9

Toward New Interdisciplinary Structures

Performing interdisciplinary research (IDR) often requires additional resources, such as extra startup time, complex equipment, and extended funding. The nature of the structure in which IDR takes place—which may be an actual or virtual space—can help or hinder its progress. The hindrances created by some structures, discussed in Chapters 4 and 5, have prompted experiments designed to lower and even remove barriers and to facilitate IDR in other ways.

Convocation Quote

The academic research community has yet to grasp completely the degree to which interdisciplinary research probes at the heart of what the American research system has come to be, at least in terms of the role of the independent investigator. There are deep cultural issues for individual researchers and the institutions where they do their work that are so embedded it is going to take a lot of work to overturn them. It is not going to happen very easily.

James Collins, Arizona State University

INTERDISCIPLINARY STRUCTURES

Over the last several decades, a variety of formats or structures for IDR have evolved. If they could be arranged along a spectrum, at one end might

be the individual researcher—the modern equivalent of the polymath—who has achieved single-handedly a deep understanding of two or more disciplines and the ability to integrate them. At the other end might be a structure of multiple government-funded programs staffed by thousands of scientists and engineers drawn to a goal as ambitious—and focused—as the search for life on Mars. Interdisciplinary structures may also be interinstitutional, sharing no common physical space, or they may be in physical centers or "collaboratories" of substantial size and life span.

Whatever their structure, interdisciplinary projects flourish in an environment that allows researchers to communicate, share ideas, and collaborate across disciplines. The flow of ideas and people is made possible by institutional policies that govern faculty appointments and salary lines, faculty recruitment, responsibility for tenure and promotion decisions, allocations of indirect-cost returns on grants, development of new course and curricular materials, and so on.

A VISION OF NEW INSTITUTIONAL STRUCTURES: THE MATRIX MODEL

Many researchers want to pursue interdisciplinary work more actively, but what new structures can best support them? The committee envisioned two possible modes for the creation of new structures: an incremental mode, which builds on lessons learned in the recent past, and a more transformative mode in which change comes more rapidly and discontinuously with respect to existing structures and practices.

Given the diverse nature of interdisciplinary activities, the number of formats for IDR in the future is likely to reflect the growing complexity of research. Whatever format characterizes a given IDR project, especially in academic institutions, it must operate in the context of a larger, overarching institutional framework that in many ways defines and constrains it. It is important, therefore, to examine institutional organizations and traditions critically and to ask what kinds of changes are possible and helpful for IDR.

An older management structure of universities is a landscape of separate components, or "silos," with weak coupling between them. A newer structure, which can already be discerned both in the United States and abroad and which has long been evident in industry and elsewhere, is more like a matrix, in which people move freely among disciplinary departments that are bridged and linked by interdisciplinary centers, offices, programs, courses, and curricula. There are many possible forms of coupling between departments and centers, including appointments, salary lines, distribution of indirect-cost returns, teaching assignments and course-teaching credits, curricula, and degree-granting.

A matrix structure (see Box 9-1) in a university might include many

DEFINITION

BOX 9-1 What Is Matrix Management?

Matrix management is a product of organizational theory. The term refers to a management approach that encourages the development of orthogonal (cross-cutting) organizational structures. Traditionally, the department is the primary organizational structure of a university. Departments may be considered "vertical" structures. Orthogonal structures are functional groups that involve members who span multiple departments.

Some institutions have adopted matrix structures in which colleges, departments, and professional schools form the vertical dimension and research centers and institutes constitute the orthogonal dimension. In this spirit, the National Science Foundation (NSF) has established a suite of cross-cutting programs that include interdisciplinary programs, programs that are supported by multiple NSF directorates, and programs jointly supported by NSF and other federal agencies. The University of California, Davis has established horizontal budgeting structures (see Box 5-8). The University of Kansas has developed a matrix whereby research centers and institutes' directors report to the same central research administration as the departments. Benefits of this matrix structure include pooling of resources for equipment, grant-management support, generation of "critical mass," enhancement of stature, and mentoring, all of which improve the productivity of research faculty members.

---

[a]National Science Foundation Crosscutting/Interdisciplinary Programs home page *http://www.nsf.gov/home/crssprgm/.*

[b]Roberts, J. A. and Barnhill, R. E. "Engineering Togetherness: An Incentive System for Interdisciplinary Research." ASEE/IEEE Frontiers in Education Conference, Reno, NV, October 10-13, 2001. The authors write, "This type of organization, when properly implemented, facilitates interdisciplinary research…. Universities that tie research centers and institutes to disciplinary academic units will increasingly find themselves at a disadvantage in attempting to form effective teams to compete for interdisciplinary research grants which are more and more becoming the norm." See also Barnhill, R. E., "How sustainable is the modern research university." AAAS S&T Policy Forum. Washington, DC, April 23, 2004 *http://www.aaas.org/spp/rd/barnhill404.pdf.*

joint faculty appointments and PhDs granted in more than one department which would enable participants to address cross-cutting questions more easily. It might create numerous interdisciplinary courses for undergraduates, provide mentors who bridge the pertinent disciplines, and, equally important, offer faculty numerous opportunities for continuing education whereby they could add both depth and breadth of knowledge throughout their careers.

Successful matrix structures in research universities of the future may provide robust mechanisms for allocating faculty positions to areas of IDR, cross-departmental mechanisms for tenure and promotion review, and ways

to facilitate team teaching by more flexible allocation of instructional credits. Policies that allow the return of some indirect-cost revenues to research units can be structured so as not to disadvantage interdisciplinary centers and programs that have external funding. Support for graduate students who choose to study in cross-disciplinary fields with mentoring by more than a single faculty member can create incentives for venturing into IDR. Most of those institutional changes would probably involve little cost; rather, they represent a shifting of existing incentive structures.

In the United States, many universities and other institutions are experimenting with matrix-like structures. At the US Geological Survey, researchers work in teams, but their funding may come from various programs not directly related to the teams. At the University of Washington, the Program on the Environment (PoE) has created a horizontal network to bring together faculty and students from across the university to participate in the environmental education programs (see Box 9-5). The PoE is overseen by a Governing Board that consists of 24 faculty, staff, and students representing a wide array of departments, colleges, and service units. In addition to an interdisciplinary bachelor's degree program, the PoE offers graduate certificates in three interdisciplinary fields.

BEYOND THE MATRIX

Individual students, postdoctoral scholars, faculty, staff, and other members of academic communities accommodate their aspirations and plans to the possibilities that they see in the institutional structures around them. In considering how institutional characteristics might be changed to facilitate IDR, it is useful to think of how such changes might affect peoples' abilities to reach their goals. A more dramatic or "revolutionary" vision of interdisciplinarity might be seen as a transformed matrix in which institutions strive for a more complete integration of disciplines, institutions "without walls," a high degree of flexibility and mobility for students and faculty, and research efforts that are organized around problems rather than disciplines.

An example of a "revolutionary" vision is one in which students are encouraged to look across and draw experience from a wide spectrum of scientific knowledge and mentors before choosing a field of specialization (see Box 9-2). Some graduate programs, for example, admit students into the general "biological sciences" and allow them a year or two to choose a specialization. Similarly, the new Olin College, recently founded in Cambridge, Massachusetts, trains its incoming students simultaneously in all the engineering sciences; as students gain experience, they choose specific problems to focus on; in this case, the Olin Foundation has decided to pay all student tuition and to support the college itself for a specified period.

INNOVATIVE PRACTICES

BOX 9-2 Replacing Courses and Majors with Programs and Planning Units

In the traditional academic term, students take several stand-alone courses offered by individual departments and integrate cross-cutting concepts on their own. In contrast, students at The Evergreen State College[a] are strongly encouraged to take a single *program* each term. Programs, taught by faculty teams, are designed to help students to bring together ideas from multiple disciplines, with titles such as "Leadership for Urban Sustainability," "Fishes, Frogs, and Forests," and "Data to Information: Computer Science and Mathematics." Programs are organized into "planning units" associated with faculty who have related interests. Planning units offer students a means of focusing their study; students at Evergreen end up receiving a BA or a BS without a listed major. Graduate programs are similarly organized. For example, the Graduate Program in Environmental Studies was established in 1984 and integrates the study of environmental science and public policy. The curriculum consists of closely integrated courses taught by faculty teams trained in the social, biological, and physical sciences.

Other universities have adopted similar models. Pennsylvania State University offers intercollege programs for undergraduate minors in astrobiology, environmental inquiry, gerontology, marine sciences, military studies, and neuroscience.[b] The Department of Physics at Harvard has offered a joint concentration with the Department of Chemistry for many years.[c] The concentration in chemistry and physics is supervised by a committee that comprises members of the Departments of Physics and Chemistry, and it is administered through the office of the director of undergraduate studies. As the name implies, the concentration has been established to serve students who want to develop a strong foundation in both physics and chemistry rather than specialize in one or the other. The concentration is often chosen by students whose career goals lie in medicine, but the intellectual disciplines involved provide a suitable background for careers in a variety of professions. Some 15 years ago, 14 students opted for this honors program; over the years, enrollment has steadily increased, and in 2004 there are 45 students.

---

[a]Evergreen State College home page. *http://www.evergreen.edu.*

[b]Penn State University Intercollege Program home page *http://www.psu.edu/bulletins/bluebook/$inmenu.htm.*

[c]Harvard University Chemistry and Physics Concentration home page *http://www.registrar.fas.harvard.edu/handbooks/student/chapter3/chemistry_and_physics.html* 2004.

There are models of interdisciplinarity in all venues of scholarship. Rockefeller University is organized around its laboratories (see Box 9-3); the Institute for Advanced Study in Princeton, New Jersey, admits only postgraduate "visiting members" who are free to pursue independent study and develop collaborations as they choose. The Theory Group at Microsoft Corp. and some national laboratories have no disciplinary divisions.

INNOVATIVE PRACTICES

BOX 9-3 A University Without Departments: Rockefeller University

The Rockefeller Institute/University in New York City has been the site of more major discoveries in biomedicine in the 20th century than any other institution in the world. Rockefeller has been associated with 23 Nobel laureates and 19 Lasker Award recipients. Five faculty members have been named MacArthur fellows and 12 have garnered the National Medal of Science, the highest science award given by the United States. In addition, 32 Rockefeller faculty are elected members of the National Academy of Sciences.

Hollingsworth and Hollingsworth[a] argue that "major discoveries occurred repeatedly because there was a high degree of interdisciplinary and integrated activity across diverse fields of science, and because of leadership that gave particular attention to the creation and maintenance of a nurturing environment, though with rigorous standards of scientific excellence." In essence, there are three important characteristics: a high level of scientific diversity, low levels of internal differentiation (i.e., no disciplinary departments), and visionary leadership.

The Rockefeller Institute was founded not on the basis a particular field or researcher, but to pursue diverse subjects in biomedical sciences. Researchers with diverse scientific and cultural backgrounds were recruited. Most worked in fields that crossed academic disciplines. In addition, Rockefeller did not organize the production of knowledge around academic disciplines. The institute was originally organized around two departments: the Department of Laboratories and the Department of the Hospital. The university's laboratory-based organizational structure "without walls" and pared-down layers of administration do away with the schools and academic departments that too often separate scientists. "This approach fosters a tremendously rich soup of interdisciplinary research and collaboration," says Rockefeller Professor and Nobel laureate Günter Blobel.[b]

[a]Hollingsworth, R. and Hollingsworth, C.T. Major Discoveries and Biomedical Research Organizations: Perspectives on Interdisciplinarity, Nurturing Leadership, and Integrated Structure and Cultures. In: *Practising Interdisciplinarity.* Eds. Weingart, P. and Stehr, N., Toronto: University of Toronto Press, 2000, pp. 215-44.

[b]Rockefeller University home page *http://www.rockefeller.edu/about.php.*

Some of the innovations and experiments stem from the growing literature showing that organizing information into a conceptual framework allows a student to apply what was learned in new situations and to learn related information more quickly.[1] For example, students may find that the essence of physics is best discovered by beginning with specific methods—by "learning how to learn"—rather than by beginning with formulas, facts,

[1]See for example, National Research Council "*How People Learn: Brain, Mind, Experience, and School.*" 2000. Washington, D.C.: National Academy Press.

and laws whose utility or relevance they can better appreciate at a later stage of education. Clearly, institutions that implement the kinds of changes described are placing a heavy burden of decision making on their students. The students in turn must rely on deeper and more extensive networking with teachers, mentors, and other students.

SUPPORTING NEW INTERDISCIPLINARY STRUCTURES FOR PEOPLE AND PROGRAMS

Is it reasonable for institutions of higher learning to remake themselves around new interdisciplinary structures of teaching and research (see Box 9-4)? This committee has heard many arguments for change, as well as reasons for caution. Few voices, for example, have been raised in favor of

INNOVATIVE PRACTICES

BOX 9-4 Cross-Cutting Reorganization of Academic Departments

Funding agencies can act as change agents, providing funding for programs to invigorate an emerging field of study or to establish new priorities for research universities. At least partly as a consequence of participating in an engineering research center (see Box 8-2), the Schools of Engineering of Purdue University in 2003 decided to reorganize into clusters, or signature areas. These areas are "multidisciplinary initiatives which cut across the established boundaries of Purdue's engineering schools and related disciplines."[a]

To support the eight newly created areas, Purdue is investing in new faculty positions that will be filled by using a cluster hiring process (see Box 5-4). Areas include advanced materials and manufacturing, global sustainable industrial systems, intelligent infrastructure systems, and nanotechnologies and nanophotonics. Purdue is also expanding and upgrading facilities, including the development of a transparent environment for multidisciplinary work.

The primary goal of the reorganization is to provide an opportunity for undergraduate and graduate engineering students to learn and work in an interdisciplinary environment and to gain real-world experience. To that end, Purdue has created a new Department of Engineering Education.[b] The new department will combine the existing freshman engineering and interdisciplinary engineering programs and aims to increase student interest in engineering and research in how students learn engineering concepts.

---

[a]Purdue University, College of Engineering, Signature Areas. *https://engineering.purdue.edu/Engr/Signature.*

[b]Holsapple, M. Purdue Counters Trend, Engineers Education from the Ground Up. Purdue News, April 9, 2004. Available on line at: *http://news.uns.purdue.edu/UNS/html3month/2004/040409.BOT.enged.html.*

abolishing sound institutional management that is needed to organize, support, and legitimize research programs. Many voices have confirmed the importance of mastering a specific discipline in depth before investigating new disciplines. And no one has pushed for institutional change that is forced or attempted in precipitous fashion. It seems more reasonable for institutions to adopt goals that look revolutionary now but to approach them in ways that are based on consensus, experiment, and sound models.

What might be some useful features of the restructured university—one that serves the interests of students, faculty, and the institution? The following suggestions are intended to put forward directions of desirable change without constituting recommendations. Most of these steps have been tested by institutions and might serve as models for others.

Change at the Undergraduate Level

Undergraduate students might profit by planning programs that suit their interests and abilities with continual reshaping in the light of advancing understanding and with the guidance of faculty mentors. Graduation requirements could be general, including such broad features as total amount of coursework required and requirements for independent study or research. Focused interdisciplinary programs, such as those at the intersections of natural science and social science, could be taught by teams of interdisciplinary faculty working outside the aegis of individual departments or colleges. Students could be encouraged to become active members of interdisciplinary research groups and to adopt roles commensurate with their skills, talents, and goals.

Undergraduate students have shown themselves to be responsive to interdisciplinary and problem-driven questions, especially those of societal relevance. (See Figures 4-1 and 8-1.) They can prepare to address such questions by seeking institutions that provide opportunities for IDR at the undergraduate level, have strong interdepartmental connections and interdisciplinary centers and programs, provide opportunities for cooperative experiences outside academe, and allow dual or multiple majors or majors and minors in different fields.

Change at the Graduate Level

Many institutions already admit graduate students to programs of study, some interdisciplinary, whose admissions criteria, degree requirements, and formation of graduate-study committees are administered through the programs themselves. Policies and practices are normally set by faculty members recruited into the programs. (See, for example, Boxes 4-2, 4-3, 4-4, and 4-5.)

In a more extensive implementation of this model, decisions about allocations of faculty positions to various programs, research budgets, and teaching budgets could be made by deans with responsibility for groups of programs. The graduate programs could place a premium on team teaching and on finding dual faculty mentors (see Box 4-5). Graduate degrees could be awarded by the programs with an optional focus on a particular discipline(s); for example, a student might receive a PhD in climate modeling with a focus in geology, atmospheric science, or chemistry.

Successful implementation of such a vision requires a matrix model in which the distribution of such important resources as research space and graduate-teaching-assistant positions is determined for the university as a whole rather than at a departmental or perhaps even college level.

Change at the Faculty Level

Faculty could be recruited for positions in programs as well as in departments (see Box 9-5). They could teach courses within the special sphere of a program or foundation courses in traditional areas. Advancement toward tenure could be monitored by one or more mentors in the faculty member's program and by senior faculty in traditional fields of special interest to the young faculty member. Active participation and effectiveness in one or more program areas could be expected of all faculty seeking tenure. Membership in any specific program would probably not be permanent; the program might disappear or evolve, or the faculty member's interests might change.

The concept of tenure could be more flexible. Faculty admitted to tenure after initial evaluation—after, say, 5 or 7 years—might receive 5-year reappointments. Reappointment might depend on successful review by a peer faculty committee in the areas of specialization, including external

INNOVATIVE PRACTICES

BOX 9-5 Cohiring: Collaborations between Centers and Departments[a]

How do IDR centers, which generally operate without the ability to hire faculty or grant degrees independently, attract faculty and students? Joint appointments are one way of solving this dilemma; but in many cases, faculty report personal and departmental dissatisfaction at determining just how to apportion and credit percentages of time. Cohiring is an innovative method for bringing faculty into centers.

The University of Washington Program on the Environment[b] (PoE) is a horizontally organized universitywide institute. The PoE is not a traditional academic department and does not have a faculty of its own. Instead, it plays a networking role, bringing together faculty and students from across the university to augment existing programs and to offer integrated, interdisciplinary programs that cross traditional disciplinary boundaries. Instead of allocating faculty lines, the university president has set aside a permanent budget that the PoE uses to hire faculty in collaboration with departments and schools. By obligating a smaller fraction of the PoE operating budget, this enhances the flexibility and adaptability of the program and removes it from competition with departments and colleges. Cohiring enables the university to benefit from the presence of scholars who would not readily fit into pre-existing departmental frameworks. The PoE pays for a portion of the startup costs and salary for the first 3-5 years, after which the department becomes fully responsible for the faculty member. Colleges and departments are strongly encouraged to donate faculty time to the teaching of environmental-studies courses. Student credit-hours accruing from such teaching are credited to the faculty mem-

reviewers when appropriate. The principles of academic freedom that gave rise to the tradition of indefinite tenure can be protected by strong contractual agreements and the use of multiyear rolling appointments so that no faculty member would be subject to dismissal suddenly or without substantial cause.

The concept of the university professorship, in which the recipient is appointed "at large" and not to a specific department, which allows the recipient to move between departments, could be expanded without changing the nature of departments.

Change at the Institutional Level

At the level of colleges and large institutions, the university could remain organized in more or less traditional fashion, including "colleges" of science, humanities, social sciences, engineering, education, and so on. How-

bers' home departments. The PoE can also use its budget to compensate departments for faculty teaching ("release time") in the program.[c]

The Center for the Neural Basis of Cognition (CNBC)[d] is a joint program of Carnegie Mellon University and the University of Pittsburgh. As in the PoE, the CNBC directors have spent a huge amount of time in building relationships with affiliated departments. Their overall goal is to make it clear that connections with other units are mutually beneficial: where disciplines can be seen as atoms of an inert gas, departments can bring people together with van de Waals forces, but the CNBC director says that "almost all members are in a covalent relationship." Faculty are hired collaboratively but appointed to a home department. Center funds are used to help with startup costs, and the departments thereafter assume responsibility for the hire. Promotion and tenure are integrated. Tenure decisions are made at the departmental level, but the center director is involved. Also bringing an interdisciplinary perspective to the review committees are the faculty associated with the center who are already tenured and serve on several departmental review committees.

---

[a]Partially derived from staff-conducted interviews with Ed Miles, chair of the Task Force on Environmental Education, and professor, School of Marine Affairs and Graduate School of Public Affairs (July 16, 2003); and James McClelland, codirector, Center for the Neural Basis of Cognition, Carnegie Mellon University (June 26, 2003).

[b]University of Washington, Program on the Environment home page *http://depts.washington.edu/poeweb/about/index.html.*

[c]For more on how appointments of faculty members are administered at the University of Washington, see *http://www.washington.edu/tfee/final96.txt.*

[d]Center for the Neural Basis of Cognition home page *http://www.cnbc.cmu.edu/.*

ever, these colleges could have much more porous boundaries than they do now. Faculty appointments could be more readily allocated and moved into and between colleges.

Convocation Quote

What we have found is that full-time long-term collaborations are actually not that effective. They reduce interaction, and they reduce innovation. What we need to think about is establishing long-term organizational structures that allow for short-term intensive collaboration experiences.

Diana Rhoten, Director, Hybrid Vigor Institute, and program officer, Social Science Research Council

For example:

- A faculty member with a JD degree who is interested in international law might have an appointment in a program that focuses on global hunger or on global technology transfer; the person might spend a year in team teaching in that program and the next year in teaching a foundation course in law, such as civil procedures.
- Space could be regarded as a fungible asset (see Box 9-6) so that hiring of a new faculty member in chemistry who requires wet-laboratory space might depend on arranging suitable laboratory space. The authority to make and budget for such space allocations could reside in the office of the dean or provost.
- Programs might lie not within the purview of colleges, but rather at a higher level, spanning more than one college. Furthermore, programs could be reviewed periodically, with the option of terminating those that no longer addressed subjects of high priority (see Box 5-6). The distribution of resources between colleges and programs might depend on the character of the institution, such as whether it is a private or publicly supported institution. The general objective would be to maintain a high degree of flexibility and to avoid a stultifying concentration of influence and authority at lower levels of organization.

CHANGE DRIVEN BY GENERATIVE TECHNOLOGIES

Some technologies are changing not only how researchers work on their projects but also how they work with one another. For example, the sharing of information and even the development of ideas are assisted by new ways of communicating, manipulating, storing, retrieving, and analyzing information. More and more meetings are held by using "shared-

INNOVATIVE PRACTICES

BOX 9-6 Hotel Space: The Allocation of Space by Project

Stanford's Bio-X project is an ambitious initiative designed to facilitate IDR in subjects related to biology and medicine. The physical center of the project is its newly constructed Clark Center facility, home to about 40 faculty whose interests span the scientific disciplines. Each faculty member has the traditional associated laboratory space.

The Bio-X project is also experimenting with a new model for space allocation. Some 65 benches have been set aside for temporary occupancy and designated "hotel space."[a] The benches are designed to provide an opportunity for researchers to work in proximity during the early stages of projects, and occupancy is not to exceed 12 months. Hotel space is allocated by the Bio-X Leadership Council, which is a faculty group charged with planning the Bio-X program.

The Clark Center is still in its early stages of operation, but hotel space is intended to stimulate collaboration by encouraging scientists and engineers in disparate disciplines to work together. Visiting researchers may have a specific vision for collaborating with Clark Center researchers or other visiting researchers. Other visitors may simply want to work next to researchers doing a particular type of work to investigate the possibility of collaboration.

The Bio-X project views hotel space as an experiment unto itself, but this will not be the only experiment of its kind. A similar approach is planned for the Janelia Farms research campus of the Howard Hughes Medical Institute (see Box 6-7). Hotel space is one of several revolutionary approaches whose value will become clearer as interdisciplinary projects mature.

---

[a]Stanford University Bio-X, Hotel Space in the Clark Center *http://biox.stanford.edu/clark/hotel_info1.html.*

whiteboard" software that allows participants to conduct virtual meetings; display drawings, slides, or equations; compose a document together; and poll participants instantly. Many traditional researchers insist on the need for face-to-face meetings to forge effective collaborations, but younger people growing up in a world of instant messaging may develop virtual modes of collaboration that are equally or even more effective.

Information technologies are already generating powerful new cyberstructures. For example, new techniques have made possible the design and implementation of the National Institutes of Health Biomedical Informatics Research Network (BIRN), which uses a distributed information technology infrastructure to coordinate biomedical research in multiple institutions (see Box 9-7). In what BIRN calls its "evolving cyberinfrastructure," a coordinating center was established in 2001 to achieve large-scale data-sharing among far-flung "test beds" working with brain morphometry (six

INNOVATIVE PRACTICES

BOX 9-7 Supporting Teamwork with Distributed Information Technologies: The Biomedical Informatics Research Network (BIRN)

As the amount, size, and complexity of data increase, the finding and extraction of relevant information by individual scientists become more difficult. But amid the growing complexity are unprecedented opportunities for data-sharing and data-mining. Cyberinfrastructures, also known as grids, can create structured database repositories that facilitate data accessibility and foster collaboration. The Biomedical Informatics Research Network (BIRN) is one such grid project.[a] BIRN is supported by the National Centers for Research Resources of the National Institutes of Health. Its goal is to establish an information technology infrastructure to enable fundamentally new capabilities in large-scale studies of human disease. BIRN involves a national consortium of 12 universities and 16 research groups. It consists of three test-bed projects that are conducting structural and functional studies of neurological disease: Function BIRN, Morphometry BIRN, and Mouse BIRN.

A central premise of BIRN is that the location of data and resources is less important than their organization and accessibility. One of BIRN's core efforts is to develop technologies to ensure that each BIRN site and test bed can create and manage sophisticated and highly structured data repositories. To that end, a coordinating center (CC) was established in 2001 to develop, implement, and support the information infrastructure necessary to achieve large-scale data-sharing among participants.

BIRN-CC is a partnership of computer scientists, neuroscientists, and engineers who as equal partners address a large variety of technical, policy, and architectural issues.[b] The collaboration is truly interdisciplinary, inasmuch as CC members must be interested in and committed to learning each other's disciplinary language so that they can work effectively toward common goals. In addition to designing infrastructure, the BIRN-CC is responsible for encouraging interactions among BIRN participants: the CC manages the BIRN Web site and newsletter and organizes an annual meeting to define collaborative needs and set research priorities.[c]

---

[a]Biomedical Informatics Research Network home page. *http://www.nbirn.net.*

[b]Lin, A. W., Maas, P., Peltier, S., Ellisman, M. (2004) Harnessing the Power of the Globus Toolkit. *Cluster World.* 2(1):12-14, 54.

[c]James, M. (2004) Productive All Hands Meeting Defines CC Goals. *BIRNing Issues.* 2(2):10.

institutions), schizophrenia (11 institutions), and mouse models of neurological disorders (four institutions).

CONCLUSIONS

As interdisciplinary research, scholarship, and teaching increase in importance in institutions of higher education, so does the urgency to find

new policies and structures that accommodate interdisciplinarity. Successful institutions are likely to be those that are nimble and willing enough to develop such policies. The likely outcomes of the policies could be higher levels of external support for the institutions, greater success in recruiting the most promising new faculty and students, and enhanced service to society in the form of successful scholarship and research at the frontiers of knowledge.

FINDING

The increasing specialization and cross-fertilizations in science and engineering require new modes of organization and a modified reward structure to facilitate interdisciplinary interactions.

RECOMMENDATIONS

U-1: Institutions should explore alternative administrative structures and business models that facilitate IDR across traditional organizational structures.

For example, institutions can

- Experiment with alternative administrative structures, such as the matrix model, in which people move freely among disciplinary departments that are bridged and linked by interdisciplinary centers, offices, programs, and curricula or, alternatively, create institutions "without walls" that have no disciplinary departments and are organized around problems rather than disciplines.
- Facilitate the offering of multidisciplinary courses, provide graduate students with multiple mentors, and offer faculty numerous opportunities for continuing education.
- Oversee interdisciplinary programs at the university level rather than that of a single college.
- Review programs periodically with the option of terminating those no longer of high priority so that there is flexibility to respond to emerging opportunities.

U-2: Allocations of resources from high-level administration to interdisciplinary units, to further their formation and continued operation, should be considered in addition to resource allocations of discipline-driven departments and colleges. Such allocations should be driven by the inherent intellectual values of the research and by the promise of IDR in addressing urgent societal problems.

For example, institutions can

- Put in place policies that allow the return of some indirect cost revenues to research units such that interdisciplinary centers and programs with external funding are not disadvantaged.
- Provide support for graduate students who choose to study interdisciplinary fields with mentoring by more than a single faculty member.
- Provide support for generative technologies that allow the sharing of information and ideas.
- Invest federal funds in activities that lead to the design and implementation of research activities that take full advantage of a distributed information technology infrastructure to coordinate research across institutional lines.

U-3: Recruitment practices, from recruitment of graduate students to hiring of faculty, should be revised to include recruitment across department and college lines.

For example, institutions can

- Admit graduate students into broad fields (for example, biological sciences as opposed to microbiology; engineering as opposed to mechanical engineering) with no requirement to specialize until the end of the first or second year.
- Increase the number of joint faculty appointments and PhD programs from a few to many.
- Recruit faculty for positions both in programs and in departments so they can teach both within the special sphere of a program and in foundation courses in traditional areas.

U-4: The traditional practices and norms in hiring of faculty and in making tenure decisions should be revised to take into account more fully the values inherent in IDR activities.

For example, institutions can

- Provide robust mechanisms for allocating faculty positions to areas of IDR.
- Provide cross-departmental mechanisms for tenure and promotion review.
- Monitor a tenure-track faculty member's progress toward tenure with both mentors from the faculty member's program and senior faculty in traditional fields of special interest to that faculty member.

U-5: Continuing social science, humanities, and information-science-based studies of the complex social and intellectual processes that make for successful IDR are needed to deepen the understanding of these processes and to enhance the prospects for the creation and management of successful programs in specific fields and local institutions.