connects items in some way, and the principle of that relationship is defined by the subject area under
Bates argues that a bibliography contributes value to the information by creating "an integrated structure for physical and intellectual access to recorded materials" (p. 12). She refers to Shera and Egan's (1965) notion of the macrocosmic view of bibliography. A macrocosmic view holds that bibliographies are systems of communication, one related to the other, and serving a common purpose of building an intellectual structure of the area, whereas a microcosmic view of bibliography assumes that each bibliography stands alone, unrelated to other bibliographies.

In contrast to Bates, Patrick Wilson (1992) makes a case for what he calls "pragmatic" bibliography as distinguished from "wholesale" bibliography. He characterizes the activity that leads to, or constitutes, the process of pragmatic bibliography as that of the academic researcher who identifies, selects, and describes materials for a specific purpose or project. "The inquiry might be an attempt to find out something new or might simply be an attempt to find out what, if anything, is already known on the subject" (p. 240). Because a specific limited purpose guides the activity, its key components are search and selection.

Although Wilson suggests that many professionals and graduate students practice pragmatic bibliography, his description of the process is based on the practice of the mature scholar. That is, it is indicative of the researcher who belongs to, and works within, a discipline and is thus familiar with the methods of, and the problems studied by, the discipline or specialty (e.g., see Wiberley & Jones, 1989). The scholar also knows the work of others in the field insofar as it will affect his or her own work. The scholar maintains the level of familiarity needed by communication with other scholars, by scanning tables of contents, checking footnotes, and reading articles and reviews. "This is a constant monitoring activity, a sort of directed browsing. And it is against this background of continual monitoring that any piece of pragmatic bibliography is undertaken" (Wilson, 1992, p. 242). That is, the researcher who develops a bibliography for a particular scholarly work is drawing on, identifying, and selecting materials which are likely to be known, which are cited in footnotes of published works that are already known, or which are suggested by colleagues. In this context, the scholar's bibliography serves to assure oneself that others have not already done the scholar's work. It serves to acknowledge the context in which the scholar is working and to acknowledge or rebut the work that others have done on the issue being addressed.

The nonresearcher, too, constructs pragmatic bibliographies. Such a person is not pursuing professional research but, like the researcher, needs to use published literature for a specific purpose. Wilson suggests three kinds of inquiry which vary by degree of critical approach. In making the first kind of inquiry, the person wants simply to know what is written about a particular topic—i.e., what are the basic approaches to
the central questions? In a second kind of inquiry, the person wants to know not only the main areas of discussion about the topic but also wants to gain a critical perspective on the topic. In a third kind of inquiry, which Wilson calls investigative, the person searches for answers to a particular question. In this third case, the person is less interested in learning about the shape of a topic, of intellectual fields, or of specializations but is more interested in anything that contributes to answering the question regardless of its origin. In each of these cases, the person gathering literature is engaged in the bibliographic process—i.e., searching for and selecting materials. It may or may not result in a product such as a report or an article. Each of these inquirers may use bibliographies as well. What Wilson calls wholesale bibliography—i.e., topically organized lists, catalogs, indexes, and abstracts—can provide the range of materials from which these people draw their materials. Such wholesale bibliographies are of use to those doing the first two kinds of inquiry but less so to those concerned with the third. In particular, evaluative, topically organized, and annotated subject bibliographies may be limited in their relevance to a person searching out a particular question. As Wilson notes, that person needs materials that are functionally, rather than topically, relevant.

Materials having a functional relationship are those which contribute information or insight. They may be intellectual tools, theories, evidence, or examples, "or may simply stimulate ...thinking by offering ideas, questions, hypotheses to explore" (Wilson, 1992, p. 241). These materials may or may not be about the subject in question, since topical relevance is not the primary concern.

**Interdisciplinary Work**

Interdisciplinary work is a good example of an inquiry which may use functionally related materials. Such an inquiry can take many forms (Klein, 1990). For example, Hartmann and Messer-Davidow (1991) focus on the variables of agency, perspective, values, and selection to analyze the influence of sex-gender categories on such disciplines as biology, social studies, and literary studies. Dogan and Pahre (1990) give multiple examples of research areas in the social sciences which have arisen in the "margins" of disciplinary specializations. These new "hybrids" may emerge from the adoption and recasting of concepts from another specialization, from borrowing methods, or from exchanging theories. Characteristically, interdisciplinary, integrative, or hybrid work is complex rather than complicated (Newell & Klein, 1996). Simple and complicated systems are both hierarchical in nature and operate based on a single system of rules. In contrast, complex systems are nonhierarchical, nonlinear, and based on multiple, even contradictory, systems of rules. "To understand them at the larger integrated level, reductionist thinking must be replaced by nonlinear thinking, pattern recognition, and analogy."
Such complexity explains the difficulty in searching for relevant materials. Finding relevant literature—i.e., developing bibliographies—for complex work which crosses disciplinary boundaries is often a search for functionally related materials. It may start by stumbling across an approach or perspective outside one's home discipline that generated the question but which seems to throw light on the inquiry at hand. From there, it involves searching for more information in the other specialty. Colleagues in the other disciplines are helpful in suggesting key resources, and a researcher may need to learn enough of other specialties to be fluent in the language of concepts, theories, or methods and be able to recognize important and relevant patterns or analogies. Typically, a simple bibliographic search to identify literature from other disciplines related to an inquiry is of limited use, since topically related bibliographic access tools are not organized for easy access to functional relations.

**Play and leisure**

The following discussion illustrates the problems and issues in bibliographic searching for an interdisciplinary question. The problems encountered suggest that published bibliographies are valuable for interdisciplinary or hybrid areas. The case that will be discussed is a comparison of two bibliographies of the subject "play," one produced unsystematically, the other in a more structured way using current bibliographic tools. The case does not list the materials found in each bibliography; instead, it examines the activity in developing each one. The subject of the bibliographies is play and leisure. This section will briefly examine the definitions of play and leisure in order to indicate key concepts related to each. These concepts will then be used in the search for relevant materials.

Play is a concept which applies to ordinary experience and which is also used in theoretical contexts. It is complex, that is, it is understood by examples and elements, but these do not equal play. To search for or develop bibliographies of play by reducing the concept to one or another element will yield a high percentage of irrelevant materials. On the other hand, to rely only on the generic terms play or leisure yields irrelevant materials and misses a good deal of important material.

In order to briefly examine the dimensions of play and leisure, the emphasis will be on a limited selection of works in the study of the history of civilization, child study, outdoor life, recreation, labor, and religious ethics. In his classic *Homo Ludens: A Study of the Play Element in Culture*, Johan Huizinga (1952) defines play as activity which exists for itself—i.e., not for profit nor some other end and not serious. It stands outside ordinary life, is limited in time and space, and proceeds according to its own rules. The player is often intensely absorbed in the activity. Further, Huizinga allies play with the mysterious: "It promotes the formation of
social groupings which tend to surround themselves with secrecy and to stress their difference from the common world by disguise or other means” (p. 13). In this work, Huizinga shows the significance of play by clarifying its role in such aspects of culture as law, philosophy, poetry, and even war. He does not attempt to explain play in physiological or psychological terms (pp. 1-2).

Some twenty-five years later, Caillois (1961) acknowledges Huizinga’s original work, but disagrees with his characterizations, noting that the definition carries inherent contradiction and that play takes many more forms in society than Huizinga recognized. Caillois characterizes the activity of play by the following formal qualities:

1. **Free**: in which playing is not obligatory; if it were it would at once lose its attractive and joyous quality as diversion;
2. **Separate**: circumscribed within limits of space and time, defined and fixed in advance;
3. **Uncertain**: the course of which cannot be determined, nor the result attained beforehand, and some latitude for innovations being left to the player’s initiative;
4. **Unproductive**: creating neither goods, nor wealth, nor new elements of any kind and, except for the exchange of property among the players, ending in a situation identical to that prevailing at the beginning of the game;
5. **Governed by Rules**: under conventions that suspend ordinary laws, and for the moment establish new legislation, which alone counts;
6. **Make-Believe**: accompanied by a special awareness of a second reality or of a free unreality, as against real life (pp. 9-10).

Caillois further develops a system for classifying games based on a dominant element in the game—i.e., competition, chance, simulation, or vertigo, which he called “agôn,” “alea,” “mimicry,” and “ilinx.” Within each of these broad categories, individual games and play can be located on a continuum between turbulence or improvisation (“paidia”) and its inverse, discipline or structure (“ludus”) (pp. 11-14). Thus a competitive game (“agôn”) of baseball may be as loose as a pickup game, the rules depending on the number of people, the equipment, and the area available for play, to a highly structured game of teams of players who have survived tryouts, who follow an organized schedule, whose rules carry sanctions for nonconformity, etc.

Huizinga’s and Caillois’s formal definitions and categorizations may be seen as conceptual frameworks for the study of play, but they do not determine the full scope of activities related to play nor the conditions under which humans and animals play. At best they provide clues for understanding certain activities which are ambiguous; they provide guides to the meaning of such activity; they indicate patterns of activity.

Stephen L. J. Smith’s (1990) conceptual dictionary of recreation and leisure “maps” the terrain of university departments organized to study
the area (p. viii). Although a dictionary may be constructed to provide a clear definition of terms in order to distinguish one concept from another or to map usage of terms, this conceptual dictionary in fact works in the opposite way—it covers the whole field showing the relation of concepts to one another. Smith includes four kinds of concepts: (1) elemental (the basis of the field), (2) theoretical (models and interpretations of processes), (3) research or methodological (conceptual tools for analysis of phenomena), and (4) professional (ideas from the service dimension of the field). Smith’s brief definition echoes elements of Huizinga’s and Caillois’s—i.e., he considers play as “a pleasurable, intrinsically motivated, voluntary, and repetitive or patterned activity that is separate in time from other activities and is governed by either implicit or explicit rules” (p. 238). He notes that play is an ambiguous concept which is used in a widely varied way. Drawing on the work of David Miller (1973), Smith provides a historical analysis indicating the philosophical and religious approaches to play and the shift to social science theories in the study of play.

Within these representative approaches, the concept of play can be used to understand dimensions of human culture; conversely, disciplines which study phenomena can be used to understand the manifestations of play. Bernard Mergen makes explicit the interdisciplinary character of the study of play in his two research guides, *Play and Playthings* (Mergen, 1982) and *Recreational Vehicles and Travel* (Mergen, 1985). In the former, Mergen posits the primary connection between the notion of play and children and notes that the study of children’s play overlaps with the study of “communication, imagination, social organization, political process, economic systems and ecology” (p. 3) as well as history, anthropology, psychology, and design/planning (play environments). The study of play is not confined to children’s development and activity, however, as indicated by Mergen’s work on recreational vehicles and travel in which he studies travel voluntarily taken for its own sake—i.e., for pleasure (pp. 4-5). He notes that while play is an ambiguous concept, it is useful for understanding the meaning of certain behaviors (p. 17) such as travel, as seen in the narratives of Twain, Slocum, Earhart, and Nickerson. On the other hand, although there are play aspects of travel, not all works about travel concern themselves with its play dimension—e.g., those directed to instruction, promoting products, or documenting accomplishment.

The concept of leisure also varies in scope. Josef Pieper (1952) understood it in terms of its Greek roots—as a place where we educate—and links it to the notion of contemplation. In this context, leisure takes on a higher value than work. “We work in order to have leisure” (p. 26). Sebastian de Grazia’s (1962) *Of Time, Work, and Leisure* recognizes the common equation of leisure and free time but holds to the distinction in the context of a political philosophy. More recently, Juliet B. Schor (1992),
an economist, distinguishes two approaches to leisure (p. 13). A subjective approach equates work with that which is unpleasant and obligatory; leisure, on the other hand, is a discretionary, enjoyable activity. Schor's preferred “objective” approach is to describe leisure as what remains after taking into account both paid labor and household activity.

This review of the elements of play and leisure not only briefly describes the concepts but also illustrates the complexity of any study of these areas.

**Two Bibliographies**

This case study compares the process of developing two bibliographies about play and leisure; they were compiled at two different times for two different purposes. The original bibliography was compiled between 1975 and 1982, and its comparison bibliography was gathered from 1990 to 1991 but covered approximately the same dates as the original—i.e., 1973-1982. The case study indicates differences in results between informal and structured approaches to a bibliographic project and suggests that the roots of the differences lie in the context of information-seeking behavior and in the complexity of interdisciplinary work.¹

There are two threads to this case: one follows an eight-year process of developing a set of materials to support teaching and scholarly activities, proceeding without the explicit help of librarians. Here the case addresses specific focused projects which determined what materials were chosen and the systems which helped or hindered identifying the materials. The other thread is the broad interdisciplinary theme which forms the subject of the bibliography—in very general terms, play and leisure—and the issues arising out of its interdisciplinarity.

**Original Bibliography**

The impetus for gathering the original bibliography was the development of an interdisciplinary television course made in the late 1970s called *Play & Leisure*. The course was to teach the philosophical concepts of play and leisure, to demonstrate how concepts can function as tools of analysis, and to show the cultural values of play and leisure. Three faculty members (including this author) served as producers and host instructors who provided the framework and continuity for the half-hour programs, while individual shows or segments were conceptualized and taught by guest instructors in collaboration with the hosts—assuming an interdisciplinary approach meant that instructors and guests could draw from a variety of disciplines for choice of topics, approaches, and materials.

The host instructors developed print materials to support the course (a two-volume anthology of literature and non-fiction served as a textbook, and a “playbook” provided guidance to the key concepts of the programs through exercises, guides to study, and suggested readings).
We further supplemented the course with a dynamic (that is, evolving) bibliography of scholarly and popular materials.

The original play and leisure bibliography, which fit the characteristics of what Wilson calls pragmatic bibliography, began with two core works, Huizinga’s *Homo Ludens* and Pieper’s *Leisure: The Basis of Culture*. Another useful source was David Sleet’s (1971) thesis *Interdisciplinary Research Index on Play: A Guide to the Literature*, a list of resources organized by disciplinary field. The bibliography developed as the instructors and colleagues recommended readings to one another, followed bibliographic trails, stumbled across books and articles, and even made unlikely materials relevant to the topic. The scope of the bibliography included works from all fields about, or alluding to, the role of play and leisure in culture. The bibliographic items comprised a variety of materials, including unpublished manuscripts; published articles, books, and book chapters; popular press materials; newspaper articles; and video materials. They encompassed a wide range of genres: fiction; social and political commentary; expository essays; and studies based in one or another of the social sciences and humanities. Some works were not necessarily about play or leisure but were themselves playful or exemplary of one or another concept which helped to describe or define play and leisure; still others were seemingly unrelated, but were made relevant by a participant.

In a second phase of compiling the bibliography, this author continued to develop it into a set of materials for individual and more focused, primarily academic, use—i.e., presentations at scholarly meetings, potential publications, and other projects. The search for items also became much more focused and related to specific topics of interest, for instance, play and creativity, and used tools such as the Institute of Scientific Information’s (ISI) *Current Contents*.

**Structured Bibliography**

Would a systematic approach to building a bibliography be more productive than an unstructured approach? One role of academic libraries is to provide collections which support the curriculum and research of faculty, students, and staff, and to facilitate physical access to materials they do not hold. A continuing question is whether libraries or any other information systems do an adequate job of helping scholars identify materials that they need for their work (Searing, 1992; Hubbard, 1992). Some librarians suggest that faculty miss great opportunities to improve their own work (either in quality or efficiency) when they do not take advantage of the systems that libraries provide. When asked, however, many scholars reply that they find needed information very well without using libraries’ systems except sporadically, or they say that the systems are inadequate for what they really need (Perrow, 1989). The use and utility of these systems can vary among disciplines, research focus, and length in career (Wiberley & Jones, 1989, 1994).
Many studies have been done regarding faculty use of the library and faculty information-seeking behavior. Stephen K. Stoan's (1991) review article identifies three areas of research. He notes that studies done by librarians concentrate on faculty use of library systems of access, while research done by nonlibrarians have focused on communication systems among faculty researchers. According to Stoan, both sets of studies agree that faculty infrequently use formal information systems such as indexes and abstracts. In addition, studies of systems themselves have shown that they are inadequate for the "perspectival dimension" (Stoan's term) necessary for a scholar's contributions to the development of knowledge.

This author's own study differs from those Stoan has reviewed in that it is concerned with an interdisciplinary topic, it starts with a completed bibliography which can function as a kind of control, and it uses a quantitative approach simply as an indicator. The question posed in this study was whether it was possible to duplicate the original bibliography through a subject search using electronic systems. Would the results of the systematic search offer some works that might have been of significant help during the original course development and teaching, but which were missed through the informal approach? It was hypothesized that, in fact, I would find many of the original citations in a structured search, but there would also be novel citations derived from each of the methods.

The structured search of electronic databases began with a preliminary search using truncated forms of the terms "play" and "leisure," both as controlled vocabulary (descriptors or subject headings) and as free-text terms—i.e., as words any place in a record: title, subject term, abstract, or summary. This preliminary search of twenty-eight databases with only the truncated words "play*" or "leisur*" any place in the record yielded almost 254,000 citations. Limiting the search to materials published between 1972 and 1982 yielded over 94,300 citations (duplicates were not identified). The twenty-eight databases included scholarly indexing and abstracting services covering disciplines such as education, literature, psychology, history, philosophy, the arts, architecture, business, as well as more popular magazines and newspapers. The results from Philosopher's Index, ERIC, and Psychological Abstracts alone yielded over 44,000 citations; limiting the search to publications dated between 1975 and 1982 reduced that number to 16,800.

A searcher faced with an impossibly large number of items to consider may relinquish the project (Wiberley & Daugherty, 1988; Wiberley et al., 1995) or instead may strategically limit the number of items. In this case, I limited the number of databases, used controlled vocabulary, limited the results to English, and added other terms. Of the twenty-eight original databases, five were most likely to yield the kinds of materials that had originally surfaced; Philosopher's Index, Sociological Abstracts, ERIC, Psychological Abstracts, and Literature and Language Behavior Abstracts (LLBA) were searched for writings published during 1973 through 1982. Furthermore, appropriate controlled vocabulary or subject terms were
used, and the search was limited to publications in English when a preliminary search yielded still too many citations. Terms were also added relating to theory or research in order to whittle the results to an even more manageable size.

The search strategy included several implicit decisions made without examining the assumptions. For instance, the strategies of limiting when the search yielded too few or too many cites relied on a subjective notion of what counted as "too many" or "too few." A searcher can expand or limit the search conceptually by refining the subject question or by using system protocols such as limiting by language or date. For example, a search can be limited to major descriptors in the ERIC database. To what extent is a search determined by the limitations of convenience or cost? An individual researcher answers these questions based on background knowledge of the field and of information systems. In this case, the working assumption was that the citations from the subject search would be exact (in terms of the subject) and would be most economical in terms of both time and money.

What was lost in this methodology were more inventive approaches to the database. For example, in the original bibliography, there are articles, books, and book chapters from the philosophy of science. Specifically, I had been able to relate to the subject "play" the concept of discovery in science and scientific method. Linking play with discovery was developed through activities such as browsing materials, watching television, and speaking with colleagues. Yet, at that time, had the subject of discovery been searched in philosophy of science in Philosopher's Index, I might have found references to works that appeared in the original bibliography along with many other citations, but I might not have recognized these as being important. This example shows that one fruitful approach is to ask within what context would the chosen terms have a good chance of yielding relevant materials. Knowing the shape and methods of a field, knowing buzzwords and current approaches, and making educated guesses about how a subject might show up contribute to answering an inquiry.

With the imposed limitations, the subject search of online bibliographic databases yielded just over 600 citations. My original bibliography was composed of 229 items, many of them from books, unpublished papers, and popular materials. After eliminating the questionable materials (materials unlikely to be indexed), it was reasonable to expect only about half of this list (approximately 115) to appear in the indexes searched. In fact, only twelve citations from the original bibliography were identified by an online subject search: five were found in Philosopher's Index, five in Sociological Abstracts, one in ERIC, and one in LLBA. Interestingly, for an interdisciplinary topic, none of the original citations appeared in two different databases, although one work appeared twice in
Sociological Abstracts in what appears to be two forms—once as an association presentation and the other as a published article.

Since the results were much smaller than expected, these were tested by using an online version of ERIC as a subset; between 90 and 95 known items were chosen from the original bibliography (many of which were only tangentially related to the educational field) to be searched by title or author. In this search, twenty-seven items were found in ERIC. In other words, twenty-six items were missed in ERIC using the controlled vocabulary. There are several factors that account for the difference.

In the first search, in order to reduce the number of citations to a manageable number, the search terms "theories," "research," "metaphors," or "models" were added to identify conceptual approaches. Although this strategy eliminated references to highly specialized literature, it also effectively omitted any record which did not index the record with those terms. Second, several of the citations arose from the later development of the bibliography and are not indexed with the term "play" or "leisure" but are indexed under more specific terms such as "toys," "creativity," "creativity-research," "creative thinking," or seemingly unrelated subject headings. Third, since each database has some unique characteristics, a searcher or researcher must be ready to refine the strategy during the course of the search. Therefore, each search is somewhat different from the others.

The online searches generated many citations which were not in the original bibliography; these were not analyzed because their relevance would have had to be determined in retrospect—a suspect kind of judgment to make almost ten years after the fact. Although many of these seemed worth pursuing for work in the areas of play and leisure, many held no lure.

Implications

Stoan's review of the research would suggest that the results of this study are in fact not unexpected, although the reasons for such results would vary among the disciplines in the sciences, the social sciences, and the humanities. Thus Stoan (1991) concludes that "one can therefore make a strong case that the information-seeking behavior of scholars is both logical and successful given the nature of the intellectual work they are doing and the limitations of the current access to literature" (p. 238).

Further, much of the literature that Stoan notes were studies of researchers in the sciences and social sciences particularly, as well as the humanities. These were people who were advancing knowledge in their fields. In attempting to duplicate the original play and leisure bibliography, it was assumed (in an uncritical way) that there was a fairly close connection among reading the literature, developing bibliographies, and citing other works in one's own publications. The logic is that if one
advances knowledge, one is working within a certain conversation (to use one metaphor of the process), has been following the conversation, has contributed insights (research) to it, and has thus moved the conversation along.

This, however, flies in the face of anecdotal evidence (this author's and others), which does not indicate a generic process at work—i.e., scholars often read or skim widely; develop good, bad, or indifferent ideas; go looking for literature to support their positions; get pointers from people who have already evaluated enough literature to get them started efficiently; and then follow leads. Individuals' bibliographies, collections of books, article reprints, and so on are often a hodgepodge of materials. This process of compiling materials is "pragmatic bibliography." There are two reasons for this seeming haphazardness; one lies in the context of the subject, the other in working habits.

**Context**

In the original case, the interdisciplinary introductory course based on the philosophical concepts *play* and *leisure* was not about advancing the field of the topic but was to teach a way of thinking, present alternative values for consideration, and use a pedagogy based on integrating everyday experience with academic approaches. The implication was that the theme stayed in the forefront while the disciplines informed, but did not take over, the course. The approach to the search for reading materials was not what a particular discipline says about play and leisure, but what can be learned about and through play and leisure wherever it is. The focus was the phenomena and not research of a discipline. Thus, the context of any inquiry determines the kinds of works identified in a bibliographic search. That context can range from teaching, to mainstream disciplinary research, to cross-disciplinary work, to highly innovative and difficult-to-categorize work.

**Working Habits**

The other reason for the hodgepodge of materials in the original bibliography lies in what we know about the way scholars work. For instance, the materials might support the themes of the course or might present an opposing view; they might provide an example, analogy, metaphor, or model; they might generate thinking in a new direction. An unstructured compiling of a bibliography is a little like quilters gathering materials; they buy materials that appeal to them whether or not they have a project in mind or need them at present; some day that material will find its way into a quilt. In the same way, some day a particular intellectual piece may be of use in constructing knowledge.

This should not be taken as a reductionist statement. The quilter often has to look for a specific material because of the requirements for a quilt. So too with bibliographies. Many times researchers have very spe-
cific literature needs: historical documents, particular analysis, discussion of method, and so on. A well-conceived directory of archival collections, an efficient index to literature, or a book catalog can be invaluable.

Thus the original play and leisure bibliography was both less and more than the background reading that gave birth to a particular project or to paper presentations. It was the remnants of several years of thinking, browsing, organizing, and writing about play and leisure. The development of this bibliography helped further my thinking process particularly in areas where there was a need to make new connections or develop new categories. In part, the process of unearthing relevant works (literature or scholarship or exemplars) was part of the teaching and scholarship process and not simply a heuristic.

CONCLUSION

The evidence seems to indicate that systematic or macrocosmic bibliographies are of limited use for mature disciplinary scholars whose primary concern is remaining current with information directly related to their research. Individual scholars or others involved in projects tend to create pragmatic bibliography by tracing relevant citations, following selected references from trusted colleagues, or by browsing or monitoring the literature. However, the growing numbers of electronically accessible bibliographic tools have not substituted for skillfully compiled bibliographies, since electronic indexes are not constructed to identify functionally relevant materials or to identify patterns, analogies, etc.

Interdisciplinary work is a particular example of the inadequacy of using only electronic catalogs and indexes to track relevant materials, in part either because of the inability to cull the materials retrieved in an efficient and effective way or because of the inability of systems to identify relationships such as patterns or analogies. This would indicate that there is a place for published bibliographies.

Published bibliographies focusing on an interdisciplinary or marginal area would be helpful to scholars who are working as part of teams and thus need to become familiar with the concepts, questions, and methods of disciplines or specializations of their colleagues’ disciplines. The individual scholar who identifies a potentially useful theory or framework outside his or her specialization could also benefit from such a bibliography. Bates’s (1976) requirements (drawing on Patrick Wilson’s [1968] work) for good systematic bibliography are even more important when applied to such bibliographies. These include domain and scope, selection principles, bibliographic units, information fields, and organization.

In a bibliography covering an area of study which crosses disciplinary boundaries, the user will derive more benefit in proportion to the explicit information given by the compiler. Few assumptions should be made about knowledge of disciplinary concepts, methods, problems,
theories, and resources. Thus, the compiler should carefully describe the works examined from which the items in the bibliography were drawn ("domain") and give reasons for examining those works. Examples might be works of a rare books collection identified through a finding aid or through a periodical index, for specified years, with the listing of terms. Bates suggests that unproductive avenues of search are worth describing if only to prevent the bibliography's user from repeating a futile search.

Defining the scope (range of coverage) of an interdisciplinary bibliography will not be an easy task for, by its nature, the area will be somewhat open ended. If the materials are drawn from discipline-specific areas, the disciplinary focus should be articulated. If the interdisciplinary topic is formally structured—i.e., with academic departments, professional associations, journals (for instance, covering American or women's studies)—the scope may be somewhat easier to define.

Once items are determined to fall within the scope, the compiler of a good bibliography decides whether or not to include them in the bibliography if the bibliography is to be selective. It is important that a compiler of a good interdisciplinary bibliography spell out the criteria by which the compiler makes that judgment. For instance, one principle of selection might be works on a topic by the most highly cited authors in Citation Indexes. In this case, the compiler would make clear how these authors were identified.

An interdisciplinary bibliography might cover print and nonprint (including electronic) resources, and the relative importance of one format over another—i.e., documentary films, articles, book chapters, books, technical reports, and so on—could vary by discipline. A compiler should account for the presence of each kind of publication, placing it within the context of the subject and of its discipline or specialty. The organization of these "bibliographic units" (Bates, 1976, p. 14) can add immense value to an interdisciplinary bibliography. For instance, organizing by discipline puts the focus on the origins of methods, problems, theories, and so on. Organizing by subspecialties of the interdisciplinary area focuses on the areas or problems addressed. Another approach might be to organize the entries in order to show the confluence or integration of knowledge.

It is important to determine the kind of information to include in each bibliographic entry and to provide it consistently and accurately. If a particular bit of information is unavailable, that should be noted. Finally, annotating each entry with an eye to other entries in the bibliography will serve to approach Shera and Egan's (1965) notion that macrocosmic bibliographies provide an integrated structure for intellectual access to recorded knowledge.

Notes

1 This case is autobiographical, and it is not intended as a scientific study of bibliographic searching. I was one of the compilers of the original bibliography at a time before studying librarianship; I performed a number of the searches in the later bibliography after receiving the MLS. As such, the case has limited value in its generalizability. The
comparison is also suspect in that the process discussion of the original bibliography relies on memory. Nevertheless, the case has the value of highlighting a process that a naive searcher has gone through in gathering materials for an interdisciplinary project. The added benefit is the reflective perspective born of later-acquired knowledge and skill about the organization and retrieval of information in a structured manner.

2 The asterisk functions as a generic truncation symbol.

REFERENCES


The Hybridization of Social Science Knowledge

MATTEI DOGAN

ABSTRACT
A twofold process can be seen in the growth of science: the fragmentation of formal disciplines and a recombination of the specialties resulting from this fragmentation. The division of disciplines into specialized subfields has led to the development of hybrid specialties. The process of hybridization consists, first of all, of borrowing and lending concepts, methods, theories, and praxes. The fruitful point of contact is established between sectors and not along disciplinary boundaries. The hybrid specialties do not necessarily stand midway between two sovereign disciplines. They may be enclaves of a section of a discipline into a sector of another discipline. They combine two limited domains. For this reason, the concept of hybridization seems more appropriate than the concept of interdisciplinarity.

INTRODUCTION

To the title "Navigating among the Disciplines" proposed by Carole Palmer, the protagonist of this issue of Library Trends, I would like to add "and traversing the bridges between specialties," since, in the archipelago of social sciences, there are relatively few formal disciplines but dozens of fields, subfields, and specialties. If we crossed each of the twelve principal social sciences with all the others, the result would be a grid with 144 squares. Some squares would remain empty, but most of these would be filled by hybridized specialties each having some autonomy (Dogan & Pahre, 1990).
These hybrid specialties then subdivide, giving rise, at the second generation, to an even larger number of hybrids. A full inventory of all the existing combinations cannot be obtained by crossing the disciplines two by two, even at the level of the second generation, since some of the most dynamic of hybrid fields are of multiple origin.

In addition, hybrid fields like prehistory, which are partly rooted in the natural sciences, would not appear in the 144-square grid, which is confined to recombinations of segments of the social sciences. The configuration of hybrid social sciences fields is changing constantly. Social psychology, political sociology, human ecology, and political economy have long been recognized, whereas political psychiatry is still fighting for acceptance. Some specialists in cognitive science announce that traditional psychology will soon vanish as an independent discipline and would ultimately be dissolved in a full-blown neuropsychology, which would show, somewhat as chemistry supplanted alchemy, the illusory and prescientific character of the old psychology.

Which branch of linguistics is on the right path, structural linguistics or generative grammar? The structuralists criticize the historicism of comparative grammars and the generativists reject the presuppositions of the structuralists.

In the history of science, a twofold process can be seen: a fragmentation of formal disciplines and a recombination of the specialties resulting from this fragmentation. The new hybrid field may become completely independent, like social psychology, or continue to claim a dual allegiance, like political geography. In the latter case, one may not be sure whether to place a work in the category of geography or political science. The criterion could be based on the predominance of one or the other components or on the formal affiliation of the author. Political anthropology is a branch of anthropology but is also a subfield of political science. Where does historical sociology end and social history begin? One may feel even more unsure when faced with a case of threefold recombination. As the relative proportions are not always obvious, it remains somewhat arbitrary where the essential affiliation may be said to lie, especially since the degree of kinship among disciplines varies greatly: sociology and social psychology are consanguineous, but geology and social geography are far less so, despite appearances.

From Specialization through Fragmentation into Hybridization

Some scholars praise “interdisciplinarity.” Such has often come from the most creative scientists, because they are the first to see the problems caused by gaps between disciplines. But this is not realistic. Presently, it is no longer possible for anyone to have a thorough knowledge of more than one discipline. It is utopian thinking to master two or more whole
disciplines. Given that this implies the ability to be familiar with, and combine, entire disciplines, the idea of interdisciplinary research is illusory.

Because it is so difficult for a single scholar to be truly multidisciplinary, some methodologists are led to advocate teamwork. This is what is proposed by Pierre de Bie in the monumental work published by Unesco (1970). Teamwork is productive in large science laboratories but, where the social sciences are concerned, it is difficult to achieve in practice. The only examples of successful teamwork concern data production or collection and very seldom interpretation or synthesis—with the exception of archaeology.

The multidisciplinary approach is illusory because it advocates dividing up reality. Some researchers proceed piecemeal with philological, anthropological, historical, ethnological, psychological, and sociological approaches. This alternation of approaches, that almost never allows disciplines to meet, results at best in a useful parallelism but not in a synthesis. In fact, research enlisting several disciplines involves a combination of segments of disciplines, of specialties, and not whole disciplines. The fruitful point of contact is established between sectors and not along disciplinary boundaries. Considering the current trends in the social sciences, the word "interdisciplinarity" appears inadequate. It carries a hint of dilettantism and consequently should be avoided and replaced by the phrase "hybridization of fragments of sciences."

All sciences, from astronomy to zoology, have made progress, from the sixteenth century on, by internal differentiation and cross-stimulation among emergent specialties. Each specialty developed a patrimony of knowledge as its understanding of the world developed. With the growth of these patrimonies, specialization became less a choice and more a necessity. Increasingly, focused specialization has led to the creation of sub-disciplines, many of which have gone on to become autonomous.

There are, in the literature, dozens of lamentations and jeremiads about the fragmentation of disciplines. In reality, fragmentation is the result of specialization. The division of the discipline into subfields tends to be institutionalized as can be seen in the organization of large departments of natural and social sciences.

A good indication of the fragmentation of the social sciences is the increasing number of specialized journals. In the last twelve years, dozens of specialized journals in English have been launched. Most of these journals overlap two or three disciplines, and many of them are located in Europe. Other new hybrid journals have appeared in French and in German. European unification also has had an impact on the development of cross-national journals focusing on special social science fields.

It is necessary to stress both parts of the social science division process: fragmentation into special fields and specialization by hybridization.
It is the interaction of these two processes, and not each one in isolation, that has led to the remarkable advance of the natural, as well as the social, sciences. The continuous restructuring of all disciplines has been the result of these two contending processes. However, both fragmentation and its correlate hybridization have developed much more recently in the social sciences than in the natural sciences. In the distant past, hybrid fields were the result of gaps between full disciplines. Today the gaps appear between specialized subfields among neighboring subdisciplines. As a result, in the last few decades, the fragmentation of disciplines into specialized subfields has led to the development of hybrid specialties. The hybrid specialties do not necessarily stand midway between two sovereign disciplines. They may be enclaves of a section of a discipline into a sector of another discipline. These combine two delimited domains, not entire disciplines, and do not need to be adjacent.

Sociometric studies show that many specialists are more in touch with colleagues who belong officially to other disciplines than with colleagues in their own discipline. The "invisible college" described by Robert Merton, Diana Crane, and other sociologists of science is an eminently interdisciplinary institution because it ensures communication not only from one university to another and across all national borders, but also, and above all, between specialists attached administratively to different disciplines. The networks of cross-disciplinary influence are such that they are obliterating the old classification of the social sciences.

**Scientific Progress by Hybridization and the Postulate of Paradigmatic Upheavals**

Paradigm is a word often abused. Thomas Kuhn (1979) has explicitly acknowledged that, in the social sciences, use of the word paradigm is not justified. He explains in his preface to *The Structure of Scientific Revolutions* that it was during a stay at Palo Alto Center for Advanced Studies, in the company of social scientists, that he was led to formulate the concept of paradigm with the primary purpose of making clear the essential difference between natural sciences and the social sciences (p. 8). The reason given by Kuhn was the absence of a theoretical consensus in any discipline of the social sciences.

Are there, in the social sciences, instances of paradigmatic upheavals comparable to those generated by Copernicus, Newton, Darwin, or Einstein? Can the theories of Keynes, Chomsky, or Parsons be described as paradigmatic? In the social sciences, does progress occur through paradigmatic revolutions or through cumulative processes? Are there really paradigms in the social sciences?

Several major theories may coexist within a formal discipline, but there is a paradigm only when one testable theory alone dominates all other theories and is accepted by the entire scientific community. When
Pasteur discovered the microbe, the theory of spontaneous generation collapsed, and contagion became the new paradigm. In the social sciences, however, we see at best a confrontation between several nontestable theories. Most of the time there is not even a confrontation but careful mutual avoidance, superb disregard, on all sides; this is a relatively common occurrence owing to the size of scientific communities and its division into schools. This is true for all countries no matter the size.

This mutual disregard is an old practice in the social sciences. At the turn of the century, the great scholars did not communicate at all or very little. In the writings of Weber, there is no reference to his contemporary, Durkheim. Yet Weber was acquainted with Durkheim’s journal *l’Année Sociologique*. For his part, Durkheim, who could read German, makes only one fleeting reference to Weber. Yet they worked on a number of the same subjects such as religion. Durkheim does no more than mention Simmel and Tonnies in passing. Harshly criticized by Pareto, Durkheim never alluded to Pareto’s work. Pareto’s judgment of Durkheim’s book on suicide was unfavorable. “Unfortunately” he wrote, “its arguments lack rigour” (Valade, 1990). Weber seems to have been unaware of Pareto’s theory on the circulation of elites, and Pareto, in his turn, says nothing about the Weberian theory of political leadership. Weber and Croce met only once and then just briefly. There was no exchange between Weber and Freud. Ernst Bloch and George Lukács met regularly with Weber in Heidelberg, but their work shows no sign of Weber’s influence nor was there any communication between Weber and Spengler. Of Weber’s contemporaries, the only one who referred to him was Karl Jaspers, but he was a philosopher (Mommsen & Osterhammel, 1987). As was noted by Raymond Aron, each of the three great sociologists—Weber, Durkheim, Pareto—followed a “solitary path.”

Many examples could be cited of scholars co-existing in the same discipline without influencing one another, such as Angus Campbell and Paul Lazarsfeld, who nevertheless devoted a large part of their lives to studying the same political behavior. The same remark can be made with reference to other topical fields. It is not a bad thing to pit theories one against the other, but there must be debate. There are no paradigms in the social sciences because each discipline is fragmented.

The more ambitious a theory is, the less it can be directly tested by the data available. In the social sciences, there are no “fundamental discoveries” as there sometimes are in the natural sciences. Instead, unverifiable theories are constructed. Consider Malthusianism for instance. Is it a theory or a paradigm? Malthusianism is one of the major theories in the history of the social sciences. Malthus influenced many scientists, primarily Charles Darwin, who acknowledged Malthus as one of his main sources of inspiration. A host of sociologists, political scientists, demographers, and economists took their cue from Malthus either to agree or
to disagree with him. But when demographic conditions changed in the
West, Malthus's projections were invalidated, and he was condemned as a
false prophet. However, if we consider today the gap between economic
development and population growth in Africa, Asia, or Latin America,
he could be hailed as a great visionary. We need only agree to an asyn-
chronous comparison between the England of his time and the Third
World to admit the asynchronous validity of his theory. Should we go
further and talk of a Malthusian paradigm?

Today no paradigm seeks to order any discipline of the social sci-
ences. In fact, the word *paradigm* should be excluded from the literature
unless it is placed between quotation marks. The process of hybridiza-
tion of specialties does not encounter disciplinary paradigms.

**The Spread of Concepts, Methods, and Theories Across Social Sciences**

The process of hybridization consists first of all in borrowing and
lending concepts, methods, and theories.

*The Diffusion of Concepts*

Numerous scholars have denounced the conceptual confusion and
the polysemy of terms in various disciplines. This semantic problem comes
from the spread of concepts from one discipline to another. Borrowed
concepts need some adaptation to the context of the new discipline, be-
cause a concept is not only a term, but it is also a notion or an idea. A
recent study of more than 400 concepts used in the social sciences has
found few neologisms, and this can be explained by the fact that more
concepts are borrowed than created.

We can neglect the etymology of concepts in order to stress how bor-
rowing fertilizes imagination. The word *role* comes from the theater, but
Max Weber gave it a sociological meaning. From sociology this concept
spread everywhere. The word *revolution* was proposed by Copernicus,
but it was first applied to politics by Louis XIV. Historians adopted it,
sociologists articulated it before offering it to political science. The pat-
rimony of each social science is full of borrowed concepts, which are
hybrids in the sense that they were concocted in other disciplines and
replanted skillfully into another. Using the *International Encyclopaedia of
Social Sciences* (Sills, 1968) and the analytical indexes of some important
books, this author has compiled an inventory of more than 200 concepts
“imported” into political science. In the process of adoption and adapta-
tion, many of these concepts have changed their semantic meaning.

Many concepts have multiple origins. Authoritarianism has two roots,
one psychological and one ideological. It is often inadvertently interchange-
able with despotism, autocracy, absolutism, dictatorship, etc. Authority has
been analyzed from different disciplinary perspectives by Malinowski, Weber,
Parsons, Lasswell, Kaplan, B. de Jouvenel, and C. J. Friedrich, among others. The concept of culture (civic, political, national) has many variants—e.g., cultural convergence, cultural configuration, cultural evolution, cultural integration, cultural lag, cultural parallelism, cultural pluralism, cultural relativity, cultural system, and post-materialist culture.

Max Weber and Karl Marx, both hybrid scholars, were the most prolific generators of concepts. Only Aristotle is comparable to them. Almond and Parsons are also the fathers of an impressive number of concepts. Concepts are often germinal grains of theories: structure generates structuralism, system becomes systemism, capital engenders capitalism, and so on.

**Borrowing Methods**

Distinctions should be made between scientific reasoning (in the tradition of J. S. Mill, Emile Durkheim, or Hubert Blalock), strategy of investigation, method of research, and technological ability. All four are cross-disciplinary. Sociology and political science rarely import directly from logic, mathematics, or statistics. Usually they find an intermediary in certain sectors of psychology or economics, which have played a crucial role in their methodological enrichment. Tabular demonstration, graphic presentation, summation, measures of variability, ratios, rates, sampling distribution, statistical inference, binomial distribution, multiple regression, linear correlation, contingency, factor analysis, and so on, have not been imagined by sociologists or political scientists. All have been imported, and some, after improvement, have been exported in refined forms.

A substantial number of sociologists and political scientists are familiar with the scaling method elaborated by psychologists, the path analysis imported from biology via economics, the multivariate measuring used by economists, and the linear structural relation forged by the statistician Joreskog. To the rich methodology of the *American Soldier*, edited by Samuel Stouffer (1949), have collaborated representatives of various disciplines.

Up to a certain point, the introduction of mathematics and statistics into social sciences has been valuable not only for their own contributions but also as an entree for additional borrowing. Adoption of these mathematical methods and models has paid several dividends: the rigor necessary for modeling, for example, has also been invaluable in developing logical arguments, even for work which forgoes mathematical presentation.

Because it is unnecessary to obtain a license in order to adopt a method or a research technique, the import has been sometimes indiscriminate. What is needed is good sense in applying the method to a new field. Too many social scientists are confusing scientific reasoning, research strategy, and technological tools. Today the main source of disputes
among sociologists and among political scientists is not, as many people believe, ideology, but imported methodology.

The borrowing of statistical methods and techniques is not always beneficial. Many social scientists who use quantitative methods extend the borders of knowledge. However, others are motivated mainly by an interest in technique rather than substance. They routinely build unverifiable models, over-quantify, and over-model. They often choose to discuss minor issues, spending much talent and energy to improve a correlation coefficient, or to split a hair into four by factor analysis. They are productive scholars—any input into the computer will result in a mechanical output. Few of their papers see the light of day in respected journals because most are characterized by a painful contrast between highly sophisticated analytical techniques and poor imagination in research design, or data that are too weak to support the powerful techniques utilized (Dogan, 1994).

Theories Across Disciplines

Examples of theoretical cross-fertilization abound. Interest group theory's most cited work, David B. Truman's (1951) The Governmental Process, draws heavily on sociological theories of groups. Mancur Olson's (1965) attack on traditional interest group theory, The Logic of Collective Action, was based on economics. Meanwhile, sociologists and economists have borrowed from interest group theories developed by political scientists. The theories of sister disciplines have often confronted one another on the grounds of political science. "Rational choice analysis" is a case in point. A theory is discredited only by replacing it, usually with the aid of theories from outside the discipline.

Theorists of social systems have often used extensive analogies with biological systems; biology first developed the concept of "system" as a way to organize life and of organic systems as phenomena not reducible to their constituent chemistry. Some structural functionalists have argued that social systems are like biological systems in that they are self-regulating and homeostatic. These theorists also noted that certain functions have to be performed in any biological system and used the analogy to ask what functions were vital to social systems. Systems theory drew primarily from some sectors of sociology. The theory of dependence, which seduced so many Latin American specialists, originates in the work of a group of economists, sociologists, and demographers in cooperation with statisticians from the United Nations. Theories decay, old theories are superseded by new ones. One could read today with great interest dozens of political philosophers and grand theorists of the past and cite them with pleasure. But only a handful of theories formulated before World War II are still alive. Theories survive more easily in linguistics
and economics. Specialized domains need theoretical orientations, but a discipline as a whole cannot have a universal and monopolistic theory.

**Sociology in the Constellation of Social Sciences**

In the space of four decades, sociology has experienced first a marked monodisciplinary expansion then a marked dispersal beyond its boundaries. In the period just after World War II, sociology was adopted as an official academic discipline in only a few countries, in particular the United States and Canada. In Europe it had to start practically from scratch, especially in Germany and Italy. In recent times, its growth was spectacular in many countries from Scandinavia to Japan.

In France, in 1950, the number of academics who could claim in their professional capacity to be sociologists was no doubt under two dozen. Other academics, without being primarily sociologists (e.g., historians, psychologists, geographers, philosophers), contributed to the revival of sociology. Four decades later, the Who's Who in *Sociologie Francaise et Francophone* contained some 1,500 names, including about 1,300 French, with 1,100 genuine sociologists and 200 related branches, among whom 500 lived in Paris—the biggest concentration of sociologists in the world. In the United States, the number of sociologists registered in the American Sociological Association doubled in the 1950s and doubled again in the 1960s.

Paradoxically, it was at the time when it was still modest in stature that sociology showed imperialist leanings. It would be easy to put forward a whole number of quotations in support of this assertion, but one will suffice. In 1962, at a time when sociology was not yet an independent discipline in Oxford and Cambridge and scarcely so in London, W.G. Runciman (1963) was claiming that if sociology was defined as the systematic study of collective human behavior, the disciplines of economics, demography, criminology, or politics should be considered branches of sociology (p. 1).

From 1970 on, growth started to go hand in hand with a process of fragmentation, with the result that today, in the developed democracies, sociology is a heterogeneous centrifugal discipline. Depending on how it is defined, there can be said to be between thirty-five and forty sectoral sociologies going in every direction: toward history, economics, politics, law, rural life, industry, and religion. There is no social activity that does not have its official sociologist. There are sociologies of education, of the family, of communications, of leisure, of old age, of medicine, of organizations—the list goes on and on.

As is pointed out by Neil Smelser (1988) in the introduction to his *Handbook of Sociology*, the likelihood that sociology will be denotative of an identifiable field will be diminished; it is likely that commitment to the discipline in general will diminish, and that smaller groups will seek
their interaction and identification in suborganizations that are inside or outside the American Sociological Association (p. 13).

This is true, for instance, of urban sociology. There are now more experts and researchers in the field of town planning than in the whole of traditional sociology. It is true that these experts include representatives of town planners from a wide array of disciplines—i.e., geography, economics, architecture, etc.—who have cut the umbilical cord attaching them to the mother discipline. But the most heavily populated subdiscipline in the United States at the present time is the sociology of medicine, where most of the research work is becoming bogged down in fields devoid of theoretical horizon.

As soon as the problem being addressed concerns society as a whole, cross-specialization becomes inevitable, so much so that it is often necessary to bring together a variety of specialists. What follows is a description of the content of a book which, in its day, enjoyed some success:

Each contributor has been an articulator of diverse disciplines: Boulding spans economics, mathematics and sociology; Coleman relates mathematics and sociology; Etzioni, organizational sociology and international relations; Kardiner, psychiatry and anthropology; Klausner, sociology and psychology; Levy, social theory and sinology; Pool, sociology and political science; Rapoport, biology, mathematics, philosophy, psychology and sociology; and Tiryakian, sociology and philosophy. They were chosen as men familiar with the problem of bridging disciplines, to build an image of a total society. (Klausner, 1967, p. 15)

Replace the word “discipline” with “polyspecialty” and add a generous dose of history, and you will have a better idea of the real content of this book.

As it has matured and spread out in every direction, sociology has become aware of its excessive fragmentation and of its dispersal and has felt the need to come back to its center without yet succeeding. This process is described by Ralph Turner (1991): “Sociology has gone through a cycle from emphasizing theory with little testable empirical basis to an atheoretical empiricism and back to the evaluation of research primarily for its relevance to grand theory” (p. 63). But at no time has sociology been willing to retreat behind its official borders.

**Political Science: Borrowing from Neighbors**

All major issues are crossing the formal borders of political science: the breakdown of democracy, anarchy, war and peace, generational change, the nexus of freedom-equality, individualism in advanced societies, fundamentalism in traditional societies, ruling class, public opinion. There is no communication between two political scientists analyzing the crisis of the social security system, one by abstract modeling and the other by vernacular language. The first is in contact with modelers in economics, and the second cites scholars from other disciplines.
There are many hybrid branches of political science: political sociology, political psychology, political philosophy, political geography, public administration, area studies, and so on. Other hybrid fields or subfields can be mentioned: mass behavior (related to social psychology), elite recruitment (related to sociology and history), urban politics (related to social geography), welfare states (related to social economy and social history), values (related to philosophy, ethics, and social psychology), governmental capabilities (related to law and economics), poverty in tropical countries (related to agronomy, climatology, and economic geography), and development (related to all social sciences and to several natural sciences).

Between psychology and political science, there is a hybrid domain flying its own flag: political psychology. This is a hybrid at the third generation, because psychology itself was born as a hybrid discipline, rooted partly in the natural sciences and partly in the social sciences. Political psychology has two sisters: an older one, social psychology, formally recognized in all major universities of the world; and a younger one, cognitive science, today the best endowed of the young sciences on both sides of the Atlantic. Political psychology rarely meets cognitive science, but it is in permanent contact with social psychology.

In a recent survey, D.O. Sears and C.L. Funk (1991) write that political psychology, being "an interdisciplinary endeavor runs the danger of falling between the cracks in academic institutions [because of pressures for] disciplinary orthodoxy induced by bureaucratic inertia" (p. 346). But the inventory they make, by showing how political psychology penetrated political science departments, does not justify this fear. The journal Political Psychology is a good window on this hybrid field.

In the field of political psychology, we find the provinces of political socialization, role theory, alienation, psycho-biography, personality analysis, political attitudes and beliefs, small groups, topological analysis of political leaders, national character, mass participation, generations, political dissatisfaction, and a rich methodological area—i.e., attitude measurement, sociometric measurement, content analysis, clinical method, quasi-experimental approach and, particularly, survey research.

Just as there are intersections between political science and psychology, there are multiple connections between political science and geography: geopolitics, electoral geography, urban politics, territorial bases of federalism, spatial organization of society (core-periphery, city-hinterland), environmental problems, urban-rural differences, territorial aspects of social mobilization, etc. Demography is an intervening dimension in political geography.

In the collection The Structure of Political Geography by Kasterson and Minghi (1969), many chapters are of interest even for political scientists who are not oriented toward geography (Ratzel's laws of the spatial growth...
of states, geopolitical regions, transaction flow analysis, heartland and rimland, the impact of black migration, and so on). The concept of center-periphery has obviously a geographical dimension.

Political science and geography meet also in the domain of electoral geography, particularly for the analysis of aggregate data in countries characterized by a great territorial diversity, and for which information is available at the level of small administrative units. The privileged countries from this point of view are, or were until recently, France, Italy, Spain, Portugal, Belgium, Norway, Finland, Austria, and Canada.

The hybrid field of geography has a series of specialized journals which are interdisciplinary bridges—e.g., *Economic Geography, Urban Geography, International Journal of Urban and Regional Research, Political Geography*.

Political scientists and sociologists are still adopting, as a unit of analysis, the nation-state at a moment when there are in the world more giant cities with over 1 million inhabitants than independent states which reach this level. The world is increasingly dominated by giant cities (Dogan & Kasarda, 1987). Geographers and urbanists are in the forefront of this domain, proposing theoretical frameworks, concepts, and methods of measurement. Urban studies are expanding and may soon become an independent discipline. Today in almost all countries, advanced and developing, the number of specialists in “urbanology” is higher than the number of political scientists. “Urban politics” is a growing field.

**HISTORY AS AN OPEN DISCIPLINE**

History is no doubt the most heterogeneous discipline, dispersed in time and space. It is also, by reason of circumstances, the most open discipline. Sooner or later everything falls into the historian’s net.

The dispute over the role and borders of history, which in France goes back to Durkheim, Simiand, and Seignobos, does not seem to be over. Three generations later, history has been excluded from the social sciences under the authority of an international institution, Unesco. History is not numbered among the so-called nomothetic sciences covered by the first volume published by Unesco (1970) on “Main Trends of Research in the Social and Human Sciences.” The historians do not appear to have reacted vigorously to this affront. Indeed, some historians have come to terms with it. Thus, for Pierre Chaunu (1979), “the progress of history in the last 50 years is the result of a series of marriages: with economics, then with demography, even with geography...with ethnology, sociology and psychoanalysis. When all is said and done, the new history sees itself as something like an auxiliary science” (p. 5). And here we have the word *auxiliary* which was previously such a sore point. Such is not the opinion of the *Annales* School (*Annales, 1989, p. 1323*), which is
resolutely committed to interdisciplinarity. "History will progress only in the context of interdisciplinarity, and one of its tasks is to renew the bases of interdisciplinarity" (Le Goff, 1991, p. 4).

Provided that the focus is on the long time span and the comparative approach, there is agreement between Durkheim and Braudel. At a distance of sixty years, using different words, they say much the same thing: history can be a science only insofar as it compares, and there can be no explanation without comparison.

Once it starts comparing, history becomes indistinct from sociology (Durkheim in the first issue of *l'Année Sociologique*). Braudel (1960), for his part, is just as accommodating: "Where the long time span is concerned, the point is not simply that history and sociology tie in with each other and support each other but rather that they merge into one" (p. 93). But here we are talking about only a part of history, that part which compares while considering the long time span, for other fields of history have nothing, or very little, to do with sociology. Similarly, there are not many sociologists who need to have recourse to history for the resolution of a problem with which they are concerned. Durkheim and Braudel would have been more explicit if, instead of considering their discipline as a whole, they had referred clearly to their condominium, which is now called comparative social history or historical sociology. Once it is accepted that history and sociology overlap, only in certain important but delimited areas, the long territorial dispute between history and sociology becomes a thing of the past.

Like all the formal social sciences, "history must attend to its own provinces" (*Annales*, 1988, p. 293). But this means that each sector of history is brought face to face with a sector of another discipline. Exchanges with economics have thus generated economic history, which is of interest only to some historians and some economists. However, this interest has been in sufficiently large numbers to provide material for several major journals. Each human activity has its historian, who, in order to perform his task, has to hunt in other people's lands. In the history of urbanization, for example, where the historian meets geographers, demographers, economists, and sociologists, he or she can hoist his own flag. However, urban history is not an independent field, whereas economic history is well established.

**FROM SOCIAL ANTHROPOLOGY TO HYBRID "AREA STUDIES"**

In a few years, toward the end of the 1950s and the beginning of the 1960s, about fifty colonies achieved national independence. At that time, some 3,000 American social scientists were sent, with the financial help of American foundations, to Asia, Africa, and Latin America in order to
study the new independent nation states. They covered the planet with hundreds of books and articles and have become "area specialists." They have replaced the European scholars who returned home after the withdrawal of Britain, France, Belgium, the Netherlands, and Portugal from their colonies.

This spontaneous generation of area specialists was born hybrid. The topics of their research blurred the disciplinary boundaries. They and their successors were confined to non-Western underdeveloped countries, to stateless societies, to what Joel S. Migdal (1983) calls "weak states and strong societies," that is to say to the privileged territory of an old discipline, anthropology, which had flourished in Western Europe around the turn of the century. The European anthropologists had discovered these "primitive" societies long before the American area specialists had done so.

There is a basic difference between the two. The European anthropologists were monodisciplinary scholars with a clear identity, vocabulary, and theoretical framework. They were exporters of knowledge to the entire spectrum of social sciences. Some of them had imperialistic ambitions, proclaiming that anthropology was the master science. All other disciplines, including political science and sociology, were considered by these academic imperialists to be provinces of anthropology.

But when the European empires, which covered half of the planet, started to disintegrate, these anthropologists lost their research fields. Anthropology shrank. The abandoned territories were delivered to specialists in area studies. In contrast to their predecessors, the new invaders did not fall within a specific discipline. Few of them were trained in anthropology, and most of them were neither theoreticians nor methodologists.

As a result of these developments, David Easton (1959) was eager to establish a new subfield—political anthropology. He published, in 1959, an essay under this title. Retrospectively, it can be said that this was a sickly child, born at a moment when the new hegemonic power needed nondisciplinary specialists of these new countries and not experts in anthropology, a discipline which began to be overtaken by other disciplines. It is significant that, at the same moment, Margaret Mead, Alfred Kroeber, and Clyde Kluckholm were concerned by seeing their discipline "swallowed [and] isolated from the community of scientists and scholars" (Mead, 1961, p. 475). The established field of anthropology fell from imperialism to being an "unsuitable scientific repository" (p. 476).

Meanwhile, a French demographer-economist-sociologist, Alfred Sauvy (1956), suggested calling these underprivileged new countries "The Third World" by analogy with the Third Estate before the French Revolution. This label survived even though the "second world" had already imploded. It is probable that sooner or later this label will be abandoned.
because it includes an enormous variety of countries: old civilizations like China and artificial states in Africa, rich countries like Saudi Arabia, and extremely poor countries. Which discipline will propose the new labels?

Area studies in the Third World give priority to topics which seem important to understanding a particular country. "They do not respect disciplinary boundaries" (Lambert, 1991, p. 190). In area studies, humanities are well represented. "Area specialists who are in the social sciences are likely to have a great deal more contact and shared intellectual activity with human sciences than do most of their non area-oriented disciplinary colleagues" (Lambert, 1991, p. 192). It is at the junction of anthropology, history, literature, and political science that "much of the genuinely interdisciplinary work in area studies occurs" (p. 192).

Describing the struggle between the conventional disciplines and area studies, which has affected the self-identity of scholars, Lucian W. Pye (1975) writes: "The emergence of area specialization has changed perspectives and raised questions which go to the foundations of the social sciences" (p. 3). These foundations have been altered much more by the hybrid fields at the interstices of disciplines.

**THE IVORY TOWER OF ECONOMICS: THE CONSEQUENCES OF MONODISCIPLINARY SELF-CONFINEMENT**

Some economists advocate an "imperialistic expansion of economics into the traditional domains of sociology, political science, anthropology, law and social biology" (Hirschleifer, 1985, p. 53). Several of these imperialists are famous scholars, including a few Nobel laureates. A kind of manifesto has been published in *The American Economic Review*.

It is ultimately impossible to carve off a distinct territory for economics, bordering upon but separated from other social disciplines. Economics interpenetrates them all, and is reciprocally penetrated by them. There is only one social science. What gives economics its imperialist invasive power is that our analytical categories are truly universal in applicability...Thus economics really does constitute the universal grammar of social science. (Hirschleifer, 1985, p. 53)

This view is anachronistic and contrasts with the perception of economics as a shrinking discipline: "Economics as a formal discipline is suffering because its main achievements—conceptualization, theory, modeling and mathematization—have been accompanied by an excessive isolation from the other social sciences" (Beaud, 1991, p. 157). In reality, the recent history of the social sciences shows that vast areas of scientific knowledge have been abandoned by the science of economics. These areas have been taken over by neighboring disciplines.

At one particular point, economics reached a fork in the path: it could have chosen intellectual expansion, the penetration of other
disciplines at the cost of diversification and at the risk of dispersal; it chose instead to remain unflinchingly pure, true to itself, thereby forfeiting vast territories. Yet many economists consider that the choices of purity, methodological rigor, and hermetic terminology were the right ones.

Self-sufficiency, to use a word familiar to economists, leads sooner or later to a shrinking of borders. But this does not imply general impoverishment since the areas abandoned by the economists were soon cultivated by others. Those abandoned areas now have their own realms: management, political economy, development science, the comparative study of Third World countries, and economic and social history. The position of economics in the constellation of the social sciences might have been more enviable today had it not withdrawn into itself. This situation is particularly surprising in that few classical scholars have failed to assign a central place in their theories to the relationship between economy, society, and politics, from Marx and Weber to Schumpeter, Polanyi, Parsons, and Smelser (Martinelli & Smelser, 1990), not forgetting Pareto.

A whole army of famous American economists has given priority to the study of political phenomena, even if they have kept one foot in economics. Some eclectic economists denounce the reductionism advocated by other economists, particularly with reference to research on development: development is reduced to economic development; this is reduced to growth; which in turn is reduced to investment—in other words, to accumulation. It has taken several decades to dethrone per capita gross national product as a composite indicator of development. Gunnar Myrdal, the great economist, railed against economists who were in favor of unidisciplinary models.

In many countries, large numbers of economists have locked themselves up in an ivory tower and, as a result, whole areas have escaped their scrutiny. Their contribution to the problem of the development of the Third World, for instance, is rather modest when compared with the work of political scientists and sociologists. This is particularly true in the United States, Latin America, and India.

If a discipline has a tendency to turn in upon itself, if it does not open up enough, if its specialties do not hybridize, the neighboring territories do not remain barren. Many economists have had a somewhat condescending attitude toward political science. This has resulted in the development, side by side and in competition with economics, of a new corporate body, with an extremely active and large membership in the United States, the United Kingdom, and Scandinavia: political economy, protected by only one of its parents and renamed through the revival of an old name from the French nomenclature of the sciences. Political economy is currently one of the main provinces of American political science with a prolific output and renowned journals. It is one of the most popular sectors among doctoral students in political science. Political science is the greatest beneficiary of the monodisciplinary self-confinement of economics.
Thirty years ago, F.A. Hayek (1956) wrote that “nobody can be a great economist who is only an economist—and I am even tempted to add that the economist who is only an economist is likely to become a nuisance if not a positive danger” (p. 463). It may now be too late for economics to recoup the territories conquered by political science, sociology, economic history, and particularly by political economy. Some economists are still hoping: “It is necessary to reduce the use of the clause *ceteris paribus*, to adopt an interdisciplinary approach, that is to say to open economics to multidimensionality” (Bartoli, 1991, p. 490). Abandonment of reasoning by assumptions and by theorems would not be enough because the reality has changed: “Economic issues become politicized and political systems become increasingly preoccupied with economic affairs” (Frieden & Lake, 1991, p. 5).

**Conclusion**

In the beginning, there were seven academic disciplines: logic, mathematics, geometry, grammar, rhetoric, music, and astrology. These disciplines remained separately sacred until the seventeenth century when a few heretics challenged them. Some time later, the philosopher Auguste Comte, the founder of positivism, had built a hierarchy of sciences, with mathematics at the summit and biology at the bottom, followed by a second classification with sociology as the youngest and the most complex discipline. But soon this naïve scaffolding was demolished. Since the middle of the nineteenth century, the history of science is, first of all, a description of the multiplication of subdisciplines and of new branches of knowledge.

At a certain point in time, the map of scientific knowledge became so unmanageable and confusing that librarians, particularly at the Library of Congress in Washington, DC and at the Bibliothèque Nationale in Paris, and also in London and Berlin, started to make inventories and open avenues, alleys, and passages through the “scientific jungle” but by doing so they have in fact cemented the old borders of disciplines. Today, librarians know better than scientists that libraries are in part cemeteries of books and repositories of out-of-date knowledge. They know that the living part of libraries does no longer recognize the older borders between disciplines. The problems generated by the hybridization of social science knowledge and the emergence of new special fields are today also the problems of the librarians.

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ADDITIONAL REFERENCES


Meeting the Information Needs of Interdisciplinary Scholars: Issues for Administrators of Large University Libraries

SUSAN E. SEARING

ABSTRACT

LARGE UNIVERSITY LIBRARIES FACE particular challenges in selecting information resources, organizing them, and providing direct services to support interdisciplinary scholarship. The tension between generalization and specialization is manifested in these core activities and in the debate over branch versus centralized libraries. External factors affecting library strategies include the organization of interdisciplinary research and teaching, institutional downsizing, new management theories, changes in scholarly communication, and the forthright political nature of some interdisciplinary fields. Although this article focuses on describing the challenges posed by interdisciplinarity rather than recommending solutions, examples of innovative approaches are noted.

INTRODUCTION

Interdisciplinary research and teaching is blossoming in North American universities. Enrollments in programs designated as interdisciplinary have increased dramatically, while the revival of general education requirements has helped to mainstream interdisciplinary approaches to undergraduate learning (Gaff, 1989; Casey, 1994). This trend has triggered a crisis within traditional disciplines. From art history to physics, the utility of “discipline” as both concept and practice is now widely questioned (Klein, 1993). As Michael T. Ryan (1994) notes: “The ‘I word’ is all-pervasive; its consequences are everywhere: in the curriculum, in hiring decisions, in research, in the organization of institutions” (p. 100).

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LIBRARY TRENDS, Vol. 45, No. 2, Fall 1996, pp. 315-42
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Despite its prevalence, however, this trend has failed to attract the attention of academic library leaders. A search of the literature on librarianship and higher education yields few publications that grapple with the implications of interdisciplinary research and teaching on academic libraries.

The frog-in-the-soup-pot metaphor seems apt here. A frog tossed into a pot of boiling water will instantly leap out, but a frog immersed in a pot of lukewarm water, being a cold-blooded creature, will contentedly simmer to death as the water climbs to the boiling point. Librarians sit in the middle of the soup pot of higher education. They make incremental changes in library policies and practices in response to changing realities in research and teaching on and off campus. The curriculum bubbles around them, and so much else is going on in the busy kitchen—the delivery of new high-tech gadgets, the temperamental antics of knife-wielding budget chefs, the demanding special orders of influential diners—that it is easy to overlook the obvious.

**Challenges for Library Administrators**

This article aims to provide an overview of administrative issues in supporting interdisciplinary library use at large universities. Most librarians still conceptualize their responsibilities in terms of major library functions:

1. the selection, acquisition, and management of information resources, still dubbed "collection development" although the stress on local ownership is fading;
2. the organization of information, encompassing cataloging, classification, and their variants in the electronic environment;
3. direct services to users, including reference and its younger sibling, library instruction.

The scant literature on the impact of interdisciplinary scholarship on research libraries circles around these three themes; consequently, this article employs these as useful lenses for examining current thinking and practice. All three areas reveal a tension between generalization and specialization, which is written large in the organizational structure of multi-library universities. After looking at the issues internal to libraries, this article turns its vision outward toward the broader domains of higher education and the scholarly community, with particular attention to the politics of interdisciplinarity. Although this article focuses on describing the challenges posed by interdisciplinarity rather than recommending solutions, examples of innovative approaches are noted.¹

**Information Resources**

The university library is obligated to provide knowledge resources in support of the intellectual pursuits of faculty and students. How can library
policies and procedures assure that interdisciplinary subjects do not slip through holes in the collecting net?

Ryan (1994) describes the challenges that selectors face in keeping abreast of new ideas, vocabularies, and research methods in the disciplines. The emergence of hybrid interdisciplinary fields exacerbates the problem for the individual selector and adds a problem of coordination for the library overall. Generally speaking, the work of collection development is organized to mirror the organization of knowledge within the university, with materials budgets linked to specific academic departments. At libraries with a number of selectors on the staff—all seeking to maximize the impact of their limited budgets—a constant redrawing of boundaries between one’s subject domain and another’s often ensues. A subject can easily be “lost” if no one accepts responsibility for it—a particular danger in interdisciplinary and “supradisciplinary” knowledge areas (Metz & Foltin, 1990).

One solution is to establish a full- or part-time position to focus on building the collection in a new field. The Diversity Librarian at the University of Michigan, for example, is responsible “for developing and managing interdisciplinary collections in areas variously described as minority studies, sexual orientation studies, and multicultural studies” (University of Michigan, 1994). Other examples include the Women’s Studies/Women in Development Librarian at the University of Illinois at Urbana-Champaign and the Environmental Resources Librarian at Harvard. The latter takes a proactive role in the creation of electronic information services as well as acquiring published resources.

Michael F. Winter calls for restructuring and strengthening the subject specialist approach in libraries (in this issue of Library Trends). But the prospect of hiring a new subject specialist for every new interdisciplinary program troubles senior library managers, who “conjure up a Pandora’s box full of unwanted staffing increments and budget-busting program costs” (Ryan, 1994, p. 102). Some libraries are experimenting with creative solutions. For example, the University of Minnesota and the University of Michigan are sharing a selector for South Asian Studies. He is based in Minneapolis but makes frequent visits to Ann Arbor; his responsibilities include collection management, in-depth reference service, faculty liaison, and library instruction using distance education methods. A different approach has been taken at New York University, where an oversight bibliographer has been designated to monitor interdisciplinary acquisitions across several subjects.

A convincing argument for “dedicated expertise concentrated in a single person” cannot always be made. While new academic programs usually bring new service needs, “their impact on collection development policy may be marginal, since the literatures they use and to which they in turn contribute already exist somewhere in the library” (Ryan, 1994,
In the early days of women's studies, for example, attention was focused on rediscovering forgotten texts by and about women and reassessing the classics, from Shakespeare to Freud. As the field matured, it generated more and more original literature, and the need for specialist librarians became evident (Searing & Ariel, 1987). The difficult question for library administrators is: when does it become more cost-effective to centralize decision-making in a single expert instead of coordinating it across several people? Because there are no simple criteria for determining this, campus politics can play a prominent role in the creation or continuation of specialist positions.

Collection development in interdisciplinary fields often hinges on collaboration among existing staff with traditional subject backgrounds. Individualistic selectors must undergo a "resocialization" process to learn cooperative work styles (Ryan, 1994, p. 104). Good communication is essential to avoid gaps in the collection, and detailed collection development policies are desirable, especially at multi-library institutions (DeFelice & Rinaldo, 1994). Libraries are no different than other university units where scholars and researchers pool their talents and erudition in collaborative interdisciplinary projects.

A small body of practical literature is available to assist selectors in assessing and building interdisciplinary collections. The hurdles they face include crafting effective approval plan profiles (Cox, 1987; Allen, 1987), identifying relevant items from small presses and noncommercial publishers (Fisher, 1987; Gregory, 1987), choosing nonscholarly materials (Metz & Foltin, 1990; Searing & Ariel, 1987), and keeping abreast of "invisible" subliteratures (Faries & Scott, 1995; Porter, 1995). The lack of standards, core bibliographies, and assessment tools, like the RLG conspectus, amplifies the difficulty (DeFelice & Rinaldo, 1994). Additional challenges arise when interdisciplinary fields themselves overlap and converge, as do area studies and women's studies (Mitchell, 1995).

While these problems confront the individual selector, larger managerial issues also loom. For instance, how can new interdisciplinary fields be incorporated into an existing fund allocation matrix? Of course one may ask a selector to expand his or her intellectual horizons, but if dollars do not accompany the assignment, it will be difficult to carry out. If the collection development budget mirrors the university structure of schools and departments, as is frequently the case, how will new transdepartmental interdisciplinary units be folded into library planning? The competition for resources that pits traditional departments against new research institutes and cooperative teaching programs may be carried over into the library setting.

The administrator's job would be simpler if there were consensus on the best model for organizing and staffing collection development activities in research libraries, but there is none (Cogswell, 1987; Pitschmann,
Some libraries rely primarily on full-time bibliographers, while others disperse collection responsibilities to part-time selectors with additional assignments; many combine the two approaches. No organizational model appears inherently better for interdisciplinary studies. The process of collection development may be more critical than its organization. Hur-Li Lee (1995) argues that interdisciplinary studies spotlight deep flaws in the ways librarians approach collection development. Insisting that "collections are built as the result of social interaction over time," she argues for abandoning the piecemeal attention to the various components of collection building—i.e., evaluating sources, writing policies, calculating funding formulas—to focus on the overall process and the factors that shape it (p. 186).

The "overall process" of collection development and management includes acquiring materials in all formats, enabling access to remote resources, and preserving deteriorating print and media collections. Interinstitutional partnerships have great potential to stretch library budgets and guarantee scholars access to specialized information. It is telling that three of the six subjects chosen by the CIC for cooperative collecting are interdisciplinary in scope: South Asian studies, African studies, and gay and lesbian studies.¹

**CATALOGING AND CLASSIFICATION**

Interdisciplinary scholars rely on the information structures provided by library catalogs. Their productivity as researchers and teachers often depends on convenient and effective bibliographic access to multiple bodies of literature. In turn, they create new ideas and new literatures, which catalogers attempt to fit into existing schema or, failing that, endow these with new categories and terminology.

With recent experiments in outsourcing, debates about cataloging as a core library activity have again flared into brushfires (Gorman & Holt, 1995; Waite, 1995). Arguments over standards and quality feed the flames. Limited budgets dictate a trade-off between bibliographic completeness and streamlined record production, but where should the line be drawn? This is not a new question, but it is posed with renewed urgency as serials prices continue their steep rise and library administrators face pressures to reallocate resources away from traditional functions to fund the information access enabled by new technologies.

Libraries have long sought both to control costs and to assure quality by sharing bibliographic records. Sharing can only succeed when standards are accepted and maintained. For library users seeking materials on interdisciplinary subjects, however, the standards pose problems. The two standards that cause the most difficulty for research library clientele in the United States are the subject headings and classification system promulgated by the Library of Congress.

These standards serve a gatekeeping function by maintaining knowledge frameworks into which new branches of study and new ideas must
be fit. LC subject headings are derived from the works cataloged for the Library of Congress collection and thus are, in their genesis, reactive to and reflective of the real universe of published works. Once established, however, subject headings quickly become prescriptive. Holding a newly acquired work in her hands, a cataloger seeks first to match it with existing headings. Although the Library of Congress Subject Headings is a dynamic authority in a constant state of revision, critics claim its slowness to change inhibits its usefulness (Berman, 1993; Rogers, 1993). Online catalogs typically offer keyword searching as an alternative to searching for LC-sanctioned subject terms; unfortunately, many library users do not grasp the difference between the two methods and do not conduct effective subject searches (Markey, 1984).

Even less hospitable to interdisciplinary works than the subject heading system is the LC classification system, for the simple reason that a catalog record may have multiple subject headings while a book carries only a single call number. The classification structure is a theoretical map of human knowledge, but in practical terms, it is a map of the stacks, guiding readers to places where works on similar topics can be found in physical proximity. In the electronic environment, texts are freed from the limitations of physicality, so in theory, any number of classes can be assigned. However, few catalogers are bothering to classify electronic resources, even when they do enter them in the online catalog.

Many writers have commented on the failure of current cataloging and classification practices to adequately describe interdisciplinary materials, and some have proposed alternatives or reforms (in the field of women's studies, for instance, see Marshall, 1977; Capek, 1987; Mowery, 1989; Olson, 1992). But as Klein (in this issue of Library Trends) points out, "categories of knowledge are institutions, not in the conventional sense of buildings and organizations but a set of constructed and maintained marks in cultural space." It is the nature of institutions to resist change, but fortunately institutional foot dragging has not completely silenced the critics and visionaries.

New approaches to subject headings are gradually being implemented, as the long-held dream of enriching catalog records with keywords from tables of contents and back-of-the-book indexes has garnered support from vendors of bibliographic data. This improvement will especially benefit the seekers of interdisciplinary writings, because cutting-edge articles and symposium papers are often gathered in collective volumes. Recent research by the ACRL Women's Studies Section, for example, has confirmed Searing's (1992) contention that anthologies constitute a significant portion of the total book output in women's studies, and that bibliographic access via standard indexes and catalog records is incomplete.

New approaches to classification are less common in practice, but some interesting ideas have been advanced. Charlene S. Hurt (1991) suggests that electronic bibliographic access may someday replace shelf
browsing, even for traditional print collections, and thus free us to shelve books in new ways:

By devising software that helps library users move among disciplines without difficulty, and by providing the expert systems that will help them follow linkages from source to source, we can replace some of the serendipity that happens when browsing in the stacks. Once we can browse the online catalog as effectively as if we were standing at the shelf, perhaps we could give up arranging all of our books in call number order on the shelves. Rather we could shelve together all the books written in the 1950s, or those attributed to the post-modern movement. These arrangements could change as the curriculum changes or as a new organization comes to mind. (pp. 11-12)

Hurt leaves open to speculation what forces would determine this ever-changing arrangement of materials, and one can easily imagine a dystopian scene, in which library administrators are called upon to referee among conflicting views of knowledge structures, and in which the stacks are in constant disarray as shelvers scurry madly to reposition materials. In fact, this vision could only be implemented in the sort of high-use, open environment with a limited collection size that Hurt describes in her article.

Gary P. Radford (1995) takes an approach that is at once more philosophical and more practical. Quoting several postmodernist thinkers, Radford rejects the positivist models of knowledge that have shaped the contemporary library. He acknowledges that “there is a tension between the goals of order and completeness with the goal of providing the user with service” (p. 337) and further asserts that, in an electronic information environment, the “subjectivities and ambiguities of the individual user” and the ways that he or she chooses to order and relate texts constitute the real knowledge structures. “The librarian’s role becomes that of a guide, not only to the pre-existing order of the library that comprises its catalogs and indexes, but to the creation of new orders [emphasis in original] made possible by the capabilities of computer searching” (p. 339). “Temporary collections of texts,” not on shelves as determined by librarians but in electronic files as created by users, will become the norm (p. 339).

Both authors envision “libraries”—in Hurt’s case a building, in Radford’s a virtual library—which are highly responsive to changing information needs. In the face of complexity, which Klein identifies as a salient characteristic of contemporary knowledge, organizational flexibility is key. Yet libraries are typified by high levels of standardization, especially in cataloging, and standardization has an “insidious effect...in stifling creativity” (Allen, 1995, p. 656).

Library administrators must balance the value of excellence in cataloging against other demands on the library’s resources. They also ought to consider whether certain workflow patterns inhibit, support, or have a neutral impact on the processing of interdisciplinary materials. The
traditional division of behind-the-scenes work by function rather than subject is vanishing. Among the successful alternative models are the University of Illinois at Urbana-Champaign, with subject experts in forty-five departmental libraries to provide multifaceted library service including cataloging; and the University of Wisconsin-Madison, where technical work in acquisitions and cataloging is centralized and "clustered" along broad subject lines (humanities, social sciences, sciences, area studies). It is not clear, however, that any particular model is best suited to interdisciplinary fields.

**Direct Services to Library Users**

The third broad area of library operations, usually labeled "public services," encompasses the many ways in which information seekers interact with library staff and library systems. Historically denoting reference and circulation services dispensed from a desk or counter, "public services" have expanded to include document delivery, user instruction, library publishing, interface design, and outreach. Do information seekers in interdisciplinary fields need different kinds of services than scholars in traditional fields?

Bryce L. Allen and Brett Sutton (1993) observed researchers at the Beckman Institute at the University of Illinois at Urbana-Champaign, a research center on human and machine intelligence, to determine ways to structure library service to "user communities that do not fit the typical department-centered or discipline-based structure" (p. 500). They mapped "boundary-spanning groups" who require a broader range of information than do traditional, discipline-based research teams, and they discovered that the researchers' reading interests shifted markedly from one semester to the next. Allen and Sutton concluded that "planning for library service to a rapidly changing user community seems to require new and flexible approaches" (p. 514). For example, services alerting interdisciplinary scholars to a range of new information outside their core fields are more valuable than typical SDI services based on narrow interest profiles.

Meeting the needs of interdisciplinary scholars entails developing new services and rethinking old ones. At the State University of New York at Buffalo, customized new books lists spotlight recent acquisitions in user-selected fields (Pikoff, 1991). More and more libraries offer unmediated access to current awareness services, such as CARL UnCover Reveal, that permit end-users to establish personal profiles by topic or journal title. Such services help satisfy the singular and unpredictable information needs of interdisciplinary scholars.

*Library User Education*

Where information needs change rapidly, and where subjects interconnect in ways not foreseen by catalogers or indexers, information
seekers must become skilled in formulating searches and evaluating results (Fiscella, 1989). A commitment to empowering library users underlies recent advances in library user education. Early instructional programs stressed orientation to the library's organizational systems, both spatial and conceptual but, over the past twenty years, the focus has shifted to "information literacy," transferable skills, and lifelong learning (Breivik & Gee, 1989; Baker & Litzinger, 1992; Farmer & Mech, 1992). Librarians who teach library users understand that "bibliographic instruction...is significant when it develops a user astute and flexible in information gathering. An intelligent approach to information involves the ability to apply learning obtained in one area to fresh problems, and to bring the skills of critical thinking to the process of information gathering" (Frick, 1992, p. 14). An integrative approach to library instruction encourages information seekers to conceptualize their queries not as topics in particular disciplines, but as questions that may be answered from numerous perspectives; thus library instruction outfits students with a "toolbox" of searching skills and bibliographic knowledge (Chu, 1993).

Most writing on the library's growing role in teaching information literacy overlooks interdisciplinarity as a factor, focusing instead on advances in pedagogical method, changing student demographics, and the ascendency of electronic information (Baker & Litzinger, 1992). However, contemporary notions of information literacy fit comfortably with an interdisciplinary perspective. The reinstatement of general education requirements for undergraduates, often with an explicitly interdisciplinary and multicultural slant, creates opportunities to integrate basic library instruction into every student's core educational experience. Building on basic problem-solving skills, library instruction in upper-level and graduate courses typically emphasizes techniques and tools for optimal use of discipline-based literatures. Indeed, one way to comprehend the parameters of a discipline is through an understanding of its bibliographic conventions and structures. Yet students in interdisciplinary courses may benefit the most from library instruction, since emerging fields usually lack the bibliographic apparatus of a mature discipline. Bibliographic instruction creates classroom opportunities to explore "scholarly and institutional inclusion and exclusion," to interrogate the division between "academic" and "popular" sources, and to present reference works as "cultural artifacts" (Broidy, 1987, p. 93). Librarians are also positioned to teach how biases can influence every stage of information processing, including what gets written, published, acquired by libraries, preserved for posterity, covered in bibliographic tools, and selected by the researcher (Fink, 1989).

Perhaps because of their focus on generic searching skills and critical thinking, user education librarians tend to downplay specialization in subject fields: "Librarians are the only profession that has any hope of
gaining a comprehensive grasp of all information and knowledge as a whole, rather than just one narrow part of it, and being able to translate any given part of it to a broad range of people” (Miller, 1992, p. 155). Or, as Fink and Loomis (1995) put it:

We are no longer experts—masters and practitioners of a known body of knowledge. We are no longer experienced guides to a familiar terrain. We must be—can only be—explorers, scouts, and pathfinders, navigating unbounded, evolving sources of information to map the way for users who are now fellow searchers. (p. 3)

Reference Services

Like the pundits of library instruction, the leaders of the movement to “rethink reference” make little mention of interdisciplinary studies as a precipitating factor. Institutional downsizing, the specter of virtual libraries, and the customer-centered philosophy of quality management are the usual reasons advanced for seeking new models for reference services (Lipow, 1993). Nonetheless, the research consultation model implemented at Brandeis, Johns Hopkins, the University of Michigan, and elsewhere may be especially beneficial for library users with interdisciplinary queries. This service model places support staff or well-trained students at the public desk, with librarians available for consultation by appointment (Massey-Burzio et al., 1993).

Unfortunately, there has been no research to show what model of reference service responds most effectively to interdisciplinary needs. One might hypothesize that putting the best, most highly trained generalist professionals on the front lines provides optimum service. If the organization of the library’s resources is so tradition bound that the interdisciplinary scholar cannot find the needed information for herself, why must she be doubly inconvenienced by waiting for an appointment with a librarian? On the other hand, librarians working under the pressures of a high-demand desk shift may not have the time to reflect upon a complex inquiry and make the connections from it to all appropriate sources, terms, and approaches.

Library users wish to be self-reliant, and librarians reinforce a do-it-yourself attitude by offering open stacks, ample signage, user-friendly online catalogs, and so on. Library instruction sends the message that once one learns the system, one should be able to negotiate the library with minimal help. Yet the desire of library users to be self-sufficient is often accompanied by a counter-productive anxiety (Mellon, 1986), and “the duality of the interdisciplinary search task—the need to find information and the lack of knowledge of another discipline—potentially heightens the level of uncertainty and anxiety for the researcher” (Bartolo & Smith, 1993, p. 347). The Gateway to Information at Ohio State University is a model for empowering the user at the usual point of initial
contact with the library—the online catalog workstation—through an interface to a variety of networked electronic resources and search pathways that point to print materials as well. This approach has been adapted to facilitate interdisciplinary research in women’s studies (Krikos, 1995).

The provision of reference services to interdisciplinary scholars is complicated by the inadequacy of the secondary literature. Evidence suggests that both standard bibliographic tools and new ones intended for interdisciplinary users can be incomplete and poorly constructed (Hurd, 1992; Gerhard et al., 1993; Mesplay & Koch, 1993; Koch & Preece, 1995). Klein (1994) sums up the difficulty:

The problem of interdisciplinary information is the problem of information scattering. Appropriate materials do not appear in a single location, nor are they readily identified by cataloguing, indexing, and online services, which tend to mirror existing disciplinary categories....Searchers must develop some expertise in moving across the varied assumptions, structures, and forms of disciplinary literatures as well as the invisible colleges, networks, and hybrid communities in which interdisciplinary knowledge often develops. (pp. 15-16)

Interviews with scholars indicate that the humanities in particular cry out for a bibliographical infrastructure better attuned to the prevalence of interdisciplinary work (Gould, 1988). Online and CD-ROM databases offer more options for effective searching, but the welter of interfaces is an initial barrier for researchers whose topics span disciplines.

The Impact of Information Technology

Information technology holds considerable promise for interdisciplinary studies, even though many of the electronic reference resources available today are merely digitized versions of discipline-based print tools. In electronic formats, disciplinary resources can be manipulated with greater ease and effectiveness. Boolean searching, while often misused or underused by novice searchers, is a powerful tool for teasing specific data and references from mammoth databases. From the standpoints of time expended and precision of retrieval, end-user searching has significant benefits for the interdisciplinary researcher (Bartolo & Smith, 1993). Meanwhile, more sophisticated electronic information sources are evolving that are explicitly interdisciplinary in their content and use. Geographic information systems are a prime example.

Scholars have strong feelings about the advent of the electronic library. “[F]or some, this conception of the library as an ever-expanding web of intellectual freeplay is...the source of profound anxiety,” while others celebrate the potential to “recover the Enlightenment dream of a library that offers not only comprehensive or universal access to knowledge but also the power to move freely within its perimeters.” With access to an encyclopedic virtual library, “it will become possible for readers
to integrate older and newer bodies of knowledge into ever-changing synthetic forms” (Bloch & Hesse, 1993, pp. 6-7). Since the faculty and students who use academic libraries range from fearful to enthusiastic, librarians must develop flexible instructional and reference services.

Librarians, too, voice a spectrum of opinions, some cheerfully utopian, some gloomily pessimistic. Most chart a cautious course between the hype and the worst case scenarios (Crawford & Gorman, 1995). On a practical level, librarians grapple with many issues in managing the new technologies. How shall one select, from the plethora of commercial products and the jumble of Internet resources, those that best meet the needs of the library’s diverse clientele, including both discipline-based and interdisciplinary researchers? How should one organize, index, and promote electronic resources to alert users to their availability? How can library staff provide the same quality of assistance that they deem appropriate and necessary for users of print collections? How can they teach users to locate and evaluate electronic information? How can they guide and assist at the moment of use, when that use may occur in the office, computer lab, or home?

Increasingly, libraries are incorporating e-mail and the World Wide Web into their basic mix of services. The multimedia capabilities of the World Wide Web and its unprecedented linkages make it an attractive communication method for interdisciplinary scholars, librarians, and amateur subject specialists. Web users can easily move between general and specific information. The very quirkiness and unpredictability of the web’s information content may be an advantage at the cutting edge of interdisciplinary inquiry.

At this writing, web searching capabilities are primitive. It is hoped that improvements in search interfaces and evolving projects to “catalog” web sites will preserve the benefit of serendipitous browsing, which is arguably the web’s greatest attraction. So far, an authoritative system for selecting and indexing network resources has not emerged; OCLC’s NetFirst and similar projects are vying to set the standard. The CyberStacks project at Iowa State University is especially intriguing. By employing the Library of Congress classification system to group internet sites in science and technology, the CyberStacks home page presents users with a conceptual framework that is familiar, thus easing the transition from print-based to digital information. However, it risks replicating the known rigidities of the LC classification system (CyberStacks, 1996). The University of Tennessee Libraries also use the LC classification system as an optional path for locating and linking to web sites (UTK Libraries, 1996). Designers of home pages for interdisciplinary topics may well prefer to invent their own organizational systems.

The electronic environment calls into question many pre-existing assumptions, including notions about user behavior:
Either implicitly or explicitly, much of the current work on digital libraries assumes this idealized model of use: the lone researcher sitting at a workstation, browsing, scanning, searching, retrieving, reading, and writing. But this idealization is at odds with observed work practice... Libraries are meeting places where joint research is carried out; research is a highly collaborative activity.... Even information-seeking, the digital library activity apparently most consistent with the idealized image of solitary work, is more collaborative than generally realized.... (Levy & Marshall, 1995, p. 80)

In interdisciplinary research, project teams are the norm and, in interdisciplinary teaching, team-taught courses are common. Library administrators must consider the social context in which electronic resources will be consulted as they plan for acquiring and disseminating them.

Even when licenses or technical limitations restrict the availability of electronic information products to library settings, the challenges are daunting. At the University of Wisconsin-Madison, for example, the Electronic Library home page points to hundreds of resources, including the online catalog, bibliographic and full-text databases running on local servers and CD-ROM networks, databases accessed via scripted telnet or web connections, and the campus information system. In addition, most UW-Madison libraries have mounted their own home pages, and subject specialists are constructing subject-oriented sites—all as components of the electronic library. This rich set of electronic resources is accessible from nearly 500 workstations in thirty-four campus libraries. Students seated in the Music Library can search Medline, while faculty at the Health Sciences Center can log into the MLA Bibliography. Moreover, electronic library workstations have full Internet access via Netscape, linking users to a universe of information sources that have not been filtered through the library’s selection processes. Reference staff, especially at those libraries with longer hours, are increasingly called upon to help users search for information outside the subject scope of those libraries. In the print environment, reference librarians had a limited number of sources at their disposal; they referred users to another library if the query could not be answered from in-house collections. Now, some users expect a breadth of staff expertise that is impossible to provide on the spot. Information technology lends new urgency to the old dilemma—should reference staff be generalists or specialists?

Anne Page Mosby (1994) sees strength in the librarian’s role as a “generalist who is willing to go exploring with a library user, investigating any reference question” (p. 211). This sentiment is echoed in recent writings by instructional librarians, who emphasize generic, transdisciplinary research skills (Fink & Loomis, 1995, quoted above). Winter (in this issue of Library Trends) insists the opposite. He argues that “specialization is a coping mechanism for dealing with the overwhelming
mass of output" and that it "permits the librarian to understand enough
of textual form and content to be of more help to users."

Collegial communication is the real key to improving reference ser-
ices. Librarians need to crank up the referral mechanisms among dis-
tributed libraries and oil the gears of collaboration. Whitlatch's (1990)
study of reference service confirmed that the subject knowledges that
both librarian and patron bring to a reference interaction are significant
factors in the outcome. "In many transactions neither user nor librarian
have a good grasp of models, problems, and vocabulary of the discipline";
this situation must be exacerbated when the patron's query crosses disci-
plinary lines. Yet "in only 7 percent of encounters did librarians indicate
that they consult with other librarians in answering the question"
(Whitlatch, 1990, pp. 43-44). The model of reference work as a one-on-
one exchange between librarian and patron does not stand up to the
pressures of interdisciplinary questions.

It is surely no accident that frontline librarians at UW-Madison are
initiating more staff exchanges since launching the electronic library. First-
hand knowledge of another library's policies, personnel, and layout is a
definite plus when making referrals. Libraries are also making a greater
effort to publicize their uniqueness, particularly through their home pages,
which detail hours, loan policies, names and responsibilities of staff, scope
of collections, and so on—a level of specificity not previously offered in
handouts. Paradoxically, as both librarians and users become better in-
formed about the differences among campus libraries, library adminis-
trators at many universities are pondering the future of branch libraries.

Library Organization at Large Research Universities

Interdisciplinarity poses particular challenges to large research uni-
versities with distributed library environments and services. Stephen E.
Atkins (1991), in his sweeping historical overview of American university
libraries, asserts that "libraries became decentralized into branch librar-
ies for two reasons: collections grew faster than space could be provided
and faculties demanded that collections in their specialties be housed
near them" (p. 149). After World War II, as campuses embarked on large-
scale building programs, library administrators moved to reestablish cen-
tralized collections and to take control of independent departmental and
professional school libraries. The 1949 reorganization of the Stanford
University Library exemplifies this trend. However, strong faculty resis-
tance has preserved branch libraries on most large campuses.

Now, the economic stringency of the 1990s is exerting a powerful
counterforce. Several major research universities have consolidated small
libraries in recent years. In 1995, for example, the University of Michi-
gan merged its chemistry, physics/astronomy, natural sciences, and math-
ematics libraries into a central science library. At the University of
Washington, collections that supported a wide range of users outside the primary discipline, such as the Philosophy Library, emerged as top candidates for blending into the central library. Through surveys, focus groups, and analysis of circulation data, UW librarians also discovered areas of interdisciplinary learning that were poorly matched to the existing library organization. For example, the forestry curriculum has changed considerably since the advent of interdisciplinary environmental studies, so that students now utilize several libraries spread inconveniently across campus. This realization sparked plans for a natural sciences cluster of information services. Likewise, at UCLA, librarians envision broad subject-focused clusters of services and collections housed in six library buildings as an alternative to the old model of a central library with branches. While the term “cluster” can mean many things in practice, from merged collections and staffs to loose networks, the wisdom of addressing scholarly information needs in broader, more interdisciplinary, contexts is obvious.

From the first discussions of academic branch libraries in the professional literature more than a century ago, the arguments pro and con have included both practical considerations and philosophical views on the nature of knowledge (Watts et al., 1983; Shkolnik, 1991). Research tends to support the centralized library model. Paul Metz (1983) came to this conclusion after analyzing circulation data at Virginia Polytechnic Institute (VPI) (with a central library and only two branches) and the University of Nebraska at Lincoln (with a dozen branches). At VPI, faculty read more widely outside their primary disciplines, indicating that “where subject literatures are segregated along branch lines, multi-disciplinary reading is discouraged and reading preferences come to mirror the structure of library systems” (p. 99). Julie M. Hurd (1992) likewise concluded that scientists are ill served by specialized departmental libraries after discovering that barely half of the journals cited in publications by members of the University of Illinois-Chicago’s chemistry department were in the field of chemistry.

Labeling the debate over centralized versus decentralized collections a “hot potato,” Atkins makes the valuable observation that the debate has shifted ground from politics and space needs to “a philosophical controversy over the nature of information flow” [italics in original]. Proponents of centralized libraries argue that “growing interdependence of knowledge, convenience to the user, and expense” justify a retreat from branch libraries. On the other hand, the champions of decentralized collections argue that new information technologies make distributed library services as convenient and cost-efficient as centralized ones. Atkins trenchantly notes that “regardless of the merits of this new turn in the debate, the fact remains that politics determines the fate of branch libraries, not philosophical discussions over information flow. The teaching faculty wants branch libraries, and it will fight to attain or maintain them” (Atkins, 1991, p. 150).
University libraries, like any campus unit, operate within multiple contexts. The unique shapes that interdisciplinary programs take on a particular campus determine personnel and budget strategies (Casey, 1994) and influence the ways librarians learn of, and respond to, information needs. Bound by its mission to facilitate teaching, research, and outreach, the library must negotiate the pressures of interdisciplinarity in each of these contexts.

The library's role in supporting interdisciplinary inquiry will be framed, in large measure, by the demands of the curriculum. Interdisciplinary studies are "being mainstreamed in the form of topical first-year seminars, required core courses, advanced courses on problems or intellectual themes, and senior 'capstone' seminars and projects" (see Klein in this issue of Library Trends). Phenomenal growth has occurred in the number of interdisciplinary BA and MA degrees awarded since the late 1970s, and new degree and certificate programs are frequently proposed. Declaring that new interdisciplinary programs are both desirable and inevitable, Miller and McCartan (1990) supply educational administrators with criteria for judging their worthiness. The list includes concerns about quality (e.g., can the new field claim its own body of literature, recognized scholars, reliable learning assessment methods?) and pragmatic concerns (e.g., can proponents mobilize funding, create a workable structure within the university, sustain student interest, and guarantee a job market for graduates?). The list omits a crucial criterion—is the library prepared to support a new academic initiative?

Faced with a new interdisciplinary program on campus, library administrators should ask: Will it be a full-fledged department, and will the library be expected to provide the usual materials budget, liaison, perhaps even a special collection or reading room that other departments have? The supporters of new programs often argue that the costs will be marginal, since they will draw on existing faculty and cross-list established courses. Actually, the start-up and continuation costs may be considerable. "[T]he more a program is designed to be truly interdisciplinary (team-taught courses, multidisciplinary scholarship and meetings, extensive development of new courses unique to the program), the higher the price tag" (Miller & McCartan, 1990, p. 34). Even when libraries own or can access most of the information content needed to support a new interdisciplinary program, they may experience fresh needs for reference and instructional services.

Like the curriculum, interdisciplinary research efforts can assume varied organizational forms. The research center, either free-standing or associated with a teaching department, is ubiquitous; however, there is considerable variance in the shape of interdisciplinary research units at universities (Klein, 1990, pp. 121-39). Large, relatively permanent,
research centers may have their own professionally staffed libraries, independent of the central library system (the Primate Research Center at the University of Wisconsin-Madison, for example, supports an internationally renowned primatology information center). Other centers may house a reading room but may rely on the university library for extensive collections and assistance (UW-Madison's Institute for the Humanities follows this model). Finally, there are research centers with no "center" to speak of—networks of colleagues drawn from several departments, perhaps even from other campuses, who, despite the lack of a physical home base, conduct research, write grants, host conferences, produce publications, and the like (the Center for the History of Print Culture in Modern America at UW-Madison functions on this model). In the first case, library managers are challenged to build and maintain good working relationships with the library and information specialists working at campus research centers. In the latter cases, library managers must make sure that research centers that depend on the campus library get the support they need, both in terms of information resources and research assistance. Library staff should be encouraged to involve themselves in the work of the centers (e.g., assisting in workshops and grant writing) just as they would participate in the work of a traditional department.

Particularly at publicly supported universities, research and outreach are intertwined. University administrators and politicians increasingly stress the value of public-private partnerships and the transfer of knowledge from the university to the community. Many university libraries have developed fee-based information services to businesses, industries, and nonprofit agencies as an expression of their basic mission. The "research drift" observed by Burton R. Clark (1995)—i.e., the de-coupling of research and teaching under pressures from government and industry—blurs the lines that define an academic library's clientele.

Other Contextual Issues

Other influences on university libraries include institutional downsizing, new managerial theories and practices, and changes in scholarly communication. Each trend has implications for the support of interdisciplinary studies.

Tight budgets are forcing many universities to trim programs and reduce staffing levels. When faculty vacancies go unfilled, interdisciplinary programs spearheaded by individual professors can founder. The identification of interdisciplinary projects with particular faculty members is a fact of academic life—a manifestation of the "institutional complexity" that characterizes interdisciplinary scholarship (see Klein in this issue of *Library Trends*). As star faculty come and go, and interdisciplinary programs fade or regroup, libraries must reassess the depth and scope of their collecting and service strategies (Ryan, 1991).
University libraries, too, are gripped by funding pressures that dictate staff reductions. Where expertise in an interdisciplinary field is concentrated in a single librarian, leaving a position unfilled can mean losing coverage of the subject. Downsizing often prompts the consolidation of branch libraries, which, as noted above, may have beneficial effects on interdisciplinary scholarship. But downsizing may spread the remaining staff too thinly, leaving them responsible for such a breadth of subject matter that they cannot develop in-depth knowledge in any area.

Faced with multiple demands on their shrinking resources, many university libraries are exploring new organizational models and management approaches. This is good news for those who believe that existing models cramp the development of interdisciplinary collections and services. “The bureaucratic organization of most libraries is so inflexible that new, interdisciplinary fields cannot easily be accommodated in existing systems. Much energy is wasted in fighting the system and competing for resources” (Lee, 1995, p. 185). How might libraries be re-engineered if responsiveness to interdisciplinary inquiry was their primary goal? Would a flattened organization prove more flexible? The University of Arizona Library’s radical experiment in team-based organization deserves careful evaluation on this point. Surely, the tenets of Total Quality Management hold promise for making libraries more adaptable. Enjoining librarians to “focus on the customer” suggests that bureaucratic inward-oriented workplaces can be transformed into user-friendly service-oriented hubs for campus information work.

Finally, changes in scholarly communication affect libraries and have an impact on interdisciplinary scholarship. Interdisciplinary fields have spawned new journals, book series, and electronic forums—exacerbating the problem of information overload already faced by scholars working across disciplines (see Wilson in this issue of Library Trends). Although rising serial prices and conflicting views of copyright have provoked a sense of crisis in scholarly communication (ARL Task Force, 1986; Cummings et al., 1992), interdisciplinary research continues to find outlets. Indeed, the proliferation of publications challenges librarians to select the best and most relevant. Where a new journal subscription requires the cancellation of a pre-existing subscription—a sad condition more and more prevalent in academic libraries—only the boldest selector will add an interdisciplinary title that has yet to establish its reputation.

In evolving fields of knowledge, alternative communication channels are very important. Symposia sponsored by research centers and thematic sessions at annual disciplinary conferences are important venues for advancing interdisciplinary perspectives. Such events often result in published proceedings or special journal issues. Listservers, newsgroups, and other electronic communication mechanisms serve to link interested scholars worldwide. In certain fields, like gay/lesbian
studies, small independent presses produce titles that cross the lines between the scholarly, popular, and self-help genres. To serve interdisciplinary scholars successfully, libraries must have a broad and eclectic collection of information resources outside the mainstream.

THE POLITICS OF INTERDISCIPLINARITY

The tired image of the ivory tower and the vaunted notion of scholarly objectivity are targets of some interdisciplinary scholars, especially in fields that derive their intellectual vigor from focusing on problems and inequities in contemporary society. Such fields have, in turn, come under attack from other scholars who seek to preserve traditional knowledge bases and a core curriculum grounded in Western culture and values. Women's studies, ethnic studies, and gay/lesbian studies have become lightening rods for controversy, sparking strong reactions both on campus and off, to their perceived sociopolitical agendas. Critics dismiss them as tainted by "identity politics," ethnocentrism, and weak scholarship; proponents champion them as effective means for diversifying higher education and revitalizing traditional disciplines. Although less often singled out today, area studies, particularly of the third world, have also been criticized for political content that overshadows theory (Klein, 1990). Positivists are suspicious of their colleagues who justify interdisciplinarity "in terms of an instrumental alignment of knowledge and action, suggesting a new logic of inquiry and new standards for judging scholarly work" (Klein, 1990, p. 96).

Within the academy, the link between interdisciplinarity and politics is announced most loudly in the humanities (Berman, 1992). Reading traditional scholarly and literary works through the lenses of race, nationality, gender, class, and sexuality, liberal humanists find fault with much of what has heretofore been accepted as the canon of Western culture. Giles Gunn (1992) applies the umbrella term "ethical criticism" to feminist criticism, African American criticism, postcolonial criticism, ideological criticism, and cultural studies—those interdisciplinary specialties "that seek to submit literary forms to moral scrutiny" (p. 242). The personal, the political, and the scholarly are enmeshed in these fields. In the late nineteenth century, African Americans embarked on the study of their own history and literature; other strands of ethnic studies were engendered by the social and political movements of the 1960s (Butler & Schmitz, 1992; Gates, 1992). Interdisciplinary cultural studies were born of the "self-conscious linking of literary and cultural study with questions of cultural identity and political power" (Bathrick, 1992, p. 328). Feminist and gender studies derive their intellectual vigor from individualized perspectives:

There is a struggle at the seminar table between increasingly fragmented constituencies, and yesterday's marginal subjectivities are always in danger of becoming tomorrow's gatekeepers. But, and for
Although some renowned scholars, Stanley Fish (1994) among them, assert that human diversity can and should be investigated within the disciplines, there is a decided openness to interdisciplinary approaches among those who study minorities and women.

Klein (in this issue of Library Trends) writes of "critical interdisciplinarities"—fields that intentionally "oppose traditional notions of unity and organic relation." Pritchard (1995) notes that women's studies:

challenges the very notion of distinctions, whether among disciplines, between teachers and students, or among the academy, the state, and the populace. Feminist thought has posed new theories about the connections between subjects, criticized philosophical notions of objectivity and universalism, uncovered bias in the canon, and questioned the idea of a canon [emphases in original]. (p. 16)

Conservatives have made the literary canon a rallying point for debates about "political correctness" (Berman, 1992). Interdisciplinary programs that deliberately question the canon receive sharp criticism, even ridicule, from many quarters. Popular culture studies are easy targets; because they study "texts" such as Hollywood movies and comic books, scoffers dismiss them as frivolous. In a similar vein, women's studies and racial/ethnic studies are denounced as subscholarly fields that cater to the self-esteem needs of special interest groups. Some conservatives write in panicked or nostalgic tones about the loss of a common core of knowledge among educated Americans. Interdisciplinary studies are derided as both symptom and cause of a disintegrating civic culture. (For an overview of conservative writings, see Jayne, 1991; for a sampling, see Berman, 1992.)

Liberals, on the other hand, defend universities against a simplistic "back to basics" doctrine. They argue that the history of American higher education provides no basis for the belief that "at one time there were harmony, tradition, and shared values [within the academy] that can be regained" (Thelin, 1992, p. 17). Today's realities demand a multicultural and interdisciplinary curriculum. They claim: student demographics are shifting; the United States is part of a global economy, and white Western culture no longer has a stranglehold on the minds of intellectuals. To criticize new interdisciplinary courses for focusing narrowly on the "special problems" of women and minorities, their developers insist, is to miss the point entirely. All curricula are political; all teaching shapes students' attitudes and behaviors. By focusing on issues of difference and power, fields like women's studies and ethnic studies merely make the connection between the classroom and the wider community explicit (Butler & Schmitz, 1992.) (For representative liberal opinions, see Berman, 1992.)
Although the positions seem irrevocably polarized, the debates about multiculturalism and interdisciplinarity have taken some interesting turns. For example, a scholar who advocates the study of diverse literatures staunchly defends the traditional disciplines (Fish, 1994), and a former chair of a women's studies program excoriates the field for its ideological excesses (Patai & Koertge, 1994). In this conflictive, often hostile, environment, librarians must chart a course that recognizes the special information and service needs of evolving fields without slighting scholars in traditional fields. The ethics of librarianship prohibit the insertion of personal opinions or beliefs into the processes of selecting, organizing, and interpreting library materials, hence, the individual bibliographer, cataloger, or reference librarian can take refuge in the standards of balanced collections and equitable service. The library administrator, however, may be swept into political and ideological battles.

The larger philosophical conflicts are likely to be overshadowed by the local skirmishes of campus politics. Because interdisciplinary programs assume a variety of institutional shapes, librarians should avoid falling back on rigid policies that define levels of service or collection strength based on the university's hierarchy of schools, departments, and programs. For pragmatic reasons or on principle, successful interdisciplinary programs do not always attain the official status of a department; instead, they may "continue to 'float' on the white space of administrative charts" (Casey, 1994, p. 54). By drawing faculty and students from several departments, an interdisciplinary program may either multiply its power or dilute it. It will likely fare well in the competition for campus resources if it has the support of influential faculty or senior administrators; it will founder if it lacks a solid power base within the hierarchy.

The allocation of a separate materials budget or subject specialist to an interdisciplinary program may bring protests from conservative members of the university faculty or even from community pressure groups outside the university. By the same token, doing away with special allocations or arrangements already in place may alienate another vocal constituency. The politicized nature of these fields circumscribes the library's flexibility to meet their proponents' information needs.

The growing pains of new interdisciplinary programs can affect libraries. During the evolution of library support for women's studies at Rutgers, divergent political stances within feminism had to be negotiated (Lee, 1995). The perennial issue of designating a subject specialist versus distributing responsibility among existing staff echoes philosophical debates within women's studies and racial/ethnic studies over autonomous versus mainstreamed curricula (Schmitz, 1985; Butler & Walter, 1991). It seems normal and desirable for an emergent field to evolve from a few scattered courses to a full-fledged department, but some academics have raised serious doubts about "ghettolizing" radical interdisciplinary studies within separate departments. The
underlying issues are similar to those that shape considerations of branch libraries. Library administrators may prefer to couch such discussion in the neutral language of costs and benefits, but they should not ignore the political meanings.

On the plus side, libraries have opportunities to take a leadership role in visibly supporting interdisciplinary inquiry. The process of establishing and legitimizing interdisciplinary programs can shine a momentary spotlight on library collections and services. For instance, student pressure to institute African American studies at Georgia State University included not only demands for increased library acquisitions but offers to help evaluate the existing holdings. By responding to the students’ expressed needs, the library positioned itself to have representation on the faculty task force that established a new interdisciplinary minor (Mosby, 1994). Librarians should never forget that, in the endless jockeying for resources and prestige, university departments and programs grant enormous symbolic significance to concrete library issues such as branch libraries, separate budget lines, and designated subject experts.

**Conclusion**

Why has interdisciplinarity evoked so little attention from library leaders? Like the preoccupied frogs in the soup pot, do they forget to taste the changing seasoning of the simmering broth around them? Are they unaware of scholarly trends at their own institutions and worldwide? Do they take it for granted that other factors, such as the rapid transformations of information technology, will exert greater influence on the future of libraries than will shifting intellectual boundaries? Or are library administrators well informed about interdisciplinary scholarship but unfazed by the necessity of supporting it?

The fact that interdisciplinary studies, by and large, have not weakened or supplanted established academic fields makes them easy to ignore. Indeed, interdisciplinary teaching and learning have sparked a paradoxical revaluing of the traditional disciplines in some quarters. For example, the "writing across the curriculum" movement evolved from a focus on building generic composition skills to a focus on writing in the disciplines and on teaching students the knowledge structures and rhetorical conventions of their chosen fields (Herrington & Moran, 1992). This same dynamic can be observed in library user education. Librarians teach new students the basic principles of information organization that transcend disciplines, but they also provide upper-level students with advanced bibliographic instruction in specific academic fields. By many measures, the traditional disciplines are thriving both outside and within libraries.

Another obstacle to seeing library services in light of an interdisciplinary reality is the hidden (some might say subversive) nature of much interdisciplinary scholarship, which is carried out within the familiar
supportive structures of the disciplines. Klein (in this issue of Library Trends) quotes Keith Clayton regarding the "concealed nature of interdisciplinarity" that flourishes behind the "subject façade" of such established fields as agriculture and geography. On the one hand, librarians may observe self-proclaimed interdisciplinary programs (e.g., ethnic studies) struggling for even a marginal claim on campus resources, and conclude that interdisciplinary programs are by nature weak. On the other hand, librarians may fail to notice or appreciate the robust interdisciplinary teaching and research occurring under the aegis of existing departments.

Klein's three "explanations" for relationships between the disciplines and interdisciplinary inquiry form a useful framework for understanding the university library's choices in responding to the challenge of interdisciplinarity. Views of interdisciplinary inquiry as "normal," "exceptional," or "oppositional" lead to different conclusions about the library's role. If one perceives interdisciplinary innovation as a normal part of the scholarly process, there is surely no cause for alarm or special measures.

The "normal" explanation holds that crossing boundaries is a usual characteristic of knowledge growth, evident in extensive tool borrowing and the migration of intellectual workers across disciplinary borders to solve problems. In the logic of the normal explanation, permeations are part of, and thus brought back into, the disciplinary order, even if they have an initial counterdisciplinary thrust. (Klein, 1993, pp. 206-07)

From this standpoint, continuing to strive for excellence in support of discipline-based programs will automatically create library collections and services that will support interdisciplinary experimentation on the part of faculty and students. "Normal" library practices will suffice for the "normal" ebb and flow of knowledge categories.

One may, on the other hand, view interdisciplinary programs as exceptions to business-as-usual in academe and therefore devise "exceptional" measures in response.

The "exceptional" explanation holds that disciplinary boundaries are substantial obstacles to cross-disciplinary inquiry, spawning an adhocracy of mechanisms such as cross-departmental programs, research teams, centers, and hybrid fields. Yet even in the logic of the exceptional explanation the disciplinary center still holds and permeations end up being either normalized or marginalized. (Klein, 1993, p. 207)

Seen from this perspective, relatively minor ad hoc adjustments are required—a realignment of the book budget, the expansion of a librarian's liaison responsibilities. Since the library's mission embraces all facets of the university's teaching and research activities, librarians continually
adjust budgets and re-order priorities in the name of equitable service. While such accommodations may be painful in times of tight budgets, they can be achieved without major restructuring.

The third view of interdisciplinarity discloses a deep discontent with, and opposition to, the familiar structure of the disciplines:

The "oppositional" explanation goes beyond assertions that disciplinary boundaries are arbitrary...to contest the very premise of disciplinary organization and argue instead for permanent cross-disciplinary structures, problem-focused intellectual work, and political intervention. (Klein, 1993, p. 207)

This view suggests that academic libraries as we know them—with collections, catalogs, and services framed by subject categories—cannot meet the needs of scholars who work within an interdisciplinary paradigm. The oppositional viewpoint is unlikely to gain a hold in academic libraries. It is difficult to imagine librarians flatly rejecting the knowledge categories that have shaped their profession for a century. True, some librarians envision a future where information is freed by technology from the structures of organization. Yet barely at the threshold of such a future, other librarians are sounding an alarm and rushing to devise means to control the chaotic electronic information environment. If libraries have meaning at all, it lies in the very categories that librarians apply to select, organize, and dispense knowledge. These categories change, split, and merge over time, but the essential fact of categorization remains.

Sarah M. Pritchard (1995) writes: "Libraries serve as gatekeepers of culture and learning. In selecting some topics and ignoring others, in codifying knowledge through cataloging and classification, in actively assisting users or passively standing by, libraries control access to, and impose a structure and relational value on, all forms of information, creativity, and communication" (p. 16). Given the power of libraries to shape knowledge structures, university library administrators must pay closer attention to the exigencies of interdisciplinary scholarship. The selection of information resources, their organization for retrieval, and the delivery of expert assistance through reference and instructional services needs to be assessed in light of interdisciplinary information needs. The ongoing tension between specialized and general approaches and the political nature of some interdisciplinary fields must not be overlooked. Academic libraries that ignore the rise of interdisciplinarity risk becoming irrelevant to a growing portion of students and faculty.

ACKNOWLEDGMENTS

The author thanks Joseph Branin, Angela Carreno, Lucinda Covert-Vail, Larry Dowler, Christine Jenkins, Janice Koyama, Abigail Loomis, Carole Palmer, Patricia Renfro, Alex Rivera-Rule, and Betsy Wilson for supplying examples and suggesting avenues for inquiry.
NOTES
1 Most of the examples in this article are drawn from the humanities and social sciences, reflecting the author's background in women's studies and the subject scope of Memorial Library at the University of Wisconsin-Madison where she works. While the issues are similar in the sciences, there are important differences rooted in the nature of scientific communication, the funding of research, and other factors that are not explored here.
2 The Committee on Institutional Cooperation (CIC) consists of the Big Ten universities plus the University of Chicago and the University of Illinois-Chicago.
3 Questions of selecting, funding, and managing electronic information and its requisite hardware and software do indeed preoccupy library administrators. However, when a group of stakeholders in academic libraries—faculty, university administrators, library directors, information technology managers, publishers, research consortium directors, and foundation directors—were asked to identify trends affecting the information environment, they rated "more interdisciplinary approaches to teaching and research" of equal importance with the impact of new technologies (Dougherty & Hughes, 1993, p. 8).

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Specialization, Territoriality, and Jurisdiction: Librarianship and the Political Economy of Knowledge

MICHAEL F. WINTER

ABSTRACT
Recent work on interdisciplinarity and knowledge growth has produced a variety of models to capture a process of bewildering complexity. Prominent among these are organic models, which compare knowledge growth to biological processes (e.g., hybridization), and spatial models, based on various suggestive geographical parallels. Part of the background of the dynamic formation, interaction, and dissolution of disciplines is a broader and perhaps more pervasive social process that particularly affects the knowledge-intensive occupations in the advanced industrial societies and indirectly affects all forms of work. This process is presented as an opposition between the impulse to integrate and consolidate across fields and the impulse to discover and perhaps colonize new knowledge domains in a manner resembling territorial conquest, expansion through annexation, and resulting claims to exclusive jurisdiction. This article draws on some key ideas of recent social theory, the sociology of the professions, and other sources to outline librarianship’s current situation.

INTRODUCTION
The general orientation of this article is the idea that human activity is, roughly speaking, ecological—a process that involves interaction between social groups and environments. Because current use of the term "ecology" strongly connotes the physical world, it is useful to point out that it is descended from an ancient Greek word (oikeos) meaning “household” in the broad sense of a human settlement and thus a complex interweaving of fields of social action. The verbal forms suggest inhabiting,
settling, governing, controlling, managing, and similar activities, and are applied to organizations and states as well as to smaller social units like families and other kin groups. While not excluding, and indeed including, a part of the physical world, this notion thus focuses on the social environment. This article emphasizes that part of the social environment where the production and distribution of formal knowledge occurs. Its domain, shared with the principal domain of the other articles in this issue of Library Trends, is the organization of formal knowledge.

**INTEGRATION, SPECIALIZATION, AND THE GROWTH OF KNOWLEDGE**

Recent work on interdisciplinarity has made much progress in trying to understand the often overwhelming complexity of contemporary knowledge growth (Klein, 1990; Dogan & Pahre, 1990; Easton & Schelling, 1991), even though the advances seem more striking in understanding theoretical work than problem- or policy-oriented research (Easton, 1991, pp. 14 ff.). By undertaking the difficult work of describing, classifying, and organizationally mapping patterns of contact among disciplines, this work provides a kind of ethnography of knowledge production, which in turn provides a number of essential starting points for model building and theory construction.

Julie Thompson Klein's (1990) ambitious and synoptic overview of this very complex set of problems provides some hope that some of the better-known disadvantages of specialization may yet be overcome. And indeed one of the abiding themes in the literature on interdisciplinarity is the hope of integration which haunts it (Easton, 1991, pp. 16-18). If many natural scientists have either abandoned that hope or never entertained it in the first place, librarians and humanist scholars keep it alive; social scientists, depending on their situation, fall somewhere in between. The common hope of controlling the literary output of the many fields of learning is reflected in the early modern quest for a universal bibliography (Chartier, 1991), in the first efforts at modern knowledge classification developed by Francis Bacon (1606) in *The Advancement of Learning* and later applied to book collecting by eighteenth-century figures like Thomas Jefferson (Gilreath & Wilson, 1989), and underlies the application of these schemes to book and library classification in more recent times.

In the United States, this hope of unity was pursued with some energy and enthusiasm at least through the first half of the twentieth century. Perhaps it was energized by the reform-oriented progressivism that permeated American life between 1880 and 1920 (Wiebe, 1967). The post-World War II period, on the other hand, has not been as kind to the movement. In the 1920s and the 1930s, American thinkers like John Dewey, George Herbert Mead (from the pragmatist tradition), and others like Otto Neurath (from the positivist side) developed "universal" and "systematic" theoretical schemes intended for a variety of disciplinary con-
texts (Fuller, 1988, pp. 6-7). This integrative impulse was also evident, famously, in the utopian projects of pedagogical visionaries like Alexander Meiklejohn and Robert Hutchins, who urged the abandonment of narrow specialization and the adoption of broader and more ecumenical views in higher education (Winter, 1991).

Somewhat later, Talcott Parsons, though nominally a sociologist, began intellectual life as a political economist, co-founded a multidisciplinary program of social relations, and developed a broad conceptual framework for the explanation of social action across the disciplines embracing sociology, social psychology, anthropology, economics, and political science. And throughout the 1950s, there were ambitious efforts at integration from behaviorism, Marxism, systems theory, semiotics, structuralism, and other quarters (for an overview of the "integrative process," see Klein, 1990, pp. 188-89). As Easton (1991) has pointed out, at different times, teamwork, general theory, and general methodology—and, he might have added, bibliography, classification, and the study of organizing information for retrieval—have been enlisted in the cause of integration and synthesis (pp. 16-20).

**Specialized Advance, Territorial Impulse, and Intellectual Colonialism**

But it is specialization, not integration, that seems to prevail, at least for the present; the energies of many able scholars seem devoted to what Easton (1991) has called, in a very apt phrase, the Cartesian impulse to endlessly decompose subjects into ever finer analytical domains (p. 12). This may be more true for the industrialized West than for other parts of the world. Easton (1991), for example, argues that scholarly work in China is not nearly as specialized as research in the United States, the United Kingdom, and Western Europe (pp. 8-9). And some European exceptions should be noted, as the protests against specialization in papers by scholars as diverse in political orientation as Helmut Schelsky (1987, pp. 119-37) and Theodor W. Adorno (1987, pp. 232-47) indicate. Whether this is because the logic of inquiry itself in some way mandates an increasing spiral of specialization, or because all scholarship seeks to emulate natural science models, or again because ours is an age of radical pluralism and differentiation, are questions of some interest and difficulty. In any case, "the magnitude of achieving synthesis has been underestimated" (Klein, 1990, p. 116).

Perhaps for this reason, the models following the development of specialization are particularly useful, if only because it is now the dominant pattern of research. Intriguing examples are the organic models, which compare intellectual fields to biological organisms and species produced by a kind of "hybridization" process (Dogan & Pahre, 1990). Much of the appeal of this model is derived from its comparison of
intellectual movements to processes found in the study of the ecology and evolution of plant and animal species. Reversing the original root relationship between the "ecology" of human life and the animal world, it locates a specialized form of human intellectual activity in a larger biological universe.

Another promising family of models uses spatial, regional, and geographic concepts instead of organic ones. For example, Berger (1972) compares disciplinary networks to archipelagoes and islands (Klein, 1990, pp. 40 ff.). Price (1981) compares the established intellectual domains of elite scholarship to continental masses with characteristically dense cosmopolitan centers of privilege; the newer emerging fields, like their counterparts in frontier societies far from the fronts of tradition, are thinly populated intellectual outposts where intellectual fortunes can be made overnight and many languish in obscurity. Garfield and Small (1985), seeking to map the "geography of science," use citation data to plot proximity, level of activity, and possibly the influence between and among groups of researchers staking out intellectual territories.

There is no inherent opposition between the two approaches, and they might be combined to form a third that integrates the two types; after all, organism and environment mutually imply one another. It is not possible to do this here, but it is useful to suggest that what the organic and the spatial approaches have in common is the pursuit of acquisitive specialized advance; they are territorial, competitive, and expansionist. In both cases, the underlying idea is to make and reinforce implicit jurisdictional claims analogous to the territorial claims that both human and animal populations make to ecological niches. They share, in other words, a general pattern of exploiting available resources to produce new life forms and new settlements, and thus to create, occupy, populate, and colonize new intellectual regions. This is probably especially true in the newer fields, which lack older jurisdictional foundations. But it is particularly true in any field that has a comparative dimension (for an especially clear example profiling comparative literature, see Loriggio, 1995).

In looking at the intellectual response to disciplinary growth, Klein, in this issue of Library Trends, sees a rhetorical duality: there are, on the one hand, "metaphors of place—turf, territory, boundary, domain"—but also "metaphors of connection—network, web, system, field, overlap, interconnection, and interpenetration." It may be useful to mention this here because, although my own argument obviously places a strong emphasis on the first of these and suggests that specialization works against integration in any systematic way, it does give rise to its own characteristic style of connection. Thus if integration seems substantially eclipsed by the movement of territorial advance, there is still a kind of mutual interdependence that provides some sense of interdisciplinary unity (to explore this in any detail is not possible here; we should point out, however,
that the general idea is based on Durkheim’s idea that mechanisms of social cohesion depend on the complexity, differentiation, and specialization of function found at different stages of social evolution). Advanced industrial society shows a high level of differentiation and thus a correspondingly low level of common culture, but there are durable social bonds formed by the fact that specialized roles promote a kind of integration through interdependence (see Kopytoff, 1988, pp. 12-13).

GLOBALIZATION, CULTURE FLOW, AND THE EMERGENCE OF TRANSNATIONAL CULTURAL SPACE

The age of the nation-state, we are told, is over. And not only the state, which has served since the early modern period as a kind of central underlying framework in charting the diffusion of culture, is showing signs of obsolescence; the traditional categories of language, class, gender, ethnicity, and region still exist but are now overlaid with an emerging world order that is much more mobile, fluid, and shifting. The older national boundaries no longer mark their peripheries. “Cultural transactions between social groups in the past have generally been restricted, sometimes by the facts of geography and ecology, and at other times by active resistance to interactions with the Other...” (Appadurai, 1990, p. 1). In place of an earlier isolation that, for a variety of reasons, prevented much of the contact among social groups that occurs much more routinely today, a labyrinthine welter of “public cultures” now spreads across large parts of the globe (Appadurai & Breckenridge, 1988). Capital, once largely, if not exclusively, invested in a pattern that reinforced these traditional structural patterns, now flows much more easily across increasingly more permeable boundaries.

In this situation, some of the more dramatic changes are in patterns of migration, employment, and trade. Everywhere, people and peoples are on the move, reflecting, among other things, the increased mobility of capital—for just as capital seeks lower costs to maximize profits, so does labor seek a higher return on its investment of physical, social, and intellectual energies (Banks, 1986; Lie, 1995, p. 303). The result is the emergence of a richly textured, culturally pluralistic, highly unstable emerging world order at the end of the twentieth century; it is no accident that the present period of intense world economic activity is marked by volatile political activity. While for obvious reasons public attention focuses on the intense drama created by the broad picture of this human movement, our focus here is on the movement of ideas and expertise; we look to this general framework as a setting for asking how this has affected the production and distribution of formal knowledge.

As political barriers to increased movement came down in the United States beginning in the mid-1960s (Grewal, 1994, pp. 53 ff.), the increased mobility meant not only a supply of agricultural workers from Mexico
and Central America, but many different skill levels and types of labor from all over the world, including highly skilled and educated professional and technical workers in the physical, life, and health sciences (Stalker, 1994). Some of those seeking to reach the United States were from English-speaking countries (Schuster, 1994), but large numbers were from South and East Asia, where population expansion created surplus populations (Grewal, 1994; Gonzalez, 1992). Their arrival in the United States had obvious consequences for the expansion and creation of scientific knowledge in a number of capital-intensive research fields. Without their contribution, a number of areas—biotechnology, pharmacology, and computer science provide some obvious examples—would have developed much more slowly, and these developments, with their accompanying literatures and bodies of new knowledge, provided an essential impetus for growth in the fields of special and research librarianship.

But the new “diaspora,” as the worldwide movement of peoples is often called, is by no means restricted to the circulation of experts in the natural sciences. The diffusion of humanists and social scientists cannot of course match the numbers in the more technical fields, but the transformation of the cultural landscape of late capitalism in the West is nonetheless unmistakable and far-reaching. Much of this has occurred since the 1960s in tandem with the cultural revolutions of that pivotal period that forced university curricula to include the narratives of a wide range of American minority groups, it has highlighted a whole series of contested intellectual territories and emerging fields of inquiry.

In practical terms, the globalization of cultural space means an expansion in the demand for the study and teaching of the histories, cultures, and societies of the newer immigrant groups, and certainly a willingness to devote resources to collecting their literatures. And so the “Americans” whose grandparents once knew very little indeed about the Germans and the Irish and the Italians and still less about their histories, and whose parents as students in the 1960s were the first generation systematically exposed to the new literatures of marginalized minority cultures, are now in their own student years facing the necessity of understanding the trailing clouds of culture from northern India, Sri Lanka, the more populous parts of China, Korea, and Taiwan to say nothing of the Caribbean, Mexico, the northern end of Central America, and Eastern Europe at the end of the Cold War.

All of these and more play central roles in producing the globalized immigrant cultures of today, still partly rooted in the localized territories of “home” and yet at the same time so clearly abandoning them. Thus the cultures that were once the province of an academic anthropology or history based on a kind of professionalized academic tourism and a construction of native cultures as pungent and exotic contrasts to the rationalized bureaucratic rhythms of the West are now among us and rapidly
entering the mainstream of American society, where they join the earlier strains of the French, Spanish, Dutch, English, and other Western European groups that fanned out in the early modern period in search of new frontiers and new markets. The landscapes of Washington Irving, Nathaniel Hawthorne, and Mark Twain are joined by the cultural worlds of V. S. Naipaul, Anita Desai, and Naguib Mahfouz. Thus globalization offers a particular challenge to professional students of culture, as Marcus (1995) has observed about the major changes in the way ethnographers accumulate their "intellectual capital." Certainly the ethnographer can no longer appear as an explorer from the center of civilization, sent to shed the light of science on its outlying regions. For librarians, this means that the center and periphery of collectible bodies of literature are not what they were even a generation or two ago, as the intellectual capital of past epochs gets redefined as part of the spoils of Western imperialism.

This challenge to, and invigoration of, the intellectual life of the United States is certainly not unprecedented, for there have been earlier diasporic movements which brought not only an extraordinary flow of scientific talent, but also a wide variety of scholars in other fields, to say nothing of artists, musicians, and performers. The most remarkable, and in many ways the most influential, of these movements occurred between about 1930 and 1950, as thousands of European refugee artists, writers, journalists, scholars, and professors in a number of fields sought asylum in the United States, where they introduced a profound and continuing Europeanization of what had been a staunchly isolationist and proudly naïve American culture of the home-grown and the self-made (Fermi, 1968; Fleming & Baily, 1969; Hughes, 1975).

**Disciplines, Occupations, and the Quest for Jurisdiction**

Researchers commonly complain about organizational and institutional barriers to interdisciplinary inquiry. And it is true that the departments, institutes, and the agencies that impose administrative order onto research activity can have an inhibitory effect (see Searing’s article in this *Library Trends* issue). Yet, as one writer has observed, these barriers, however real, are actually superimposed upon a deeper set of constraints that issue directly from the distinct and often incompatible disciplinary subcultures that give rise to them in the first place (Bauer, 1990, p. 105). Disciplines are not merely groups of minds pursuing common intellectual goals; they are, first and perhaps foremost, social groups with distinct cultures as is suggested by the common jocular references on university campuses to academic departments as "tribes."

There is really no reason, however, to reach for similes that ironically compare post-industrial intellectuals to preindustrial hunters and gatherers or horticulturalists. Disciplines, with their differences of value, worldview, method, technique, leading ideas and theories, to say nothing
of the characteristic ceremonies, rules, norms, rites of passage, patterns of apprenticeship, and hierarchies of authority are, like any social grouping, subcultures whose attitudes, behaviors, communication patterns, and vocabularies are frequently incomprehensible and impenetrable to outsiders (Bauer, 1990, p. 112; Marcus, 1995).

A much more appropriate comparison would be to the “social fields” of Pierre Bourdieu’s sociology (1969, 1973, 1981). A discipline, in other words, is an area defined by the relative positions of individuals and groups, their social networks, their dynamic interactions, and whose shifting outlines are dictated in large measure by the social, economic, political, cultural, and intellectual resources that participants bring to them as they occupy the research field (Bourdieu, 1986; Marcus, 1995). To report one of Bourdieu’s (1981) more concise statements, it is “the objective space defined by the play of opposing forces in a struggle for scientific stakes” (p. 260).

The nature of disciplinary fields is manifestly intellectual, and their boundaries are at least partly traced by their characteristic forms of argument and discourse: “[A] discipline,” writes Fuller (1988), “is ‘bounded’ by its procedures for adjudicating knowledge claims” (p. 191). Thus the “argumentation format,” or template of discourse, determines in advance the kinds of issues that may be discussed and what counts as evidence, proof, justification, etc. (Fuller, 1988, pp. 191 ff.). But the boundaries marking the limits of a field are also dictated by a kind of latent territorial logic of social control. These procedures, nominally intellectual, also function as elaborately codified means for controlling access to knowledge and its use and to a wide variety of social practices.

Thus the discipline is more than an intellectual field, even though it is often exclusively represented as such in academic language, for while it is situated in a large and complex network of neighboring intellectual fields, with many different kinds of contact and interrelationships with them, it is simultaneously rooted in a larger and even more complex process of claim-staking that permeates the occupational structure of the society around it. It has an internal social organization, social networks of influence and communication, and it has dynamic relationships to many other occupations. If disciplines are engaged in a competitive struggle to stake claims to intellectual territory and occupy new niches, these claims are rooted in more fundamental claims of professional jurisdiction, claims which assert the rights of the group to a certain form of social practice and the enjoyment of its rewards. “The central phenomenon of professional life,” in this view, is “the link between a profession and its work, a link I shall call jurisdiction” (Abbott, 1988, p. 20).

It is on this larger field of occupational organization that the dramas of the professionalization of disciplines are played out, as occupations seek to make and legitimate their claims to exclusive jurisdiction (Abbott,
Naturally, not all occupations will be equally caught up in the professionalization process, but professionalization has a special importance for the knowledge-intensive work of the middle- and upper-middle classes in the advanced industrial societies. In these cases, higher education credentials and special learning experiences play a critical role in controlling access to work and in legitimating the group's jurisdictional claim to the outside world (Freidson, 1986; Abbott, 1988). Thus surrounding and, in a sense underlying, the complex world of the academic fields is this larger atmospheric envelope of professional work, which Abbott calls the "system of professions." From this viewpoint, occupations and professions appear in a fashion recalling the organic models of discipline growth, as "growing, splitting, joining, adapting, dying" (Abbott, 1988, p. xiii). By the same token, however, they also appear as organized colonies seeking to define territories and guard them from encroachment; they are, to use the language of another recent sociologist of the professions, attempts to create labor market shelters (Freidson, 1986, p. 59). This very imagery, though invoked in the effort to understand professional occupations, fits well with the dynamic expansionist model of the knowledge fields.

**Globalization, Professionalization, and System Disturbances**

The academic occupations we call disciplines are, by reason of the large-scale social transformations occurring on a global scale, in a dynamic expansionist mode. If the freer circulation of global culture creates new fields and expands older ones to a point where they might as well be new, it has problematic consequences for professional work. In brief, it exacerbates the tension between professionalism, with its penchant for "protectionism" and the opposing "free trade" emphasis of capital mobility. Increased flows of resources are of great benefit to corporate capital, which mobilizes them for short-run gains and then moves on to the next opportunity. But how are long-term investments in knowledge, expertise, skill, and judgment—the kinds of investments that use expert knowledge in problem-solving—to be justified when the flow of capital is so rapid that, in the leading fields, the cycles of product development may be as short as two or three years? Unless the worker enjoys a very well-protected luxury of specialization, it will scarcely be possible to keep up. Further, as capital-intensive specialization advances, it marginalizes less specialized forms of work, making them appear provincial and overly general by comparison. Simultaneously, of course, managerial and administrative authority appropriate general control over organizations (Winter, 1993, 1994).

Thus the globalization of capital and the resource flows which result may have some of the "system disturbing" effects that Abbott (1988) refers to in his account of professional competition and conflict (pp. 91-98).
Aside from sharp inequalities of material reward, the consequences of extreme fluidity of culture flow are particularly disturbing in the knowledge handling fields. The concept of "intensification," which has been applied to teachers and other distributors of culture (Connell, 1985, pp. 70-71), applies to librarians as well. Intensification, which has, on the surface, a beneficial upskilling effect because it exposes practitioners to wider varieties of material, ultimately undermines an occupation's ability to deliver quality by gradual increments of overloading. At some undefined point, processing the load takes precedence over adding value to the product through creative distribution.

Thus the broader picture of globalization, capital flow, and cultural production, while reassuring in some ways because they seem to counteract some of the provincialism and isolation that has prevailed for some time, presents challenges to information workers that are at the least extraordinary, and at most assume an almost Sisyphean aspect. Perhaps because librarians have been so preoccupied for so long with the issue of bibliographic control of the output of publishing, they have understandably paid somewhat less attention to challenges from occupations much closer to home than academia and publishing, the two primary sources of the informational overload. We return to this issue after sketching, in the following section, some general remarks about librarianship's role in knowledge treatment.

LIBRARIANSHIP AND THE ECOLOGY OF KNOWLEDGE DISTRIBUTION

Librarians sometimes function as knowledge producers, but their place in the larger ecology of formal knowledge is more accurately distributional than productive. For this reason, they generally do not come into direct competition with scholars, writers, and artists (on the distinction between intellectuals as producers and distributors, see Lipset, 1981, pp. 333 ff.). But librarians do share the distributional function partly with publishers and booksellers (Eco, 1983) and perhaps also partly with teachers (Connell, 1983, p. 245). Nonetheless, these functions are usually separated by distinct lines of jurisdiction which provide some insulation from competition. Librarians, to borrow from the ecological register of comparisons, occupy different niches even though there is an overlap of function.

But the case is otherwise with some of the newer information-treating groups, although some care is required in order to mark off some jurisdictions which are insulated from some which are not (naturally, it is from this latter group that an occupation gets serious competition). In developing a theory of the professions as an interacting system, Abbott (1988) suggests that "information professionals help clients overburdened with material from which they cannot retrieve usable information" (p. 216). But alone this is not quite enough, since within this group there
appear to be two rather distinct jurisdictions. Accountants, management engineers, statisticians, operations researchers, and systems analysts, for example, deal with quantitative information, while librarians, along with many academics and journalists, and some business specialists like advertisers, deal with information in its qualitative aspects (p. 216); the contrast Abbott is drawing here recalls the distinction between the numerical and the textual. Naturally, this distinction will not be perfect, since there are librarians and other information specialists working with both kinds of information and otherwise making recommendations based on quantitative analysis—e.g., collections librarians who use citation analysis to make decisions on the selection or retention of sources.

**SYSTEM DISTURBANCES AFFECTING LIBRARIANSHIP**

Nonetheless, librarianship has, at least until fairly recently, dominated a significant part of the qualitative range of information distribution (Abbott, 1988, p. 217), although it probably would be better to focus more specifically on the treatment of texts and their users and tighten some of the more obvious slippage in the concept of the "qualitative." Some of the reasons for this are, as Abbott (1988) points out, adventitious: the growth of librarianship as an occupation in the United States more or less coincides with the spread of significant library collections, much of which occurs after the Civil War (pp. 217-18). So American librarians occupied some emerging cultural and intellectual territory at a very early stage, long before any competitors arrived. If librarians have not noticed some serious challenges in more recent times, this is partly because this domination has been so virtually complete. No doubt it is also because the globalizing, crisis-inducing expansionist movement of publishing amid the ever-increasing bodies of literature it produces have made it extremely difficult to keep up with the core tasks of the field and develop a general sense of historical direction.

In any event, librarianship presents a case in which a number of functions originally assigned and carried out internally have now split off into newer occupational groups which have grown so much that they are now taking over substantial parts of the old "qualitative" domain. The most dramatic example is the library assistant, whose functions originated in the more clerical end of technical services and which, thanks to automation and other trends, have now colonized much of the routine task areas of acquisitions and cataloging within libraries. Simultaneously, the core areas of professional expertise in cataloging have substantially migrated to the bibliographic utilities which now produce the catalog record that was originally the province of the catalog librarian (although it is not possible to present a detailed analysis here, the trend is evident in data collected by the Association of Research Libraries and shows that the paraprofessional group has grown much faster than the professional group).
The same trend appears in academic libraries generally (see Oberg et al., 1992, pp. 220-21). At present, this picture is clearest in technical services, but if library assistants continue to expand into other areas of work once reserved for professionals, the trend could easily appear in public services. To imagine this, picture a busy reference desk at a major facility staffed only by paraprofessionals whose function is, while not precisely to answer reference questions, to shunt or route them to a central public services authority which first provides an answer, then routes the answer back to the paraprofessional, who in turn passes the material on to the user. In this scenario, the public services “authority” functions much as the bibliographic utility does in technical services, and the reference function becomes commodified and streamlined and poured into the mold of mass production to be sold to libraries for distribution, along with the output of the publishing industry, much in the way cataloging is now. Today, in technical services departments in many large libraries, an occasional professional is required only to supervise the work of a much larger staff of library assistants; perhaps that too is the fate of the reference librarian.

But the paraprofessional case is not the only one, even if in many ways it is the clearest example of the trend toward restructuring through internal differentiation and splitting off in a process that ends with a new occupational group. In the process which Abbott (1988) likened to an organismic progression of “growing, splitting, joining, adapting, dying” (p. xiii) has been gestated not only a new presence of paraprofessional workers, but also new configurations of administrators, managers, accountants, systems analysts, computer resource specialists, development officers, and student assistants. All of these are now staking claims to various parts of the territory once rather blithely assigned to “librarians.” And yet, if we retreat enough in time to gain historical perspective, we do indeed come to an age in which librarians performed most of the entire range of functions now much more widely distributed among these new arrivals.

THE NEED FOR SPECIALIZATION

If this “system disturbance” perspective is accurate, it leads naturally to the question of how librarianship, as a discipline and occupation, might respond. There is one response, one might say at the outset, that should be avoided, however tempting it may at times seem, and that is the idea that librarians should become specialists in generality. The track record of integrative generality in knowledge production generally should warn us away from this tack and, in any case, the prevalence of hyperspecialization in knowledge production should tell us that a retreat from reality into generalism is more an expression of frustration than an attempt to come to terms with the growth of knowledge. This does not mean that librarians, information specialists, and their affiliates in the domain of
text distribution should abandon general classification or controlled vocabularies or any of the other developments of earlier periods of librarianship any more than people who drive cars should abandon bicycles; wherever possible, continued use of older tools is often the best option available.

It does, however, mean that, in a world where knowledge and culture producers, along with consumers, are very specialized, librarians and other distributors must themselves be very specialized in order to cope with some basic realities of professional work at the end of the century. First and perhaps most important, specialization is a coping mechanism for dealing with the overwhelming mass of output; by narrowing the focus, it filters out some of the flow and makes the rest easier to manage (see Wilson’s article in this issue of Library Trends). Second, it permits the librarian to understand enough of textual form and content to be of more help to users. Deeper knowledge of content also enables the librarian to understand new knowledge from the inside and to benefit from the filtering mechanisms that experts in the field themselves use. And librarians must also be specialized otherwise they cannot hope to have any semblance of collegial contact and communication with a wide range of their user groups.

Aside from these considerations, and somewhat closer to our concern with disciplines as the intellectual expressions of occupations, specialization is also required to colonize appropriate new niches to replace the older ones that are now occupied by new groups of workers. In increasing levels of specialization, librarians can recover some lost ground by defining exclusive new jurisdictions as autonomous domains of expertise. If, on the other hand, librarians resist specialization, they invite continued and increased encroachment from two major sources: capital looking for new markets on the one hand and, on the other, from the ever-larger number of workers who find themselves more and more superfluous in the highly competitive, endlessly downsizing political economy of the late twentieth century.

There are many possibilities. Some of the more obvious, and yet among the more neglected, are specialization by subject, geographical area, and language. “Culture area” is a form of specialization closely related to both geography and language and yet clearly distinct from either which has special promise in a multicultural age. There are many areas of culture, language, dialect, and discourse that librarianship seems not to have penetrated at all, yet these define new territories and new user populations in need of bibliographic control, interpretation, and mediation. These niches seem particularly promising for building connections and social networks with a wide range of academic and research fields, to say nothing of the many specialized areas of popular taste; area and language specializations are of special importance in the human studies, which deal increasingly with the globalization of culture.
Subject specialization, though relatively uncommon before World War II, has existed in American academic libraries for fifty years. Yet it seems to have barely grasped the extraordinary advances in the specialization of knowledge occurring at a rapid pace all around it and is thus long overdue for restructuring. To look at the assignments of reference librarians and bibliographers in many academic and the larger public libraries today and the organizational structures of the professional associations they support, one would think that the only "subjects" that librarians are capable of covering in specialized depth are the most traditional and broadly defined fields that have been institutionalized by college and university curricula for much of the postwar period—i.e., physics, chemistry, biology, history, anthropology, economics, sociology, literature, art, and philosophy—along with a few others that came somewhat later, during the 1960s, like ethnic or women's or gay and lesbian studies, or perhaps environmental studies.

While there is room for development even in this crowded center, the more pressing need is for coverage and control of newer areas. Expanding on Dogan and Pahre (1990), Klein (in this Library Trends issue) observes that "density at the core opens up room for innovation at the margins"; yet, while we have a highly developed librarianship at the core, we have much less development at the periphery.

Aside from subject assignment, looking at professional activities like conference programming and publication, one might conclude that librarians seem almost unaware of the many hybrid disciplinary creatures now populating the intellectual landscape—i.e., fields and subfields like anthropogeography, health psychology, psychoimmunology, human-animal relations, social studies of disease, ethnopharmacology, sociobiology, medical anthropology, cultural studies, critical legal studies, discourse analysis, ethnophilosophy, historical sociology, the law and literature movement, ecohumanism, museum studies—to name only a few of the more recent specialized niches that have been staked out by scholars over the last twenty years. All of these are examples of specializations not yet embraced that would provide new perspectives, help define new user populations, and provide much fuel for professional development. Add to this the realignments of the Eurocentric canon of ideas and methods that are occurring with the globalization of culture, and the possibilities multiply even further.

There is different but promising territory in the areas of functional and format specialization. If librarians are able to rethink the problems of classification, cataloging, and bibliographic control in ways that make new and emerging fields more accessible, and thus promote more mutual awareness of possibilities for collaboration where specialized researchers might not have noticed them, they will simultaneously define new landscapes of technical services and new services for users. Format spe-
cialization, already partly represented in librarianship by government documents, special collections, maps, and children's literature, is being restructured by the arrival of a range of newer digital formats. Of these, only government documents and digital initiatives seem to have generated high levels of interest; other areas seem unaccountably neglected, as is also the general area of textual authority, of increasing concern as digital formats in some areas replace print sources.

The Need for Integration: The Social Organization of Knowledge

If librarianship follows this path of increasing specialization, however necessary that may become in order to keep current with new knowledge, does it then simply break up into so many balkanized specialties and lose whatever unity it once may have had? To some extent this is inevitable, but it does not mean that there are no paths to integration. Earlier versions of this dilemma have been faced in the past. For example, in the United States at the end of the nineteenth century, the research output mushroomed and the great university libraries took shape (Bestor, 1953, p. 176). At the same time, the professionalization of teaching took over the domain of education. In response to both trends, librarians developed general classification schemes and cataloging services. These are still being used and continue to exercise both practical functions in retrieval as well as a general intellectual function of cognitive organization.

This older path to integration is well worth keeping, but there is another that could also be followed to somewhat different effect. This path is not new either, but it has emerged much more recently than the bibliographic control schemes that mark the heyday of progressivism in American librarianship; it is rooted in the histories and sociologies of knowledge. It is an approach that was first called "social epistemology" in the early 1950s (Wilson, 1983, p. viii; Egan & Shera, 1952) and as recently as the late 1980s (Fuller, 1988). Basically, it is the study of the social organization of knowledge production and distribution or, alternatively, the sociology of formal knowledge. "Production" takes care of the original work of the scholar, writer, scientist, and artist, and overlaps with the publishing industry that transforms this work into a distributable text; "distribution" covers the activity of the librarian proper—i.e., selecting, acquiring, gaining access to, collecting, controlling, assessing, evaluating, mediating, and all the other functions librarians fulfill in matching texts with their users (the word "text" like the word "work" is deliberately format-neutral, as it will have to be in a multiformat knowledge environment).

From this viewpoint, what underlies and integrates the work of all librarians is that it deals with texts that encode the knowledge works of their producers. A widening of the traditional jurisdiction, in effect
making the librarian a kind of specialist in the social organization of knowledge, brings some of the integrative potential which so often seems to disappear as knowledge production itself becomes more specialized. As librarians become more specialized in respect of subject, language, area, and format, they follow the differentiating trend, but as they understand the underlying social activity of knowledge production, they discover an integrative force that binds together all knowledge-treating activity. It is obviously not possible to treat this in depth here, but it is reasonable to present some sense of a general outline of the social organization of knowledge as it affects librarians.

Work, Text, and Collection

The collections of materials that librarians are typically charged with managing contain two very different, but closely related, types of cultural objects, the ideal or intangible creations of primary producers, usually called “works,” and those physical objects (books, articles, periodicals, microforms, computer disks, tapes, and a range of other materials of various formats and media) designed and used as vehicles to present works. These are produced in a secondary sense by publishers. To distinguish the physical from the ideal object, these can be called “texts.” This basic distinction is essential for a number of reasons which cannot be further treated here, but which include the central problem of textual authenticity, or credibility in a general sense, or perhaps what Wilson (1983) more generally calls cognitive authority, as applied to knowledge producers and their products, which users expect librarians to know about.

Use Values and Exchange Values of Cultural Objects

It is clear that cultural objects have two distinguishable types of value as all commodities do. Just as one may traffic in material goods either to make direct use of them or to exchange them for something else, one may seek a text to make direct use of it or to compare it with others. Works and texts are resources which are simultaneously products, items in circulation or use, and items which acquire a certain value in comparison with other items or exchange value. Exchange value, because it does not involve direct consumption but rather comparison with other objects, acquires a special symbolic significance which enables comparison to flourish. Thus an intellectual work, whatever physical form its textual vehicle may take, is a product because it is the result of human labor; it is in use or circulation when consulted, read, cited, quoted from, etc.; and it can be exchanged for or, more accurately, compared with other works judged more or less equivalent to it. A certain work was produced by an author and then published (i.e., made into a text) by a publisher; the text moves back and forth among readers, library and bookstore shelves, and, in some cases, museums as it is accessed, read, discussed, quoted, or observed; and finally it acquires a position in relation to other works of its kind which determines its exchange value.
One of the reasons why we distinguish between work and text, aside from the fact that they are two different things, is because they have such clearly different exchange values. The intangible work has a purely qualitative value, expressed by its reputation, or the prestige it has achieved (the work is judged "superior," "extraordinarily important," "ordinary," "not quite what we had hoped for," etc.), while the tangible text can be physically described and measured and exchanged or compared on the basis of cost, price, length, format, typography, condition, etc. Thus the question of comparing a work of Plato's to something by Aristotle or Aquinas or Marx is not a matter of measurement in any literal sense but rather a matter of judgment of intellectual worth; whereas the comparison of one text to another is indeed expressible in quantitative terms—e.g., a certain sentence appears on page sixty-five; this edition is in a red cloth binding or appears on certain size magnetic tape; the text has so many pages; the text block is so many centimeters long, occupies so much disk space, etc. These two provinces are distinct enough to have given rise to two completely distinct and perhaps incompatible types of scholarship or inquiry: that which focuses on the work and that which focuses on the text. Yet work and text both are produced by the same underlying human activity even though "critics" deal with the former and "bibliographers" with the latter.

Although library and information users may turn to critics and commentators more than to librarians in determining exchange value, it is clearly essential for librarians to know something about both, because users are concerned about both. Thus the use-oriented question about a certain text (does it contain what is required for a task?) may easily involve an exchange-oriented question (how does this version compare with that, etc.).

Cultural Capital Formation in Knowledge Production

The broadly socio-economic or political-economic cultural capital formation approach allows us to describe and understand knowledge and information managing activity in terms of the circulation of resources that make it possible. This circulation of resources does not appear to the user directly and remains hidden even though it is the common thread uniting the differentiated specialties. The specialized fields, in other words, are centers of intellectual capital production, use, and exchange.

By "capital" is generally meant wealth or resources used in various kinds of production, particularly those which are set aside for the purpose of generating more wealth or resources. The ultimate reason for capital's existence is that production takes time, and thus there must of necessity be an investment of resource before there is any possibility of return (Lerner, 1968). The concept of "investment" is critical, with its implication of risk, of commitment of resources, before return. Also,
there is an implicit contrast between economic production and mere consumption of what lies ready at hand and can be consumed with no productive labor. The various types of capital are accumulated, circulated, inherited, invested, and generate, as the case may be, different types of return. Economic historians were among the first to note that "capital," far from being a purely material notion indicating the tangible inputs into production (land, labor, and machinery), has the very broad reach used here (Nicholson, 1925, pp. 217-19).

To apply this here, one makes explicit an implicit distinction between resources whose form is material (land, labor, energy, machinery, raw materials, etc.) or economic capital and resources whose form is intangible (social connections, taste, knowledge, insight, educational achievements, expertise, etc.). In some cases, the circulation of these resources results in material advantage, in others it contributes rather to the accumulation of an intangible wealth.

In what is perhaps the clearest statement in English of a characteristic position, the French sociologist Pierre Bourdieu (1986), having first separated the material from the immaterial form of capital, distinguishes two very broad types of immaterial capital—i.e., the cultural and social (pp. 243-44). Cultural capital, which includes intellectual resources, in turn is of three kinds: it may be embodied in a person or a group (dispositions, ideas, cognitive styles, orientations, values, "taste"), it may be presented as a product or "objectified" (writings, works of art, etc.), and finally it may appear in the social processes which legitimate expertise and serve as markers or guarantees of intellectual authority (titles, honors, degrees, formal qualifications, educational curricula, etc.). Social capital, which is not divided into subtypes, refers to the resources accessed through group membership and personal connections which provide various advantages. Though not reducible to cultural capital, social capital is of great indirect relevance to its accumulation, since scholars and researchers are highly dependent on social connections and channels of communication. Librarians, information specialists and brokers, booksellers, and some teachers enter the picture at the distributional end of the process of intellectual capital formation. To some extent, perhaps, they overlap with museum curators in dealing with cultural capital per se.

Since most knowledge producers and distributors pass through the elaborate and lengthy process of becoming educated, a more complete treatment would require reference to education, particularly higher education, as the legitimating source of much of the activity that goes into intellectual capital formation and circulation (Apple, 1995). And this, in turn, obviously requires reference to the complex processes, touched upon briefly in this article, that have contributed to the development of social control mechanisms, such as the professionalization process, in which domains of expertise are rooted in educational certification and credentialing.
This possibility of achieving intellectual integration through social epistemology is obviously highly theoretical, but it also presents some opportunities for policy-oriented developments which are quite interesting in their own right. If librarians have expertise in the social organization of knowledge, might this expertise be used not only to help people find and evaluate information sources, but also be used in a more broader evaluative enterprise? Thus, with expertise in information retrieval, subject or area knowledge, and social epistemology, the librarian might well have a role in what Fuller (1988) has called “knowledge policy studies” (pp. 289 ff.).

ACKNOWLEDGMENT

The author would like to thank Carole Palmer for her role in launching the project and for the invitation to contribute. Thanks are also due to Julie Klein and Axel Borg, who read and commented on earlier versions, and to Michael Peter Smith, for some very useful help along the way.

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