Interdisciplinarity is an inflationary concept in the discourses of higher education and science policy. Yet, some recent structural reforms in European and US universities reflect fundamental changes in the organization of knowledge production and teaching. This publication takes a fresh look at the meaning given to the concept of interdisciplinarity with these reforms. It presents examples of different forms of interdisciplinary research and teaching. These case studies are put in the broader context of reflections on developments in the organization of universities and their implications for knowledge production.

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Interdisciplinarity Again … or Still?

Peter Weingart and Britta Padberg

Interdisciplinarity, the need for it, its uses, how to realize it, why it fails—these and related issues naturally concern the Center for Interdisciplinary Research (ZiF) which is committed to promote it in its research program. When the 100th anniversary of its founder’s (Helmut Schelsky’s) birthday came closer and with it the question how to most fittingly commemorate it, we decided on an academic rather than a purely laudatory format; namely, to once again address problems of interdisciplinarity. In contrast to previous occasions when requisite meetings were concerned with the institutional conditions conducive to interdisciplinary research at universities and research institutes—or at the ZiF itself—this time we wanted to take a closer look at the organizational barriers to interdisciplinarity in universities and models that stand out for having overcome these barriers. The timeliness of this slight shift of focus is suggested by the fact that, e.g., in Germany in the wake of the so-called “excellence initiative,” the political call for interdisciplinary structures has met with reform efforts by several universities. Incidentally, a number of them consist of the foundation of interdisciplinary institutes for advanced studies. But also beyond the German experience the specific problem of organizational obstacles has been addressed in other countries as well, above all in the US
where the National Academy of Science (NAS) and the National Science Foundation (NSF) have given considerable attention to the issue.

Thus, this collection of essays is the product of a conference held in April 2012 under the title “Giving Meaning to Interdisciplinarity in the Organization of Universities—A Symposium on the Occasion of Helmut Schelsky’s 100th Birthday.” Contributions were thoroughly re-written in reaction to comments at the meeting. Two, one by Armin Grunwald, another by Britta Padberg were solicited afterwards.

This book stands in the continuity of two previous publications that were produced under the auspices of the ZiF. The first, “Interdisziplinarität,” edited by Jürgen Kocka and published in 1987, focused mainly on the special features of the ZiF and their relevance for interdisciplinary research within its own confines. The second, “Practicing Interdisciplinarity,” edited by Peter Weingart and Nico Stehr, assembled the contributions from two conferences, one at the ZiF in 1995 (Centers for Interdisciplinary Research—A Model for Institutional Innovation in Science in Europe) and the second (Practicing Interdisciplinarity) at the then newly founded Peter Wall Institute for Advanced Studies at Vancouver in 1997. As the titles indicate, these conferences and books respectively focused on examples of the actual practice of interdisciplinary research at universities and institutes. This book, then, is the third, focusing on model institutions. The crucial questions almost two decades after the look at the practice of interdisciplinarity are now: to what extent scientific disciplines still play a dominant role in the structure of universities, how and under which conditions they can and are being replaced by new structures and what are the specific obstacles to the realization of interdisciplinarity at universities?

The publication consists of two parts: In the first part, different models of interdisciplinary structures at German, American and Dutch universities are presented. Some of them comprise new structures for interdisciplinary education (Leuphana University Lüneburg, Maastricht University). Others are focused on interdisciplinary research (Karlsruhe Institute for Technology (KIT), Center for Interdisciplinary Research (ZiF)) and the additional ones aim to implement interdiscipli-
narity as a guiding institutional principle for the entire university (Arizona State University).

The second part reflects on the context and effects of the growing importance of interdisciplinary structures at universities. How is the current development stimulated and regulated by science policy (Marquardt/Wilhelmy)? How can the university leadership deal with challenges resulting from new grown interdisciplinary structures within disciplinary universities (Schimank)? Are interdisciplinary structures more capable to face rising expectations by society than disciplinary structures are (Weingart)? And does the disciplinary mode of academic knowledge production come to its end (Frodeman)?

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The establishment of Bielefeld University in 1969 as an interdisciplinarily structured new “reform” university reflects a vanguard approach to institutional design that contrasts sharply with the entrenchment of most American colleges and universities in conventional disciplinary academic organization. The Zentrum für interdisziplinäre Forschung (ZiF), or Center for interdisciplinary Research—modeled on the Institute for Advanced Study, in Princeton, New Jersey, and comprising the nucleus of the university—has deservedly been termed the “premier example” of an interdisciplinary “think tank” (Klein 1990, 48). Its centrality within the institutional matrix underscores the incisiveness and foresight of Helmut Schelsky and his colleagues who perceived the transformative potential of an inherently interdisciplinary structure for knowledge enterprises. The prescience of their conception is further underscored by its precedence in relation to the groundswell of interest in the various forms of interdisciplinary inquiry and collaboration that would follow in succeeding decades, an impetus that too often would meet with inertia and resistance from an academic culture attuned to disciplinary processes and practices. The university they envisaged epitomizes the requirements for the optimal advancement of knowledge
specified by Jonathan Cole, provost emeritus of Columbia University, in his important recent monograph on the American research university: “Almost all truly distinguished universities create a seamless web of cognitive influence among the individual disciplines that affects the quality of the whole” (Cole 2009, 5).

With simultaneous pressures impelling scholarship toward increasing specialization on the one hand, and greater synthesis, integration, or convergence on the other, the implications of the organizational context of knowledge within the complex matrix of a research university are not always readily apparent. Insufficient focus is typically devoted to an appreciation of the reflexive relationship between knowledge and its organizational context and thus also the role of institutional design in the advancement of interdisciplinarity. Many would dismiss a critique of conventional academic organization, epitomized by an articulation of the limitations of the congruence between academic disciplines and departments, as mere quibbling over the disposition of the requisite bureaucratic substratum that undergirds epistemological superstructures. Organizational theorists John Seely Brown and Paul Duguid capture the essence of this disregard for organizational context: “In a society that attaches particular value to ‘abstract knowledge,’ the details of practice have come to be seen as nonessential, unimportant, and easily developed once the relevant abstractions have been grasped” (Brown and Duguid 1991, 40). Yet the implementation of any institutional platform is inherently the product of a sequence of decisions that cumulatively determine its structure and functions. Following the theory of “structuration” articulated by Anthony Giddens, we observe that knowledge, organizational structure, and social relations are intrinsically interrelated (Giddens 1984, 25). And to an extent insufficiently appreciated, organizational structure could be said to be determined by a “design process.”

The concept of the “design process” is itself often overlooked or taken for granted. In his explication of the concept, the computer scientist Frederick P. Brooks paraphrases the definition of the verb “design” found in the *Oxford English Dictionary* to underscore its implicit im-
perative for planning prior to implementation: “To form a plan or scheme of, to arrange or conceive in the mind for subsequent execution” (Brooks 2010, 4). The process of institutional design may thus be construed as “design science,” following the articulation of the concept of the “sciences of the artificial” by the polymath Herbert A. Simon. In his expansive usage, everyone is a designer who “devises courses of action aimed at changing existing situations into preferred ones.” While the natural sciences are concerned with how things are, as he puts it, the artificial sciences focus on with how things ought to be. Design determines the form of that which we build, whether tools or farms or our organizations and institutions (Simon 1996, 1-24). There is thus no reason why the design or reconceptualization of an institution or organization cannot represent a process as focused and deliberate and precise as the work undertaken by scientists, engineers, and other scholars.

Despite broad consensus regarding the imperative for inter- or transdisciplinary approaches to inquiry and scholarship, the relationship between institutional design and the advancement of knowledge in the American research university is often regarded as nothing more than a mere perfunctory administrative decision. But inasmuch as the design of our knowledge enterprises is not merely adventitious to the advancement of knowledge, we contend that university administrators and academicians should balance consideration of the epistemological dimension of intellectual culture with its administrative and sociocultural dimensions. As the sociologist Immanuel Wallerstein points out, the academic disciplines are “three things simultaneously... intellectual categories—modes of asserting that there exists a defined field of study with some kind of boundaries, however disputed or fuzzy, and some agreed-upon modes of legitimate research. … The disciplines are in addition institutional structures that since the late nineteenth century have taken on ever more elaborate forms. … Finally, the disciplines are cultures” (Wallerstein 2003, 453). We must consider institutional structure as well as epistemological content in the academic process because optimal design, especially when construed interdisciplinarily,
facilitates teaching and research. We must organize for collaboration across disciplines in order to establish the preconditions essential to discovery, creativity, and innovation, as well as constructive social and economic outcomes (Crow and Dabars 2013).

An appreciation of the implications of the organizational context of knowledge derives from reference to more than a half-century of empirical study and theoretical analysis, beginning with pioneering work by Thomas S. Kuhn. The recognition that “science is a social formation amenable to sociological investigation” has been traced not only to Kuhn but such figures as Ludwig Wittgenstein, Jean-François Lyotard, and Richard Rorty (Miller and Fox 2001, 668-669). Robert K. Merton provided a conceptualization of “socio-cognitive networks” that underscores the importance of a researcher’s milieu in understanding and contextualizing discovery (Merton 1973). Derek J. de Solla Price brought historical perspective to assessments of social networks associated with research frontiers as well as quantitative approaches to an analysis of the proliferation of scientific publications (Price 1986, 103-134; 1965, 510-515). Because it would be superfluous here to attempt an exhaustive chronicle of the many possible paradigms for inquiry and organizational models, the mere few examples adduced must be taken to suggest the extent available from the sociology of science, organizational theory, and social network analysis.

The context for our discussion of institutional design is the set of American research universities, which uniquely combine the functions of teaching, research, and public service. Roughly one hundred universities in the United States, both public and private, are classified as major research institutions in the categorization established by the Carnegie Foundation for Higher Education, while approximately one hundred additional with less extensive research portfolios comprise a second research-grade level.1 While the research sector is largely distinct

1 The Carnegie Foundation for the Advancement of Teaching designates institutions formerly termed “research-extensive” as either RU/VH (“research university/very high research activity”) or RU/H (high research ac-
from higher education in many nations, the American research university integrates undergraduate and graduate instruction with its research enterprise. As exemplars of national systems with parallel and differentiated research sectors that compete with universities, Richard C. Atkinson and William Blanpied cite Germany, where the eighty institutes of the Max Planck Society, and France, where the Centre National de la Recherche Scientifique (CNRS), respectively comprise each nation’s foremost research organization (Atkinson and Blanpied 2008, 41-43). Moreover, public and private universities in the United States alike enjoy relative autonomy and are free to shape their institutional identities as well as their respective mission, values, organization, operations, and practices. The U.S. Department of Education does not function in the manner of most state ministries in this context, which exercise the authority to determine policy as well as the allocation of resources for instruction and research (Paradeise et al. 2009). The decentralization and relative lack of regulation that has characterized the American approach thus stands in marked contrast to the centralized national administration of higher education found throughout much of the world.²

The reflexive relationship between knowledge and its organizational context is nowhere more critically instantiated than in the institutionalization of disciplinarity and inter- or transdisciplinarity in our research universities. Whether one focuses on disciplinary genealogies or interdisciplinary confluence, an understanding of the dynamics that determine their institutionalization and dissemination requires an appreciation of their institutional embeddedness.³ The traditional correlation

² For a discussion of the model of the American research university in a global context, see Crow and Dabars 2012.
³ For an extended discussion of the trajectory of the institutionalization of interdisciplinarity in the American research university, see Dabars 2008.
between academic disciplines and departments—or units termed centers, institutes, schools, and colleges—remains the basis for academic organization and administration in the American research university. In this context, James J. Duderstadt, president emeritus of the University of Michigan, perceives the “deification of the disciplines,” which through departmental structures “continue to dominate the modern university, developing curriculum, marshaling resources, administering programs, and doling out rewards” (Duderstadt 2000, 120-121). The sociologist Andrew Abbott similarly observes that because of their “extraordinary ability to organize individual careers, faculty hiring, and undergraduate education,” disciplinary departments appear to be the “essential and irreplaceable building blocks” of American academia (Abbott 2001, 126-128).

The intrinsic impetus to advance new knowledge distinguishes research universities from other institutional platforms in higher education, but entrenched design limitations obstruct their potential to advance discovery and innovation. Rather than exploring new paradigms for inquiry, academia too often restricts its focus to existing organizational models. We seem to assume that our institutions have as a matter of course been optimally structured and moreover inherently calibrated not only to promote effective teaching and research but also to seek knowledge with purpose and link useful knowledge with action for the common good. Leaving aside urgent concerns regarding equity and access, the persistence of disciplinary partitioning in our estimation represents one of the most critical design limitations to the further evolution of research universities (Crow 2010b).

Perpetuation of discipline-based departments corresponds to an academic culture that prizes individualism over teamwork and the discovery of specialized knowledge over problem-based collaboration. Institutional design to advance interdisciplinarity promises new ways of shaping and examining problems and advancing interaction between heterogeneous groups, programs, and initiatives, which also facilitates applied research initiatives that often require large-scale team efforts to address complex and intractable problems. The well-known call to
action issued by the National Academies regarding the imperative for interdisciplinary collaboration and problem-driven research, *Facilitating Interdisciplinary Research*, envisions “scientists, engineers, social scientists, and humanists ... addressing complex problems that must be attacked simultaneously with deep knowledge from different perspectives.” The committees drafting the report called for new “structural models” to “stimulate new modes of inquiry and break down the conceptual and institutional barriers to interdisciplinary research that could yield significant benefits to science and society” and experimentation with “substantial alteration of the traditional academic structures or even replacement with new structures and models to reduce barriers” to interdisciplinary research (CFIR and COSEPUP 2005, ix, xi, 17).

The differentiation of knowledge enterprises through their inter- or transdisciplinary reconfiguration facilitates their integration into coordinated and synergistic networks, thus expanding their potential to offer multiple solutions and exert greater impact across broader swathes of knowledge. If we are to advance knowledge on a requisite scale in real time toward desired social and economic outcomes, collaboration must be construed not only transdisciplinarily but also transinstitutionally and transnationally. Only an amalgamation of transdisciplinary, transinstitutional, and transnational frameworks has the potential to advance broader social and economic outcomes. When engaged transinstitutionally, the “Triple Helix” of university-industry-government innovation described by the economist Henry Etzkowitz (2008, 1) enables the formation of knowledge networks, which inevitably interconnect and leverage respective knowledge bases from diverse inherently multidisciplinary perspectives. The development of ties with business and industry and government agencies in turn invigorates national innovation systems (Niosi et al. 1993). The objective in all cases should be to engender “perpetual innovation” (Kash 1989).

If the structure of an organization or institution is inimical to its purposes and functions, its design must be radically reconsidered. And if academic units commensurate to the resolution of a given challenge or problem do not already exist, appropriate new units must be configured.
Novel interdisciplinary configurations—what are in a sense institutional “experiments”—possess the potential to reveal new paradigms for knowledge production, organization, and application. An amalgamation of researchers representing different disciplines or interdisciplines may even begin or remain resolutely multidisciplinary. But any such experimental formation has the potential to address complex challenges or even engender the speciation of differentiated new fields. In some cases the exhaustive reconceptualization of an institution undertaken in order to remediate design limitations requires “massive change,” a concept we adapt from the designer and design theorist Bruce Mau, who together with his colleague Jennifer Leonard invoke the imperative for interdisciplinarity and elaborate that “advanced design today is dominated by three ideas: distributed, plural, and collaborative” (Mau and Leonard 2004, 16-17).

**Some Historical Perspective on Institutional Design to Implement Interdisciplinarity**

The innovative character of the conception for institutional organization at Bielefeld University is attested by its emergence in near contemporaneity with the first international conference on interdisciplinarity, which convened at the Université de Nice, September 7–12, 1970, and to a remarkable extent largely established the contemporary context for subsequent discussion of interdisciplinary teaching and research. Organized by the Centre for Educational Research and Innovation (CERI) in collaboration with the Organization for Economic Cooperation and Development (OECD) and the French Ministry of Higher Education (Ministère de l’Enseignement Supérieur et de la Recherche), the “Seminar on Interdisciplinarity in Universities” put the subject on the agenda of academic institutions. The conference proceedings were published in an influential report, edited by an interna-
tional committee of scholars, from Belgium, France, and England (Apostel et al. 1972), the latter of which proved to be particularly receptive to its recommendations (Squires 1992, 205-210).

While the Center for interdisciplinary Research (ZiF) is said to be modeled on the Institute for Advanced Study, Princeton—Björn Wittrock, director of the Swedish Collegium for Advanced Study in the Social Sciences (SCASSS), suggests other prototypes, including All Souls College, Oxford University, and the Collège de France (Wittrock 2002)—its lineage may be traced to other organizational and institutional sources conceived interdisciplinarily as well. Leaving aside the many historical exemplars of knowledge networks, organizations, and institutions that brought scientists and scholars from diverse disciplines together—one need only think of the networks of scholars that the pioneering seventeenth-century chemist and “natural philosopher” Robert Boyle termed “invisible colleges,” with reference to his peers in the Royal Society of London (Price 1986, viii–ix) to appreciate the extent to which historical prototypes for collaboration across disciplines abound—the formation of ZiF represents an important organizational development since it sought from its inception to advance the comprehensive institutional implementation of interdisciplinarity.

Leaving aside as outside the scope of the present discussion the institutional accommodation of the disciplines and interdisciplines of the natural sciences and fields of technology, which certainly remain the enduring and overarching prototypes for interdisciplinary speciation and collaboration—one need only adduce the multidisciplinarity of the Manhattan Project to glimpse the extent to which scientific discovery and technological innovation serve as sources of inspiration in this context—the short list of organizational or institutional prototypes for interdisciplinary organization in contemporary academic culture in the social sciences and humanities begins as recently as the decade of the 1920s when, according to Abbott, the Social Science Research Council (SSRC) focused conceptually on the objective of “eliminating barriers between the social sciences.” He quotes the following passage from their 1934 ten-year retrospective report:
The Council has felt a primary concern with the inter-discipline or interstitial project for the reason that new insights into social phenomena, new problems, new methods leading to advances in the scientific quality of social investigation, cross-fertilization of the social disciplines, were thought more likely to emerge here than from work in the center of established fields where points of view and problems and methodology have become relatively fixed.4

And in 1935, to cite a closely contemporaneous exemplar of this impetus, the president and fellows of Harvard University established the University Professorships, chairs intended for “individuals of distinction … working on the frontiers of knowledge, and in such a way as to cross the conventional boundaries of the specialties.”5

But frustration with disciplinary limitations had led to a more comprehensive organizational reconfiguration at another institution a decade earlier. Syracuse University established the Maxwell School of Citizenship and Public Affairs in 1924 to offer graduate professional education in public administration and international relations and graduate degrees in the social sciences, including political science, economics, and history.6 Another leading example of interdisciplinary configuration in the social sciences and humanities is the celebrated Committee on Social Thought at the University of Chicago, instituted in 1941 by then president Robert M. Hutchins. With “primary themes” of literature, philosophy, history, religion, art, politics, and society, “the Committee differs from the normal department in that it has no

5 According to the Harvard University General Catalogue: “By vote of the President and Fellows on June 19, 1935, a plan was adopted for the establishment of new professorships for individuals of distinction not definitely attached to any particular department, and these were to be known as University Professorships. It was proposed to reserve these new chairs for individuals working on the frontiers of knowledge, and in such a way as to cross the conventional boundaries of the specialties.” Official Register of Harvard University 14, no. 9 (August 29, 1991).
6 http://maxwell.syr.edu/deans (last accessed August 12, 2013).
specific subject matter and is organized neither in terms of a single intellectual discipline nor around any specific interdisciplinary focus.”

A more recent aggregation of the social sciences, the short-lived Department of Social Relations at Harvard University, merging social anthropology, social psychology, and sociology, dissolved with the retirement of its founder, Talcott Parsons (Abbott 2001, 126).

A number of institutions spearheaded some notable organizational configurations in the humanities during this period, including the formation of an avowedly interdisciplinary program for undergraduates at Princeton University in 1936 termed the “Special Program in the Humanities.” In 1937 Columbia University initiated its interdisciplinary freshman “sequence in the humanities” (“a reading list of literary, philosophical, and religious texts from Homer to Goethe”) (Marcus 2006, 16-17). But several more decades passed before the University of California would attempt a more comprehensive conceptualization in the humanities. From its inception in 1966 the Program in the History of Consciousness at UC Santa Cruz is said to have fostered interrelations between the humanities and the social sciences, natural sciences, and the arts, and advanced a “focus on problems rather than disciplines” with a curriculum predicated on methodological and theoretical issues and the integration of disciplines. During the same academic year, the Humanities Center at Johns Hopkins University began offering graduate degrees in both comparative literature and intellectual history. Program literature specifies “because of the interdisciplinary interests of some of its most distinguished faculty, Hopkins has fostered to a remarkable degree the free exchange between scholars and students across departmental boundaries.” In 1969 Stanford University established the doctoral program in Modern Thought and Literature (MTL). Deriving its methodological approach from the emerging field of

9 http://humctr.jhu.edu/about (last accessed August 12, 2013).
cultural studies, the program sought to position itself “firmly and decisively within a rigorous interdisciplinary framework with fields such as science and technology, media and film studies, legal studies, race and ethnic studies, gender and sexuality studies, medicine, education, anthropology, and history and philosophy.”[^10] The decade that witnessed the establishment of Bielefeld University with ZiF at its core thus appears to have been particularly propitious to the formation of interdisciplinary academic configurations.

A CASE STUDY IN INSTITUTIONAL DESIGN: TRANSDISCIPLINARY RECONCEPTUALIZATION AT SCALE IN REAL TIME

During the past decade, the institutional implementation of interdisciplinarity has been one of eight explicit “design aspirations” of Arizona State University, the youngest major research institution in the United States and—with an enrollment surpassing seventy three thousand undergraduate, graduate, and professional students—largest university governed by a single administration. The reconfiguration of academic departments and disciplinary fields undertaken to advance interdisciplinary teaching and research, however, must be understood within the broader and interrelated context of the comprehensive and multidimensional decade-long institutional reconceptualization launched in 2002, which was conceived with the objective of establishing a foundational model for a “New American University,” an institution predicated on the pursuit of academic excellence, inclusiveness to a broad demographic, and maximum societal impact.[^11] *Newsweek* has termed

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[^11]: Michael M. Crow articulated the vision for a New American University when he became the sixteenth president of Arizona State University in July
this institutional experiment at scale in real time “one of the most radical redesigns in higher learning since the modern research university took shape in nineteenth-century Germany” (August 9, 2008). An editorial from the journal *Nature* observes that questions about the future of the contemporary research university are being examined “nowhere more searchingly than at Arizona State University” (April 26, 2007).

While institutional initiatives to advance interdisciplinarity are often fraught with extraneous theoretical justification, its conceptualization and implementation at Arizona State University has in practice been shaped largely through exhaustive trial and error, a number of course corrections, and the best efforts of administration and faculty at the application of common sense. ASU seeks to advance knowledge and human well-being through teaching and research conducted within a flexible organizational framework that maximizes collaboration and communication between the core disciplines, some of which remain departmentally-based while others are construed across departments, centers, institutes, schools, and colleges and new explicitly interdisciplinary configurations. These new academic entities (“new schools”) have been established to advance teaching and engender research, both fundamental and applied, which possesses the interdisciplinary breadth to address the large-scale “grand challenges.”

Most colleges and universities in the United States define themselves in comparison to a set of elite institutions that comprise the “gold standard” in American higher education: the Ivies, the great...
land-grant universities, and those constructed on the foundations of private fortunes (Geiger 1986, 2-3). These fifteen institutions represent an elitist model that remains to a remarkable extent unchanged since the nineteenth century and inaccessible to the majority of students. By contrast, ASU has sought to meet burgeoning enrollment demand in Arizona, which is the setting of one of the megapolitan agglomerations emerging in the United States, the so-called Sun Corridor stretching from the Prescott area of central Arizona to the border with Mexico (Nelson and Lang 2011, 143-153). With an economy insufficiently diversified to accommodate population expansion, Arizona is confronted with major challenges associated with the environment, healthcare, social services, immigration, and the performance of P-12 education, all of which place implicit demands on the university. In metropolitan Phoenix, which is projected to increase in population from four million to eight million by midcentury, ASU remains the sole comprehensive research university. The unprecedented transformation of the regional demographic profile in one of the fastest-growing states in the nation has thus shaped the institutional “design process” undertaken to reconceptualize academic organization and operations.

Rather than extrapolate from existing structure and operations or replicate historical models perceived to represent the putative gold standard, the design process has sought to create a distinctive institutional profile by building on existing strengths to produce a federation of unique transdisciplinary departments, centers, institutes, schools, and colleges (“schools”) and a deliberate and complementary clustering of programs arrayed across four differentiated campuses. In this “school-centric” conception, academic units compete for status intramurally but with peer entities globally. In the process ASU has advanced interdisciplinarity through the consolidation of a number of traditional academic departments, which henceforth no longer serve as the sole institutional locus of a given discipline, including anthropology, geology, sociology, and several areas of biology. Transdisciplinarity thus trumps traditional academic organization and encourages team participation in projects that accomplish implementation and ap-
plication. While more than two dozen new transdisciplinary schools were conceptualized and operationalized, some have been subsequently further reconfigured or merged.

Although the correlation between discipline and department represents the conventional norm, in practice the interrelationships are sometimes complex and not always self-evident. One aspect of the design process was to clarify the relationship between core academic disciplines and the new interdisciplinary configurations that have emerged (identity), their disposition within the university (configuration), and their anticipated evolution (trajectory). A comprehensive unit-level assessment of the institutional status of disciplinarity and interdisciplinarity sought to articulate disciplinary identities and an examination of their interrelationships, including assessments of each in terms of its alignment with fundamental and irreducible disciplines, and the significance of its emergence in a novel interdisciplinary configuration. Assessments of configuration, which one may think of as positional embeddedness within institutional coordinates, examined disciplinary and interdisciplinary interactions and interrelationships, whether synergistic, symbiotic, or even antagonistic. Finally, the consideration of trajectory sought to reveal the status of an entity within its disciplinary continuum, its role in the emergence of associated interdisciplinary formations, and its relationship to emerging peer entities.

The impetus to reorganize and recombine discipline-based academic departments had already gained a foothold at ASU before the full operationalization of the design process. An ambitious reorganization of the biological faculties to overcome disciplinary entrenchment epitomized the momentum. In July 2003, the departments of biology, microbiology, plant biology, and the program in molecular and cellular biology merged to form the new ASU School of Life Sciences (SOLS). While administrative efficiency was cited as an objective, the motivation for the creation of SOLS was largely to advance interdisciplinarity: “to facilitate collaboration across the range of disciplines covered by the school; ... and to exploit the fact that the key research challenges in the life sciences lie at the interface of sub-disciplines, often involving
integration of knowledge from different levels of biological organization and across different kinds of organisms.” Its mission statement specifies that the school was conceived “without internal disciplinary barriers, allowing it to plan strategically at the seams of intersecting disciplines.” The school is currently organized into seven faculty groups: biomedicine and biotechnology; cellular and molecular biosciences; genomics, evolution, and bioinformatics; ecology, evolution, and environmental science; human dimensions of biology; organismal, integrative, and systems biology; and basic medical sciences. The arrangement allows more than one hundred life scientists, engineers, philosophers, social scientists, and ethicists to self-organize around the socially and environmentally relevant questions of the day.

Among the new transdisciplinary schools conceptualized and operationalized during the past decade within the College of Liberal Arts and Sciences are the School of Human Evolution and Social Change; School of Earth and Space Exploration; School of Politics and Global Studies; School of Social and Family Dynamics; School of Social Transformation; and School of Historical, Philosophical, and Religious Studies. These schools complement initiatives such as the Global Institute of Sustainability (GIOS), which incorporates the first-of-its-kind School of Sustainability, and the Biodesign Institute, the premier multidisciplinary research center dedicated exclusively to advancing biologically inspired design to address global challenges in healthcare, sustainability, and national security. The research of this large-scale array of labs and centers is aimed at improving human health and the environment through interdisciplinary efforts in such areas as personalized diagnostics and treatment; infectious diseases and pandemics; and renewable sources of energy. The Biodesign Institute houses ten research centers that are leveraged in a highly collaborative, team-oriented, and synergistic manner to address complex problems. Work-

ing in the broad domains of biological, nanoscale, cognitive, and sustainable systems, the transdisciplinary research centers of the institute are advancing our understanding of such areas as biosignatures, biosensors, bionics, and biofactories, ubiquitous sensing, optimized human performance, and environmental sustainability, as well as personalized medicine.

Other transdisciplinary configurations include the Complex Adaptive Systems Initiative (CASI), a collaborative effort to address global challenges in health, sustainability, and national security through the creation of new technologies and novel solutions; Security and Defense Systems Initiative; Flexible Display Center, a cooperative agreement with the U.S. Army to advance the emerging flexible electronics industry; LightWorks, a multidisciplinary effort in renewable energy fields including artificial photosynthesis, biofuels, and next-generation photovoltaics; and initiatives in the humanities and social sciences, including the Institute for Social Science Research and Center for the Study of Religion and Conflict.

The School of Earth and Space Exploration (SESE) epitomizes the limitless potential of new transdisciplinary configurations. SESE combines the conventional disciplines of astronomy and astrophysics; cosmology; Earth systems sciences; planetary sciences; and systems engineering to deepen our understanding of our planet and the universe. Within an inherently transdisciplinary framework, the school is advancing strategic research initiatives in a number of areas, including the origin and evolution of the universe; the emergence and function of planetary bodies; the origin, evolution, and distribution of life; the co-evolution of Earth’s surface environment and human societies; and science and engineering education. The school aspires to methodological fluidity in a conceptual framework that recombines modes of inquiry to address some of the most profound challenges of the epoch. The broad theme of exploration represents a transdisciplinary conceptualization of the quest to discover the origins of the universe and expand our understanding of space, matter, and time. While the conventional disciplines of the earth and space sciences are predominantly historical, according
to planetary geologist Ronald Greeley and his colleagues, the transdisciplinary conceptualization of SESE make it possible to “elevate both to predictive sciences” in order to address such questions as the ultimate fate of the universe.\textsuperscript{13}

Established in July 2006 through amalgamation of the former Department of Geological Sciences and the astronomy, astrophysics, and cosmology faculties of the former Department of Physics and Astronomy—thereafter the Department of Physics—SESE boasts a faculty roster that includes theoretical physicists, systems biologists, biogeochemists, and electrical engineers. Affiliated engineers bring technological expertise that advances the development and deployment of critical scientific instrumentation on Earth and in space. The transdisciplinary fluidity of the school inevitably facilitates collaboration and communication between scientists and engineers, engaging researchers from other schools and institutes, including the Biodesign Institute and Ira A. Fulton Schools of Engineering.

The wealth of subfields within given disciplinary areas suggests the breadth their recombination enables. Subfields within astrophysics and cosmology, for example, include computational astrophysics; physics of the early universe and the formation of large-scale structure; and the formation and evolution of galaxies, stars, and planetary systems. Subfields within Earth system sciences include biogeoscience; continental tectonics and structural geology; geochemistry; geophysics (including geodynamics and seismology); petrology, mineralogy, mineral physics, and mineral resources; surface processes (including geomorphology and hydrology); and volcanology and volcanic hazards.\textsuperscript{14}

In 2005 ASU launched the School of Human Evolution and Social Change (SHESC), combining the major areas of anthropological enquiry, including archaeology, bioarchaeology, physical anthropology, cultural anthropology, linguistics, and museum anthropology, with such areas as mathematics and computer science, geography, political

\textsuperscript{13}  Greeley et al. 2010.
\textsuperscript{14}  Ibid. 3-4.
science, museum studies, epidemiology, economics, and sociology. The new school boasts such transdisciplinary research centers as the Archaeological Research Institute, Center for Global Health, Center for Digital Antiquity, and Institute of Human Origins. The allied Consortium for Biosocial Complex Systems engages the Complex Adaptive Systems Initiative.

Transdisciplinary collaboration allows SHESC scientists and scholars to address complex problems from comparative and holistic perspectives, whether the challenge is epidemics of infectious disease, sustainable management of natural resources, or adaptation to climate change. The quest to understand human origins, evolution, and diversity engages research in such areas as societies and their natural environments; biocultural dimensions of global health; culture, heritage, and identity; global dynamics and cultural interactions; and urban-focused research on such as questions of how cities evolve and how we can ensure their sustainability. The school thus provides students with an integrated curriculum in the social, behavioral, and natural sciences focused on the evolution of our species and trajectories of human societies.\(^\text{15}\)

To broaden the reach of engineering programs, ASU now offers students with varying levels of preparation two distinct learning platforms, the one theoretical and the other practical. The Ira A. Fulton Schools of Engineering are organized into five distinct research-intensive transdisciplinary schools, including the School of Biological and Health Systems Engineering; School of Computing, Informatics, and Decision Systems Engineering; and School of Sustainable Engineering and the Built Environment. On the other hand, the College of Technology and Innovation on the Polytechnic campus focuses on use-inspired translational research, and offers students interested in direct entry into the workforce an experiential learning environment.

The design aspirations are intrinsically interrelated, and the interplay between interdisciplinarity and efforts to advance sustainability as a core value is representative of their dynamic. With the establishment of the Global Institute of Sustainability (GIOS) in 2004 and the first-of-its-kind School of Sustainability (SOS) three years later, ASU has positioned itself in the vanguard of interdisciplinary research on environmental, economic, and social sustainability. The institute brings together scientists and engineers with government policymakers and industry leaders to share knowledge and develop solutions to pressing real-world problems. With research in areas as diverse as agriculture, air quality, marine ecology, materials design, nanotechnology, policy and governance, renewable energy, risk assessment, transportation, and urban infrastructure, the faculty members affiliated with GIOS are addressing some of the most critical challenges of our time as well as training future generations of scholars, scientists, and practitioners.

To prepare students capable of integrating a broad range of disciplines in a rapidly changing knowledge economy, the School of Sustainability offers both undergraduate and graduate degree programs. The school is educating a new generation of leaders through collaborative, transdisciplinary, and problem-oriented training that addresses environmental, economic, and social challenges. Teaching and research seeks adaptive solutions to such issues as rapid urbanization, water quality, habitat transformation, the loss of biodiversity, and the development of sustainable energy, materials, and technologies. In order to engender an institutional culture of sustainability, moreover, ASU offers sustainability-themed courses in fields as diverse as anthropology, architecture, biology, economics, engineering, industrial design, law, philosophy, nonprofit leadership, and urban planning.

Along with such guiding principles of modern societies as human rights, sustainability is an epochal question that must be addressed by the citizens of a planet with a population that already exceeds six billion and is projected to approach ten billion. Entrenchment in disciplinary silos undermines the capacity of our institutions to advance research that can provide us with the means to balance wealth generation
with continuously enhanced environmental quality and social well-being. Interdisciplinary research and teaching associated with sustainability is representative of the ASU effort to design a prototype for the evolution of the American research university (Crow 2010a).

**TOWARD COMPREHENSIVE KNOWLEDGE ENTERPRISES TRANSDISCIPLINARILY CONSTRUED**

At many institutions to this day, the institutional implementation of interdisciplinarity remains piecemeal and restricted to mere recombinations of individual academic units. The comprehensive conception of Bielefeld University with the Zentrum für interdisziplinäre Forschung constituting its core thus represents a prototype that deserves recognition and emulation. While institutional reconceptualization of this order is clearly essential for other universities, the broad consensus or collective sense of urgency that would transform analysis into action is little in evidence. In a keynote address to the American Council on Education, Gordon Gee, president of Ohio State University, expressed with particular eloquence the imperative for “radical reformation” for our colleges and universities: “The choice, it seems to me, is this: reinvention or extinction” (Gee 2009). Although universities throughout the world have long been transformational catalysts for innovation and societal advancement, what remains to be determined is whether they can sufficiently lend direction and purpose to the artistic and humanistic insight, social scientific understanding, scientific discoveries, and technological adaptations that are the product of an academic culture that represents our best hope as we negotiate the backdrop of encroaching complexity in the coming decades.
REFERENCES


