

A Hybrid Vigor White Paper

**LEAD, FOLLOW, GET OUT OF THE WAY:
SIDESTEPPING THE BARRIERS TO
EFFECTIVE PRACTICE OF INTERDISCIPLINARITY**

**A New Mechanism
For Knowledge Production And Re-Integration
In The Age Of Information**

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EXECUTIVE SUMMARY

The benefits to interdisciplinary research — and the shortcomings of a world that is deconstructed and "understood" primarily by specialization — have been apparent for several decades. Over the past several years in particular, interdisciplinarity has become the darling of the research community, synonymous with all things modern and creative and progressive about science.

Leading scientists and bureaucrats state unequivocally that it is the challenges and stimulation of struggling to exchange ideas with people from other disciplines that will lead to major scientific breakthroughs and increase our knowledge of the natural world.

Even more critically, experts believe interdisciplinary research properly conducted can move beyond the bounds of discovery, increasing the explanatory power, immediate relevance, and practical application of research to complex, real-world problems.

But neither the popularity nor the necessity of interdisciplinary research is reflected in the reality of the situation today: Shockingly few researchers or institutions have meaningful experience with its actual *practice*.

The reason that such a paradox exists is clear: the practice of interdisciplinarity is difficult and fraught with roadblocks, particularly for researchers who have been raised — and who continue to participate — in the tradition of disciplinary and departmentalism. Not incidentally, no meaningful metrics and little empirical data are available today to gauge interdisciplinary methods.

Based on what data do exist, this paper makes explicit what has worked and what has not for the practice of interdisciplinary research; the assumptions made about its practice; extant organizational and psychological factors which lead to success or failure; and some recent and/or notable examples of these successes and failures.

Roadblocks explored include the strong institutional bias against interdisciplinarity at most universities; the differences in defining and achieving success for an interdisciplinary vs. a disciplinary endeavor; achieving consensus on a common problem or topic for study; establishing common understanding; access to cross-disciplinary data and publications; competition and the "geopolitics" of knowledge; the willingness to trust others outside of the home disciplines; publication requirements; and a commitment to shared resources and funding.

The MacArthur Research Network model for collaborative research is discussed as a prototype of an existing interdisciplinary program which successfully addresses many of these barriers, albeit in a narrow subject area.

The paper ends by exploring at length the Hybrid Vigor Institute's proposal for sidestepping these roadblocks which allows researchers to choose from various levels of participation — to lead, follow and/or simply observe — and establishing both a new mechanism for knowledge production and re-integration, and a resource center for researchers with interdisciplinary aspirations, that explores both the process and the content of interdisciplinary research.

It should be clearly understood before proceeding that, while arguing the need for and advocating the advantages of interdisciplinary research, this paper does not pit interdisciplinarity against disciplinary. Rather, it is our position that specialized, disciplinary research is, should be and will remain vitally important at the same time that broader approaches — such as interdisciplinarity and transdisciplinarity — are needed to focus on the increasingly vexing problems and issues of today's complex world.

We agree with the assessment of Denis Prager, former director of health programs at the John D. and Catherine T. MacArthur Foundation, when he states that interdisciplinary research "stands on the shoulders of rigorous disciplinary research; it is the next step in the building of knowledge that has the power to address the complex problems ... that threaten the health, well-being, and quality of life of people and the communities in which they live."

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INTRODUCTION

The Challenge: Knowledge is extracted from a fully integrated world. Knowledge is 'dis-integrated' by disciplinary units called Departments in Universities. How can knowledge, discovery and dissemination be re-integrated?

*Richard Zare, co-founder, BioX initiative, Stanford University;
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Despite the unquestioned arrival of Information Age, where widely available data and the networks that connect them are changing daily life down to its foundations, the academy as the institution we know today remains bolted firmly to the factory floor of the Industrial Age.

Today's universities, with few exceptions, have become exemplars of Fordist theories of production. Every section of the production line — each disciplinary unit, or "department" — has a specific, narrow and bounded function which it is expected to perform in perpetuity: that is, to mass-produce graduates in a certain field, a certain fraction of whom remain at the university to perpetuate the system by teaching and/or become expert practitioners of a particular discipline.

Where this Industrial Age mentality is most evident is in the academy's approach to interdisciplinary research. A growing number of universities and their affiliates are attempting to implement more inclusive, collaborative approaches — most notably in the merger of biology with various other disciplines, where there is great commercial potential and impetus — but departures from a discipline's bounded functions are still largely undertaken at a researcher's own peril. Post-doctoral researchers who are "caught" being interdisciplinary are likely not to be hired within their chosen discipline, or anyone else's; if already hired, they are unlikely to be granted tenure. And interdisciplinary programs are invariably the first to be eliminated during a funding crunch.

But the post-Fordist, networked economy in which we are now firmly ensconced has magnified the limits of this approach, which seems increasingly uninformed by the realities of 21st century life. While monodisciplinary studies will continue to serve an irreplaceable function in both training researchers and conducting research, we face enormous problems in complex arenas such as globalization, the environment, human health and development which monodisciplinary research is by definition unable to address.

As a result of these problems, which are characterized by new dimensions of complexity, scale, and uncertainty, calls to expand and transcend the boundaries of disciplines — from the public and private sectors, funding agencies and researchers themselves — have escalated.

What they have realized is that horizontal, cross-boundary thinking in academia and beyond is not only co-equal to disciplinaryity; it is its completion, its required partner in the dance.

The academy's resistance to interdisciplinarity is not particularly mysterious. Institutions as a rule tend to defend their bureaucracies as part of a highly developed antibody response to what they perceive (incorrectly, we would argue, for the most part) is a threat to their survival. In addition, while clearly there has been a strong uptick of interest in crossing disciplinary boundaries over the past several years — and, in fact, boundaries between disciplines and methodologies are increasingly breaking down — interdisciplinary research is extremely difficult to practice successfully. This fact has remained largely unarticulated, probably because there has been very little focused inquiry that makes explicit the factors that drive interdisciplinary projects to success or failure.¹

Thus the goal of this paper is to begin the process of making explicit what works and what does not for interdisciplinary research; the assumptions made about its practice; extant organizational and psychological factors which lead to success or failure; and some recent and/or notable

examples of these successes and failures. We then discuss the purpose and structure of the MacArthur Research Networks, which we have found inspirational in our work.

Finally, since encouraging the practice of interdisciplinary research is the Hybrid Vigor Institute's *raison d'être*, we will end with a proposal that we believe can make such practice easier and more, well, practical. We will propose a new kind of mechanism for creating and re-integrating knowledge across disciplines — an alternative, yet complementary environment to the present academic infrastructure — that can serve as a research mechanism as well as a resource center, and that can inspire and support either individuals or teams of front-line researchers, according to their preference.

We believe this mechanism, fully implemented, can help produce the kind of knowledge that can solve real-world problems in a way that is better suited to an era of global networks where people are compelled to connect, rather than protect, information.

DEFINITION OF TERMS

Obstacles around the lack of a common vernacular will be discussed later in this paper, but before beginning our explication it may serve to get some working definitions on the table, even if they are fluid and arguable.

A *discipline* is defined in part by the *Shorter Oxford English Dictionary* as "...The training of scholars and subordinates to proper conduct and action by instructing and exercising them in the same; mental and moral training."

Interdisciplinarity, perhaps the most fluidly defined of all these terms, brings separate disciplinary theories, skills, data and ideas to bear on a common problem or theme; debates rage about whether it is a pedagogy or a mechanism by which a researcher or groups engage in their work. Some prefer the term *multidisciplinary*, or *cross-disciplinary*, which more specifically allows researchers to maintain their disciplinary identities, and recognizes that few will be able to fuse all the skills of several disciplines into a single person.

The basic definition for *transdisciplinarity* is "establishing a common system of axioms for a set of disciplines." Sometimes these separate disciplines come together to jointly frame a problem, agree on a methodological approach, analyze the data and perform some kind of synoptic analysis.

Where interdisciplinarity/multidisciplinarity are more about interaction between the disciplines, transdisciplinarity strives for integration, although each may have characteristics of both. Thus *for the sake of brevity if not clarity, we will use the term "interdisciplinary" to represent all three terms unless otherwise specified.*

Please note: we assume that the rigor of disciplinary practice will be brought to bear on any integrated research project, no matter what it is called.

THE PARADOX OF INTERDISCIPLINARY PRACTICE

Interdisciplinarity is one of the great paradoxes of the research community today.

Given the knowing nods all around when the subject is raised, apparently everyone embraces the concept. In most academic circles, simply speaking the word can warm a room, synonymous as it has become with all things modern and creative and progressive about science.

But interdisciplinarity's remarkable popularity as a term and its acknowledged importance as an endeavor do not reflect its position in the real world. Considering the degree to which

interdisciplinarity is hailed (and flaunted on grant applications), it is almost shocking to discover how few researchers or institutions have experience with its actual *practice*.

In fact, at the same time the calls for interdisciplinary research are become louder and more urgent, specialization is growing faster than ever.

This is no doubt a frustration to those who are, in fact, committed practitioners, but institutions which claim one thing and do another are becoming a very real problem for agencies such as the National Science Foundation, whose director has called interdisciplinary research “nothing short of vital” and has made it a priority in all program areas.

According to Peter Weingart, co-editor of *Practicing Interdisciplinarity*, this contradictory discourse has been in process for more than 30 years as interdisciplinarity, transdisciplinarity and their inclusive kin have been “proclaimed, demanded, hailed and written into funding programs,” while specialization has increased at an exponential rate.

What forces are at work here? Why do so many researchers continue to pay such high praise to interdisciplinarity, while at the same time they constantly act its opposite? If interdisciplinary research is so great, why isn't everyone doing it?

Why interdisciplinarity matters. Great discoveries and shifts in traditional thinking have been historically attributed to researchers crossing disciplinary boundaries. Interdisciplinarity has long been hailed as the seat of innovation by leading lights such as the biologist and mathematician Norbert Weiner and the physicist Werner Heisenberg, as well as the philosopher of science Thomas Kuhn.

In more recent years, the Harvard biologist Edward O. Wilson has re-popularized the “unity of knowledge” theory, and some of the best known universities and public agencies, ranging from Rockefeller and Stanford Universities and the Massachusetts Institute of Technology, UNESCO and others, have initiated significant interdisciplinary programs in various subject areas.

Most recently, upon learning that he shared the 2000 Nobel Prize in chemistry (with a physicist and a material scientist), Dr. Alan MacDiarmid of the University of Pennsylvania stated unequivocally that it is the challenges and stimulation of struggling to exchange ideas with people from other disciplines that will lead to major scientific breakthroughs. “When people with completely different scientific backgrounds get together to solve a common problem, you have to learn a different way of speaking, a different language,” said Dr. MacDiarmid. “It's much tougher. It takes you out of your comfort zone. But it's more rewarding.”

Interdisciplinary research is not important simply because it is personally rewarding, or even because it will lead to the discovery of more interesting ideas. Rather, it is our position — and that of those who practice it — that interdisciplinary research is important because now it is the required, *necessary* thing to do: It increases the explanatory power, the immediate relevance, and the practical applicability of research for solving real-world problems.

Some significant examples of this capability include the Human Genome Project, the development of an accurate measurement for ozone depletion, the invention of the personal computer and the PC software industry, and the implementation of xenotransplantation, the use of animal organs in humans.

Within the academy, the best immediate evidence of the popularity and utility of such crossings comes from the growing numbers of new, hybrid disciplines that are being formed. Given the growing acceptance of such fields as bio-anything, industrial ecology, the cognitive sciences and scores of others, there is obviously great potential for discourse and discovery in the spaces between traditional disciplines.

But practicing interdisciplinarity is nonetheless difficult for two reasons. First, within the culture of science — that is, how researchers conduct themselves individually and socially — interdisciplinarity goes against the grain of everything disciplinary researchers have been taught to do and to protect. Second, it flies in the face of virtually every bureaucratic structure in the university, most obviously the departmental system which confers upon researchers their funding, reputation, tenure and status. Who would blame those who say one thing and practice its opposite in order to protect their livelihoods?

The dialogue about interdisciplinarity is, at the end of the day, a dialogue about innovation — that is, *change* — in the means of knowledge production. A discipline traditionally trains a researcher to produce knowledge in a very different way from the interdisciplinarian. And disciplines continue to be the executors of the transfer between knowledge production and the implementation and application of knowledge.

The difference between these two perspectives is polar. For example, from the perspective of an interdisciplinarian, disciplines are rigid, conservative and averse to innovation, while interdisciplinary research is dynamic, flexible, liberal and innovative. But from the disciplinary perspective, disciplines are tough-minded, dedicated to order and control — features that are also prerequisites for progress and innovation — while interdisciplinary research is vague and speculative.

This rather neatly describes the “essential tension” between change and tradition that Kuhn discussed in his seminal 1962 essay, “The Structure of Scientific Revolutions.” So despite the fact that a researcher might see the value of interdisciplinarity and integration of knowledge to innovation, she is likely to be more than ambivalent about putting its tenets into practice.

If synthesis and specialization must learn to co-exist (which we think they must), then more researchers must stop talking about interdisciplinarity and actually start *doing* it — by changing their behavior so that crossing disciplinary boundaries can be included or at least accepted in the normal course of their research. The search for novelty and innovation, and the creative approaches to problem solving that interdisciplinarity represents, can only be enhanced by the standards of control and competence that have brought disciplinary research the great respect it has earned over the decades.

What follows is an explication of how the tension between change and tradition is manifested by way of barriers to practicing interdisciplinarity, as well as how others have approached these problems, and how we believe they might best be resolved.

INSPIRATIONS AND IMPEDIMENTS

Academy as roadblock. Given the known value of interdisciplinarity, it is clear that specialization has become an institutional, rather than an intellectual, requirement. While interdisciplinarity emphasizes the goal rather than individual achievement,² the university department confers professional legitimacy upon individuals, and provides both funding models and the rewards and requirements for career advancement (including tenure and publishing quotas) to sustain them.

In this context, it is most fascinating to watch the march to institutional acceptance of the hybrid disciplines, such as the cognitive sciences. When they were still considered interdisciplinary, their practitioners were dancing on the razor’s edge of illegitimacy. But when they yielded sufficient individual achievement that a funding structure, rewards, journals and publishing requirements could be snapped into place around them, they then became “accepted” disciplines in their own right.

The myriad of ways in which universities strongly discourage the crossing of disciplinary boundaries are too lengthy (and depressing) to list, but one of the most problematic roadblocks is the logistics and the semantics of collaboration, particularly for obtaining funding or publishing research results.

In some fields, collaborative research is not even tolerated. For example, the *Journal of the American Society for Information Science* published a survey of authors from various scientific disciplines who published papers with an interdisciplinary focus.³ What they discovered was that co-authors who were in the same discipline or subject area were officially considered “collaborators,” while researchers outside that discipline were listed as “consultants,” no matter how integral their contribution. They claimed this was only way they could circumvent the roadblocks of peer review and not damage their chances to be considered for tenure and promotion.

The system which grants doctoral degrees is also a powerful deterrent to interdisciplinary studies, in three related areas. First, because the reputation of departments (thus the resources they receive) flow from recognition within the field, they invariably foster only research that will garner accolades from within the field.

Second, students work for and with individual faculty members as advisors whose research is usually the intellectual foundation for their own, and who exercise enormous power over the students’ studies. It is usually the advisor who decides whether a student has completed enough quality work to merit receipt of the degree. Third, it is ties to these advisors that provide most students with funding for tuition and research expenses. All these factors tie students to a home department, a discipline and an advisor that encourage specialization.

As a result, interdisciplinarity often and understandably becomes intellectually unappealing or not strategic or viable. Students also rightly fear that their work will have few outlets for publication, and not in sufficiently prestigious journals. And those who brave the departmental dragons and focus on a topic rather than a discipline still find it is difficult to find their “community” of fellow travelers, given the physical and organizational distance of other departments.⁴

How much of a gating factor is the department system, really? One highly visible indicator on the other side of the coin is the incredible success of Rockefeller University, which is organized around laboratories rather than departments. From its inception, its faculty was steeped in “scientific diversity and discovery” and worked in cross-disciplinary teams. While less integrated today than it once was, it is still less differentiated internally than any other American university.⁵ Its Program for the Human Environment, for example, brings together faculty, students and visiting scientists around the world to explore connections between environmental concerns and the biological and other research underway at the university.

The fact that there are still no departments, and that a lab closes down when the head departs, gives the organization an extraordinary amount of flexibility to adapt to new knowledge. This adaptivity explains why Rockefeller, despite its small size, is said to “tower” over all other research organizations in America. Today a higher proportion of its faculty are members of the National Academy of Sciences, and are prestigious Howard Hughes Medical Institute investigators, than in any other research organization in America. It is associated with 20 scientists who received Nobel Prizes. Moreover, its scientists receive more funding from the National Institutes of Health per scientist for biomedical research than those in any other research organization in America.⁶

Defining and achieving success. One of the stickiest cultural problems for practicing interdisciplinarity is that what constitutes a success is often radically different from success in disciplinary work. While disciplines usually require quantitative or measurable results, interdisciplinary success is based upon exploration and curiosity in the service of solving a problem or answering a question, which may or may not yield the kind of tangible result we expect from traditional research.

The prevailing, disciplinary approach to problem solving is often tightly bounded, simplistic and linear, calling into play what Margaret Somerville and David Rapport call the “symptom-treatment” coupling, which most often fails to address the more fundamental issue of basic causes. Interdisciplinary work by definition encourages more iterative, “out of the box” thinking, since the boxes (*i.e.*, disciplines) have been at least mightily perforated, if not removed entirely.

In the preface to their 2000 book, *Transdisciplinarity: reCreating Integrated Knowledge*, Somerville and Rapport also note that unlike disciplinary projects, which are often so tightly defined that it would be unusual *not* to produce a result, it is difficult to confidently predict whether a proposed interdisciplinary project will succeed. Instead, it may be more useful to pinpoint the larger, meta-reasons for failure — the personal, organizational, psychological or intellectual barriers which clearly caused a project to implode — thus setting the boundary conditions for success by avoiding obvious disaster.

At the risk of boldly stating the obvious, interdisciplinary success — no matter how else it is measured — comes down to the ability for an individual or a team of researchers to anticipate and meet a variety of challenges, both organizationally and personally. Given the breadth and depth of those challenges, this is *not* the easier, softer approach. It requires tenacity and a tolerance for ambiguity that many traditional researchers find difficult to maintain.

Consensus on a common problem or topic. From an organizational perspective, the identification of a common topic — as opposed to the transfer of an accepted problem from an already established discipline — is considered a prerequisite for the success for any interdisciplinary endeavor.⁷ This identification occurs in a number of ways, particularly in the recognition of similarities between questions, and the discovery of shared themes, between the disciplines. Overwhelmingly, failure comes from choosing too broad a topic. To encourage disciplines to engage with each other, rather than talking past each other, the topic needs to be delimited.⁸

Working on a common problem has been the *de facto* mode of successful interdisciplinarity in the technology industries (and more recently in biotechnology and bioengineering), where the intricacies of designing and building computers and software — and now, adapting them for use in biological systems — bring together people of disparate backgrounds to solve complex problems as a team.

There are many other successful extra-academic examples, such as the ongoing National Atmospheric Deposition Program, formed in 1978 to determine trends in the chemical climate of the U.S. Composed of a group of scientists from many different disciplines, public and private universities, industries and environmental protection organizations, the data the group gathered via agreed-upon sampling and methodology protocols were an important part of the motivation and scientific foundation for the Clean Air Act amendments of 1990.

Within the academy, the International and Area Studies program at U.C. Berkeley has met with great success using faculty from several disciplines to help doctoral students hone their dissertation theses. The workshop, according to the program's executive director, has "accelerated the completion of dissertations; created intense and highly productive inter-disciplinary discourse across the social sciences, humanities, and professional schools; fostered wider audiences for their individual projects; and created on-going intellectual communities and collegiality on campus, and beyond." Workshop participants do significantly better in some funding competitions, and other organizations are using the workshops as a model for their own projects. Most encouragingly, numerous participants say that the workshop "charged, or re-charged, their intellectual batteries and significantly accelerated the their research and writing."

A more cautionary tale comes from the Intergovernmental Panel on Climate Change (IPCC), established by the United Nations in the late 1980s to advise governments of the processes and likely consequences of global climate change. The group is comprised of a diverse group of scientists who, according to observers, were overly concerned with assessment orthodoxy and political propriety, thus never managed to rise above the level of their disciplines to agree on how to approach and/or narrow the common problem.

As a result, researchers did not consult each other about extremely complex questions such as how to achieve an integrated assessment of the cost and impact of climate change, thus the phenomenon was never discussed in a way that allowed policy makers and interested lay people

to appreciate the nature of the problem. Although much disciplinary data and committees and subgroups have since been generated, no synthesis has taken place to date, and overall the IPCC is perceived as a wasted opportunity.

Establishing a common means of understanding. The lack of common understanding between disciplines which use different vocabularies and modes of inquiry is widely acknowledged as the most significant personal challenge to interdisciplinarity for experienced researchers who are accustomed to great fluency and literacy within their own disciplines.

This should not come entirely a surprise, as science is surely as much about literature as inquiry. What may be even worse than simply not understanding the jargon of another's discipline is another problem which surfaces frequently: disciplines that use a common pool of language to construct their unique metaphors.

For example, the economist David Wear points out, when an economist says "competition," or an ecologist says "niche," the economist thinks "neoclassical production theory" and the ecologist thinks "identifiable components of ecosystems." But an ecologist's use of "competition" is about the forces that exclude all but the best suited species from a "niche"; for the economist, the niche is a competitive market that supports several firms.

There are countless similar examples in the literature. Needless to say, this can be not only very confusing, but can lead to serious misapprehensions, project evaluations gone awry, and unwarranted assumptions of ignorance by (and about) the unwary boundary-crossing researcher.

Thus members of a research team, or a researcher who intends to communicate results to an interdisciplinary audience, must reach agreement not only on the interpretation of the data (which already highlights differences in backgrounds and traditions) but also on the way every term is defined and used. As one researcher wrote, "This certainly increases the heaviness of the research process, not to mention the difficulties in communicating the results. I am tempted to mutter, 'If one can only speak to those who use the same words as oneself.'"⁹

Which, of course, would defeat the purpose.

Even with the increased load that such necessary translation places on the research process, the establishing of a common language, a so-called "Esperanto of science," does not seem to be a viable alternative. As Gavan McDonell, a sociologist and engineering professor at the University of New South Wales, has argued (citing Umberto Eco's *The Search for the Perfect Language*), once a perfect language has resolved thoughts into its own terms, those thoughts cannot be translated back into their native idioms. This would not be useful in a world where disciplines continue to serve a critical role; integration and specialization must co-exist, in language as well as action.

Unfortunately, there is no silver-bullet solution to this problem. The best practice for researchers who work together on projects is to first invest in a common understanding of disciplinary jargon and methods. Beyond that, or outside of a team environment, researchers must be hypervigilant about language, taking extra effort to explain themselves rather than expecting their extradisciplinary colleagues to translate between the various shorthands of lingo and metaphor, shared scholarly references and assumptions.

Access to data and publications. Gaining access and familiarity with other disciplines' published work is also serious barrier for the interdisciplinarian. When asked how they seek interdisciplinary information, only 52% of the scientists interviewed in a 1997 study published in the *Journal of the American Society for Information Science* said that they scan journals in other subject areas themselves. About 62% said that they search databases for collecting comprehensive information on a topic not in their specialties, and some 75% said that they follow up on citations or get references from collaborators.

Researchers infrequently scan journals themselves — obviously the preferable method — because of the lack of both physical and conceptual accessibility of these journals.

Physically, the journal collections of different disciplines are generally housed in departmental libraries, usually within departmental buildings. Constraints of time and attention seem to dictate that these geographic disciplinary boundaries are seldom crossed by those from outside disciplines or subject areas. In addition, very few of the thousands of academic journals published today are available in full text via the Internet and World Wide Web, narrowing their accessibility even more. When they are available, subscriptions tend to be prohibitively expensive — even more so than their print counterparts.

Conceptually, as discussed above in the section on “common understanding,” it is an unspoken but well-known practice that researchers generally “don’t go where they don’t know.” Thus, the journals of other disciplines are often *terra incognita* for researchers, presenting precipices of linguistic, theoretical, and methodological difference.

What’s more, these journals may continue to be unknown for other, more dire reasons. Due to the high (and rising) cost of academic journals, each year university libraries are reducing their journal and monograph collections — even as the production of scholarly information is growing exponentially. Create Change, a project sponsored by the Association of Research Libraries, the Association of College and Research Libraries, and the Scholarly Publishing and Academic Resources Coalition, claims that “the free flow of scholarly information, the lifeblood of scholarly inquiry and creativity, is being interrupted.” As a consequence, scholars and students around the world have access to less and less intellectual output each year.

Ironically, at the same time that access to quality material is narrowing, the influx of unfiltered, unrequested publications to the inboxes of researchers is increasing. How to cull the wheat from the chaff for researchers, across disciplinary boundaries, presents a significant challenge and opportunity for the practice of interdisciplinarity.

Turf: the ‘geopolitics’ of knowledge. The ability for individual researchers to overcome the psychological barriers of turf and competition — dubbed “the geopolitics of knowledge” by a leading transdisciplinary scholar, Julie Thompson Klein — is key to the success of any interdisciplinary venture. In fact, good interdisciplinary work is more likely to occur when there are several persons present who have both eclectic knowledge and a disregard for boundaries of others’ intellectual turf.¹⁰

On an institutional level, “de-turfing” these boundaries is the idea behind the growing number of university-hosted interdisciplinary centers, including recent entrants such as Stanford University’s Bio-X Program for Bioengineering, Biomedicine and Biosciences, the McGovern Institute for Brain Research at the Massachusetts Institute of Technology and U.C. Berkeley’s Health Sciences Initiative.

A long-running example of how transcending boundaries can work is the McGill Centre for Medicine, Law and Ethics, established in 1986. At the start of the process, three faculty deans, from Medicine, Law, and Religious Studies, were fully committed to transdisciplinarity and to “unselfish cooperation beyond their faculties,” according to the center’s founding director. Several other important reasons were also responsible for its success, including the trust that McGill University placed in individuals and the center as an institution, and the risks they allowed the center to take, launching into large, complex, controversial, highly sensitive and difficult projects, including assessment of the threat of the HIV-AIDS epidemic in the mid-1980s.¹¹

The Natural Resources Research Center at North Carolina State University was less fortunate. Despite a promising start, when three schools joined together — and quickly obtained funding — to build a center to house an interdisciplinary program, it did not take long before internal wrangling over the allocation of equipment grants and space, as well as internal politics, began chipping away at the cooperative spirit between the schools. Today there are some collaborative

contacts and cooperative programs, but as one faculty observer noted, “the dream of a highly creative Natural Resources Research Center is dead — killed off by continuing worry and unhappy memories about ... trying to work together when there was not enough communication and trust among the parties to overcome the inevitable problems of living together in the same outstandingly useful physical facility.” The verdict: opportunity lost.¹²

The nascent university centers mentioned above, and others of their ilk, would do well to heed the warnings inherent in both these examples. Obtaining the funds and building an interdisciplinary center is apparently the easiest part of the task; keeping the key players on equal footing, all pulling toward the same goals, requires ongoing and sustained effort in order to achieve long-term success.

Learning to trust, assuming equality. Trust is closely related to issues of turf and competition, particularly since it may be true that disciplines serve to discipline trust more than anything else — by their distinctive vocabularies, the ideas they advance, and the standards of proof they accept.¹³ This explains why one disciplinary language speaking to another is greeted skeptically. It has little to do with the ‘other’; it has to do with the degree of trust we confer upon those we already know. The choice, as most researchers act upon it today, is either skepticism or irrelevance.

Assuming that irrelevance is not applicable, skepticism — when employed as a method, rather than a position — can be helpful. But learning to trust is absolutely essential if interdisciplinarity is to consistently yield the kinds of discoveries and unexpected connections it has in the past; researchers cannot look for the similarities or matching patterns between their works and others’ unless they are willing to risk their position as “experts” long enough to actually focus on another discipline’s perspective. We will never know how many significant discoveries have never seen the light of day because of this pernicious brand of intellectual insecurity.

Although trust may seem like an intangible, excessively psychologized goal, it is cited consistently in the literature as a reason that many interdisciplinary projects break down. Researchers must trust that they are respected and considered as equals to those outside their disciplines — and that they are in the presence of equals — in order to feel secure enough to engage with others. (This is particularly true with researchers from the natural sciences, who tend to believe their focus on quantitative data is superior.) Cultivation of trust also creates a critically important aura of credibility around any interdisciplinary exchange.

Nowhere are the benefits of trust and credibility so obvious as at the Santa Fe Institute, where, since 1984, renowned researchers from a broad range of disciplines have come together and left their professional egos at the door (not entirely, of course) in order to exchange their expertise and learn from others. The irony, of course, is that despite its many significant successes in biological systems, in social and economic interactions, in artificial life and evolutionary dynamics, which have truly changed the course of how research in many disciplines is conducted, the Institute continues to struggle to convince the funding and academic communities at large of the value of its approach.

Scholarly publishing. Publishing is a particularly intractable barrier for interdisciplinary scholars who are required to publish in order to maintain their professional status and reputation capital. It is also an area that demands focused attention from institutions who want to encourage interdisciplinary practice.

The questions are: Where do researchers using interdisciplinary approaches *have* to publish to remain employed? And if they publish in a journal outside their home discipline, does that journal carry any reputational weight with their home department?

Beyond those critical questions, to which there are presently no clear answers, there do exist other avenues for communication across disciplines via publishing. One method which has proven effective in communicating interdisciplinary ideas is for a researcher in one discipline to

write and publish relevant research in another discipline's journal.¹⁴ This practice, called "boundary crossing," is a much more accurate form of transmitting ideas between disciplines than the usual means of borrowing from others' research, or even collaboration. It eliminates the "common understanding" problems discussed earlier; the author translates the ideas into the lingo of the new discipline, with the help of an editor, so that the ideas are as close as possible to their true meaning, rather than being cited by another researcher who may not understand their original intent.

An important publishing success is cited by the former editor-in-chief of the *Canadian Journal of Law and Society*, whose editorial board members were political scientists, geographers, historians, criminologists, sociologists, anthropologists, law professors and economists. He attributes the success of the enterprise to the fact that "none of the board members was actually required to adjust his or her own intellectual premises in order for the endeavor to work. ... It was transdisciplinarity by osmosis."¹⁵

Even in the field of specialized scholarly publishing, some researchers are beginning to believe that the problems of publishing are not insurmountable. Having a lead author who is skillful enough to weave lessons from the various disciplines into a coherent whole may be sufficient.¹⁶

The development and use of an effective vision to promote the publication of good interdisciplinarity would be even more useful, but to do so is no mean feat. The habits of journals, editors and reviewers seem to emphasize a critical approach to manuscripts. Researchers see a critical eye as their primary tool, so it may be difficult to find a constructive, inclusive editorial pen. The key to success in this area may be for editors to act on a vision, rather than to act as scorekeepers for sets of *ad hoc* reviews.

Commitment to shared resources and funding. The success of an interdisciplinary project can be made or broken by both the political and the financial commitments which support it. In addition, interdisciplinary research tends to require longer time frames to reach its end point, which often exceed the institutional attention span of most funding agencies and decision makers.

The David Rockefeller Center for Latin American Studies at Harvard University, for example, is widely acknowledged as a great interdisciplinary success story. One of the most active and highly regarded centers of its type in the country, with faculty working together from more than 10 different disciplines, it nonetheless faces a critical challenge: how it will pay its core administrative costs to keep the center functioning.

This issue is a major concern for all interdisciplinary efforts that fall outside the existing departmental structures and mechanisms of a university. The center does not have a designated, financially responsible parent organization (*i.e.*, a school) to underwrite its core personnel and operating expenses. Nor does it have a financial mechanism, such as a portion of overhead, attached to all income that would generate funds to support the center's administrative costs.¹⁷

Such obstacles can and will be surmounted as funding agencies and universities observe and begin to realize the benefits of interdisciplinary research. As with so many other aspects of interdisciplinarity, visionary administrators and program officers will have to take the lead and place their expectations on a longer timeline according to the new definitions of success that interdisciplinary research dictates.

THE MACARTHUR RESEARCH NETWORKS

Before moving into the discussion of Hybrid Vigor's knowledge-production mechanism, it would be remiss not to briefly discuss the MacArthur Research Networks (MRN), an "experiment in scientific organization" and one of the finest examples of an interdisciplinary research organization in practice today.

Funded by the John D. and Catherine T. MacArthur Foundation, these several networks (the number has varied over the years) each work on a different aspect of mental health and human development.

Calling themselves “research centers without walls,” each network has a core membership of seven to 16 people, chosen solely on the basis of talent, from various disciplines, geographical locations and institutions. Network members and network chairs participate as individuals, *not as affiliates of their institutions*, thus sidestepping any potential political or bureaucratic conflicts.

A description of the network chairs from the Foundation describes what we would call the perfect interdisciplinarian: “... [T]he chair plays an important role in modeling interdisciplinary openness and responsiveness. He or she must show serious interest in other fields ... be ready to admit *naiveté* and ask for explanation, to test ideas across disciplinary lines, to risk mentioning hunches and perplexities, and to involve the group as an intellectual resource in considering them.”¹⁸

The network on Socioeconomic Status and Health (SES), for example, is comprised of a highly regarded medical psychologist (who serves as chair), a neuroendocrinologist, a cultural anthropologist, an environmental and an institutional sociologist, a psychoneuroimmunologist and several more researchers representing other disciplines.

Notably, MacArthur funds are used *only* for projects that are directly related to building and sustaining the network’s research objectives. The sole purpose of the networks is to discover and do what can be done better by collaboration. This is a critical point which visionary funders may want to note: the Foundation’s focus on the purpose, the flexibility and the committed duration of MRN funds is *both diametric and complementary* to the traditional pattern of project-specific, limited duration grants.

As for results: SES specifically, and the MacArthur networks overall, have been tremendously productive in terms of creating databanks and resources that can be used by investigators everywhere. Their innovative research methods have resulted in several new, widely available assessment tests and methods, including the MacArthur Battery of Biomedical and Psychosocial Assessment, which includes many hypothesized determinants of successful aging; the Social Rhythm Metric, to facilitate research on depression and other affective disorders; and Configurational Analysis, a method for moving from observation to diagnosis of pathology.

The organizational structure for the MacArthur Research Networks stemmed from three major developments which have changed the nature of scientific discovery. First is the changing technology of scientific work; second, the increasing importance of interdisciplinary research; and third, the gradual democratization of academic culture.¹⁹

Designing a new scientific organization to address these developments led to the concept of a “center without walls,” so a collaborative (democratic, interdisciplinary), geographically dispersed team would not only not have to build its own laboratories, but could leverage the existing facilities of network members.

Being geographically removed from the campus environment had another positive effect as well. When the first networks were formed in the early 1980s, the Foundation advertised for collaborative, interdisciplinary groups already established at universities and other research organizations. But it quickly became clear that so-called “collaborations” were slapped together simply to gain access to the Foundation’s coffers, as is still the case today for much of what passes for interdisciplinary research.

Thus the Foundation iterated the networks’ design to its present form: there is no direct connection to an institution, and funds are administered by network administrators, so there is no overhead charge or other direct financial benefit to the institution. Institutional bureaucracy as a roadblock to interdisciplinary work is completely sidestepped.

We also believe it is noteworthy that the Foundation makes a long-term funding commitment — up to 10 years — to each network, but requires periodic re-evaluation keep the work fresh and focused. Also noteworthy: the fact that the networks work together only on collaborative projects allows members to go back to their home institutions and be as disciplinary as they'd like or need to be to maintain their professional status.

Although the MacArthur Research Networks are a powerful confirmation of many of the tenets of the Hybrid Vigor Institute's approach and our beliefs about the practice of interdisciplinarity, there are some fundamental differences.

Primarily, we support interdisciplinarity in all its forms, not solely as it is practiced in teams or collaborations; we believe that much can be done to help individual researchers who want to explore terrain outside their own disciplines. In addition, we have expanded our explorations to investigating process and content in four distinct program areas, described below.

Also, what defines active participation in the Hybrid Vigor network may vary significantly by individual, based on differing levels of interest and involvement. To support as broad a constituency as possible, we intend to provide a variety of different tools and services that it is unnecessary for MRN to provide for its purposes.

However, before we get too far ahead of ourselves, we shall stop the comparisons and move to a description of the Hybrid Vigor Institute's own experiment in scientific organization.

HYBRID VIGOR: A NEW MECHANISM FOR KNOWLEDGE PRODUCTION

The Hybrid Vigor Institute, like the MacArthur networks, believes that an “institute without walls” — working in conjunction with, but outside of, the university system — is *the best, and possibly the only effective way* to sidestep some of the extant roadblocks of funding and turf battles. By encouraging the broad and regular practice of crossing and/or transcending disciplinary boundaries, we hope to eventually wear down the resistance of academic bureaucracy so that eventually they will be more accepting of inclusive approaches.

There are several other barriers that the Hybrid Vigor proposal addresses as well, including consensus on a common problem or topic; establishing a common understanding of language and methodology; access to data and publications; learning to trust, and defining and achieving success.

Hybrid Vigor was named to represent metaphorically (thus, by definition, imprecisely) the fecundity at the edges of a field, where cross-pollination between the wild and the cultivated can increase the overall health of crops. In that same way, we believe that by taking a systematic approach to the most obvious barriers to success described above, it is possible to draw new practitioners and infuse new vitality and creativity into the conduct and production of both disciplinary and interdisciplinary research.

This systematic approach requires the design of a new mechanism for knowledge production that works in conjunction with, but does not depend upon, the university or other similar institutions — which, as discussed, continue to present formidable barriers to even the most willing researcher.

Rather than relying on a traditional, disciplinary mode of organizing research, Hybrid Vigor takes a unique approach that explores both the *process* and the *content* of interdisciplinary research. To do so, the Institute has organized its work around the principle of the common problems or topics that researchers of different disciplines share, situated within four distinct program areas (Earth Systems, Health Determinants, Human Perception, and Interdisciplinary Practice — see Appendix A for descriptions).

Earth Systems, Health Determinants and Human Perception will focus on the production of content: the actual creation of interdisciplinary knowledge. This production is undertaken with two

goals in mind: first, to solve the problem at hand; second, to help researchers better understand how to reap the benefits of interdisciplinary practice.

Interdisciplinary Practice, then, will focus on conducting process analyses of its own projects, as well as external case studies: examining and evaluating how interdisciplinary research is conducted, employed and assessed in the field, in different circumstances and with different problems; and working with experts to design new metrics for gauging the efficacy of various interdisciplinary approaches.

This new mechanism of organization might best be thought of networked communities of practice, each a kind of Roman forum for research, where researchers can choose the level at which they engage, based upon their interest and comfort level. Comprising the architecture for this community of practice are four complementary “sites” at which researchers may congregate their focus — quarterly journals or monographs, working conferences, online information management tools and post-doctoral fellowships — all organized around a series of individual topics or problems.

We believe that the “sites” or services which comprise this virtual institute are not just a means to the end of “being interdisciplinary.” They are the basic elements of interdisciplinary research itself.²⁰

By applying this problem-centered approach, Hybrid Vigor will be able to cultivate networks of researchers that span departments, institutes, and continents, who are investigating these common issues from their distinct perspectives.

Within the framework of each distinct program area, and with the organizing principle of the common problem or topic at its core, the network encourages researchers to engage in a variety of useful activities. They may choose to simply observe the forum’s participants, interacting not at all but only accessing information (i.e., reading journals and browsing cross-disciplinary databases). They might choose to venture an exploratory first engagement via casual, electronic conversation with other network members, or by contributing research to a specific topic’s database. Or they may choose to fully engage and connect intensively, via face-to-face meetings, conference participation, team projects or by hosting or becoming a fellow.

Although this mechanism cannot fully address the psychological and cultural resistance that some researchers may face, it does remove or at least lower some significant ones, and neatly sidesteps most of the institutional barriers which have served as such powerful deterrents to the practice of interdisciplinarity:

- **Trust via credible advisors.** Since fear of associating with substandard researchers, as well as trust and reputation capital, are some of the fears that keep researchers from engaging in interdisciplinary research, Hybrid Vigor has assembled a group of advisors and editors who are known and respected in their fields, and who also support and practice the tenets of interdisciplinarity.

In addition, we also believe it is critical to have people at the helm of the organization who are *not* disciplinary researchers, but who are skilled “horizontal thinkers” committed to the larger task of building networks and forging connections — between disciplines, between researchers and between ideas. [See Appendix B for the Institute’s personnel and academic advisors.]

- **Selecting topics.** To set the stage for success at the most basic level by selecting a sufficiently delimited topic, these advisors and editors will suggest and/or vet a series of topics which lend themselves to the Hybrid Vigor approach. Ideally, a selected topic is original in scope; has great potential for shifts in traditional thinking, future technological developments or breakthroughs; is connected with a perceived need for an interdisciplinary approach; and has available published research in several disciplines.

Once a topic has been selected, a topic-specific interdisciplinary “advisory committee” is chosen. This ensures credibility and the casting of a sufficiently wide net when identifying and inviting researchers to join the community of practice for a topic.

- **Quarterly journal.** After setting the foundation for topic selection, a quarterly journal or monograph — each devoted to a single topic within each program area — is the first and most fundamental part of this new mechanism for knowledge production.

The “common understanding” barrier is circumvented by virtue of being written by known and respected science writers, scientists, or researchers who are skilled at writing for a sophisticated *general* audience. [See Appendix B for the Institute’s editorial advisors.]

Credibility is assured by listing the members of the advisory committee and their *bona fides*; the methodology (when applicable) used in a research project; and as much information as possible about the projects reviewed, including funding sources where available or deemed appropriate.

The journal allows anyone from the curious to the skeptical and the enthusiastic to privately explore an interdisciplinary approach by virtue of anonymous access via the Internet. Internet access also removes the barrier of proximity to data, and to fellow researchers, as it is virtually effortless to pass along the journal via email or to others to the journal’s host website. Unlike most scholarly journals, readers are *encouraged* to copy and distribute the copyrighted contents of the journal, as long as each journal is distributed in its entirety to maintain its interdisciplinary objective.

- **Working conferences.** Topic-centric conferences, produced in conjunction with each journal where feasible, will bring together a small group of invited scholars (and an equal number of graduate students) from a range of disciplines. The goal is to ensure that critical introductions occur between key researchers in each topic sub-community and/or program area, to initiate their future and hopefully frequent interactions — both with each other and with the larger, topic-centric network — and to begin the process of instilling trust and sparking meaningful interpersonal communication via face-to-face contact.

Each presenter will prepare remarks specifically designed to be understood across disciplinary boundaries, thus circumventing the barriers of lack of common knowledge, methods and vocabulary encountered at most interdisciplinary conferences. Such conferences not only allow for connections to be made across disciplines, but also give participants *entrée* to a topic-specific network (and practitioners) that is consistently supported and facilitated by an institution outside the university walls. And the strong presence of graduate students will help inculcate the interdisciplinary process in the next generation of scholars.

- **Topic-centric information centers.** The creation of Internet-based, program- and topic-centric information centers that are populated by network participants themselves will help circumvent several critical barriers of access to data and publications for interdisciplinary research.

These information centers will remove geographic boundaries; help lower the psychological and time barrier of finding fellow travelers and their work; and aid researchers in gaining access to timely research. In addition, because the centers are not newsgroups or email lists — which are rejected by many researchers as too impersonal and time-wasters — but are instead direct connections to useful research and its authors, they build trust by automating serendipity and reducing infoglut.

- **Post-doctoral fellowships.** Program fellows will either be partnered, or encouraged to seek mentor relationships, with senior faculty who can serve as a bridge between the activities of the fellow and the departmental structure of the university. This activity provides a support for a select group of newly qualified Ph.Ds within the university without requiring a department to commit its own funds for, or lend its blessing to, interdisciplinary projects and/or scholars.

The method by which Hybrid Vigor intends to fund post-doctoral researchers will provide strong financial incentive for departments to allow, if not encourage, interdisciplinarity among their

graduate students. This allows departments to derive direct, non-trivial financial benefit from supporting interdisciplinarity, thus increasing the visibility, legitimacy and interaction between the university and young, talented researchers seeking training and experience in interdisciplinary methods. The goal is to compel departments to expand their horizons by providing an incentive to encourage their post-docs to apply, and eventually hire these skilled interdisciplinarians as permanent faculty.

BUILDING THE NETWORK, DEFINING AND ACHIEVING SUCCESS

The goal for the Hybrid Vigor Institute is to provide working researchers with a palette of tools and methods by which they can extend themselves and their work beyond disciplinary and geographic boundaries. As a result, we look to inspire fresh thought, the creation of dynamic research agendas — and, hopefully, some important discoveries.

Thus, in Hybrid Vigor's world, success is (re)defined and achieved any time a useful connection is made between a researcher and information or other researchers, particularly when that connection contributes to the resolution of a real-world problem by adding to our collective intellectual and/or technological know-how.

In order to instigate these creative connections, we must build a network of scientists and researchers who support these tenets and want to participate by contributing ideas and research papers, offering constructive critique, serving on advisory committees, and in general responding to the call. Securing this participation — more than finding topics or building software — is our most formidable challenge, requiring both time and funding commitments. To help us, and those who join us, succeed in this ambitious endeavor, we encourage funding agencies to take a MacArthur-like approach — that is, to facilitate the development of interdisciplinary *practices* — if they are serious about supporting this type of scholarly activity.

By capturing the participation of thousands of researchers around the world and developing a new model for integrative research, we hope to establish best practices, financial incentives and a new kind of reputation capital for the practice of interdisciplinary research, both within universities and organizations outside academia — yielding a new, open, multifaceted research environment and resource center for scholarly communication, cooperation and collaboration.

CONCLUSION: A NEW KNOWLEDGE ECOLOGY

Even the most organized attempt to make sense of the many dimensions of interdisciplinary research practice is so overwhelming that it seems to take on a rather unruly life of its own. Nonetheless, as interdisciplinarity has inarguably proven its value and its promise, it is incumbent upon those who believe in its importance to begin the process, as impossible as it may seem at the outset.

That process, above all, must deal with the realities — that is to say, the difficulties — of actually *practicing* interdisciplinarity. This is not business as usual. But the powerful tools of the information age — its ubiquitous data networks, its global yet intensely personal reach — combined with the thoughtful practice of interdisciplinary research as discussed in this paper, have the potential to bring us to a new knowledge ecology that includes wisdom and accountability and encourages research that conjoins complex understanding and enduring impact.

There are two ways to bring about this kind of change. One way is to challenge departmentalism to a duel: "Change or die!" This does not strike us as a particularly fruitful path to follow, first because the alleged "foe" still holds most of the arrows in its quiver, and second because specialization, far from being the enemy, is still required for the conduct of sound research.

The second way to create this knowledge ecology is to cooperate with the existing infrastructure, to help and encourage universities and research institutes and funding agencies to gain the benefits of interdisciplinarity, without requiring them to undertake the kind of radical institutional change which simply does not happen overnight.

Although we admit there is a certain quixotic attraction to the first choice, we prefer to be of service to the research community as it exists today, rather than impale ourselves upon the flawed concept of eliminating disciplinary inquiry.

That said, the task ahead is formidable for everyone who chooses to shoulder it.

If interdisciplinary work is to be respected as legitimate in the research community — and all indicators are that this must occur — researchers must be willing to face some degree of disapproval and the discomfort of ambiguity.

But with practice, it will not be long before they also experience the joy and certitude that results when they risk widening their perspectives and extending themselves beyond their individual expertise in the name of curiosity and scientific inquiry. What is certain is that they — we — will never know until we try.

NOTES

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⁵ Rogers Hollingsworth and Ellen Jane Hollingsworth, "Major Discoveries and Biomedical Research Organizations: Perspectives on Interdisciplinarity, Nurturing Leadership, and Integrated Structure and Cultures," in *Practising Interdisciplinarity*, ed. Peter Weingart (Toronto: Toronto University Press, 2000), 231.

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¹¹ Margaret Somerville, "Transdisciplinarity: Structuring Creative Tension," in *Transdisciplinarity: reCreating Integrated Knowledge*, eds. Margaret Somerville and David Rapport (Oxford: EOLSS Publishers Co. Ltd., 2000), 100

¹² Ellis Cowling, "Transdisciplinarity: Philosophy, Practice, and Future," in *Transdisciplinarity: reCreating Integrated Knowledge*, eds. Margaret Somerville and David Rapport (Oxford: EOLSS Publishers Co. Ltd., 2000), 154.

¹³ Roderick Macdonald, "Transdisciplinarity and Trust," in *Transdisciplinarity: reCreating Integrated Knowledge*, eds. Margaret Somerville and David Rapport (Oxford: EOLSS Publishers Co. Ltd., 2000), 61-76.

¹⁴ Sydney Pierce, "Boundary Crossing in Research Literatures as a Means of Interdisciplinary Information Transfer," *Journal of the American Society for Information Science* 50, 3 (1999): 271-279.

¹⁵ Macdonald, 73.

¹⁶ Robert Naiman, "A Perspective on Interdisciplinary Science." *Ecosystems* 2 (1999): 293.

¹⁷ Shawn Jacqueline Bohem and James Stiles, "Experimenting with Models of Faculty Collaboration: Factors that Promote Their Success," in *Using Teams in Higher Education: Cultural Foundations for Productive Change*, ed. Susan Frost (The New Directions for Institutional Research series, 100. San Francisco: Jossey-Bass Publishers, 1998), , 39-56.

¹⁸ Robert Kahn, *The MacArthur Foundation Program in Mental Health and Human Development: An Experiment in Scientific Organization* (A MacArthur Foundation Occasional Paper. New York: The John D. and Catherine T. MacArthur Foundation), 20.

¹⁹ Ibid., 3-5.

²⁰ Manderson, 86-94.

APPENDIX A

PROGRAM AREAS

The Hybrid Vigor Institute is focused on creating knowledge in four distinct program areas:

Earth Systems
Health Determinants
Human Perception
Interdisciplinary Practice

Each program area was selected because it is:

- * Socially or scientifically relevant and/or important; i.e., it encompasses a sufficient number of pending questions;
- * Spans a sufficient number of disparate disciplines to create the basis for a truly interdisciplinary conversation;
- * Has the greatest potential for shifts in traditional thinking, future developments or breakthroughs.

In keeping with Hybrid Vigor's intent to explore both the process and content of interdisciplinary research, Earth Systems, Health Determinants and Human Perception will focus on content: the creation of interdisciplinary knowledge in order to help researchers of different disciplines better understand how to reap its benefits.

Interdisciplinary Practice, then, will focus on process: examining and evaluating how interdisciplinary research is employed in the field, in different circumstances and with different problems.

Our investigations within these program areas will showcase different types of interdisciplinary problems, as well as different subject matter. In general, these problems are of two types:

- (1) Those where a single phenomenon is connected to various forces that are conventionally studied by different disciplines; and
- (2) Those where a series of distinct phenomena usually studied by distinct disciplines somehow resemble each other.

Both types require inter/transdisciplinary thinking, but for different reasons. In the former, the various fields converge; in the latter, they run parallel to one another.

EARTH SYSTEMS

Earth Systems will bring a fresh outlook to environmental topics ranging from the genetic modification of organisms to climate change and sustainability, as well as other global concerns. Some of the topics explored will include the study of how artifacts of modern industrial culture affect the global environment; others will explore a single natural phenomenon from the perspective of the several disciplines which study it.

In addition, this program area will closely track questions within the burgeoning new interdisciplinary area of astrobiology, which explores the origins of life on earth and beyond, from the perspective of a dazzling number of disciplines, including biologists, geneticists, paleontologists, geologists, geochemists, biochemists, astrophysicists, astronomers and cosmologists.

We suspect Earth Systems may prove particularly fruitful for the study of problems where a series of distinct phenomena usually studied by separate disciplines somehow resemble each other.

HEALTH DETERMINANTS

Health Determinants moves beyond medicine and medical research, pushing at the edges of several disciplines to connect and interweave the physical, psychological and social determinants of health in a broad range of fields ranging from genetics to social science.

Some of the questions to be addressed within this program area are likely to be related to such topical subjects as infertility, obesity and addiction, the latter two of which, at least, are considered epidemic in the United States.

Another critical aspect of Health Determinants will be the growing body of research being done by several disciplines in the area of mind-body interactions, which explores several important open questions, including the study of the effects of emotions on health, the placebo effect, sleep research and the mechanisms which influence human learning.

HUMAN PERCEPTION

Already a growing area of interest for industry-academic partnerships, Human Perception will explore the wide range of creative, rigorous and potentially lucrative research being done by many disciplines on virtually all the senses — vision, hearing, touch, smell, taste — as well as other ways of knowing.

Positive popular response to biomedical research and development has made it clear that people are quite interested in augmenting or replacing human capabilities and perception with artificial and/or technological means.

This area of inquiry encompasses neurology, physiology, experimental and cognitive psychology, sociology and psychophysics, as well as important work done by artists and gifted amateurs — most of whom, to date, do not communicate with each other at all.

INTERDISCIPLINARY PRACTICE

The study of this program area, of course, is the *raison d'etre* of the Hybrid Vigor Institute. To date, there has been very little focused inquiry regarding the factors that drive interdisciplinary or transdisciplinary projects to success or failure.

The goal of the Interdisciplinary Practice program area, then, is to make explicit what works and what does not work for interdisciplinary research. We will do so by various means, including case studies and process analyses of a wide range of projects — in the private as well as the public sector, as well as within universities — which cross disciplinary boundaries in various ways, for various reasons.

APPENDIX B

BIOSKETCHES: THE HYBRID VIGOR INSTITUTE STAFF, BOARD OF DIRECTORS and ADVISORY COUNCIL MEMBERS, EDITORIAL CONSULTANTS

STAFF

Denise Caruso. Prior to founding the Hybrid Vigor Institute, Caruso wrote a bi-weekly technology column, “Digital Commerce,” for the Monday Information Industries section of *The New York Times*. In January 2000, she became an occasional contributor to the *Times*’ Arts & Ideas section, writing primarily about scientific and academic research in progress. In addition to consulting for the Pew Charitable Trusts and Consumers Union on standards and practices for improving credibility on the Internet, Caruso has been a visiting scholar at Interval Research Corporation and a visiting lecturer at Stanford University in the Human-Computer Interaction program. She was also the executive producer of Spotlight, an invitation-only conference for senior executives from the technology, communications, media and interactive media industries. Before launching the Technology & Media Group, an information services company for Norman Pearlstine’s Friday Holdings, in 1994, Caruso was the founding editor of *Digital Media*—then acclaimed as the seminal newsletter in the emerging new media industry—and an anchor columnist for the *San Francisco Examiner*’s Sunday technology section. Her analyses have been published in *The Wall Street Journal*, *Columbia Journalism Review*, *WIRED*, *I.D. Magazine*, *the San Jose Mercury News* and the *Utne Reader*. She has also provided commentary for National Public Radio’s “Morning Edition” and “All Things Considered.”

Diana Rhoten, Ph.D. Dr. Rhoten is an assistant professor of International Comparative Education and the director of the Master’s program in International Comparative Education at Stanford University where she teaches courses in development theory and applied research methodologies. With the help of a Fulbright Research Fellowship, a Lieberman Dissertation Fellowship, two scholarships from the Stanford University Center for Latin American Studies, and the Consortium of Policy Research, Dr. Rhoten has conducted a series of interdisciplinary research on the social, economic and cultural processes of globalization in North and South America. She is the author and co-author of several articles, studies, and reviews related to the political cultural economy of policy analysis, program implementation, and organizational change. Her manuscript, *The Global–Local Conditions of Possibility: Understanding Education Decentralization as State, Market, And Society Change*, is under review by the Stanford University Press. Dr. Rhoten has consulted as a research methodologist, policy analyst and implementation specialist for a number of international and national organizations and think tanks.

BOARD OF DIRECTORS and ADVISORY COUNCIL MEMBERS

- **Nancy Adler, Ph.D.** Dr. Adler is a professor of medical psychology in the departments of psychiatry and pediatrics at the University of California San Francisco, where she is director of the Health Psychology program, vice chair of the department of psychiatry, and director of the Center for Health and Community. She is also chair of the MacArthur Research Network on Socioeconomic Status and Health. Her professional memberships include the Institute of Medicine of the National Academy of Sciences, the American Psychological Association and the American Psychological Society.
- **Mark Anderson.** A member of Hybrid Vigor’s board of directors, Anderson is president of Technology Alliance Partners and of Strategic News Service, the most accurate predictive newsletter covering the computing and communications industries. Anderson was also the founder of two software companies and of the Washington Software Alliance Investors’ Forum. He is the past director of the Washington Software Alliance and currently chairs the WSA Presidents’ Group. He is a member of the Merrill Lynch TechBrains advisory board and a principal in the investment advisory firm Resonance Capital Management.

- **Andrew Blau.** Blau is a consultant and strategist working with foundations to develop programs at the intersection of information technology and society. Previously, Blau was Program Director at the Markle Foundation, helping develop its new program priorities, particularly in the areas of public policy and civic engagement. Prior to Markle, he directed the Benton Foundation's program in Communications Policy and Practice, developing programs in educational technology, promoting democratic participation, the role of libraries in the information age, and other areas.
- **Stewart Brand.** Brand is co-founder and managing director of Global Business Network and is the president of The Long Now Foundation. He is well known for founding, editing and publishing the Whole Earth Catalogs and for founding The WELL, a computer teleconference system for the San Francisco Bay Area, considered a bellwether of today's online services. Brand is a member of the Board of Trustees of the Santa Fe Institute, a founding member of the Board of Directors of the Electronic Frontier Foundation and an acting advisor to Ecotrust.
- **Brian Greene, Ph.D.** Dr. Greene is a professor of physics and mathematics at Columbia University. His Pulitzer Prize nominated bestseller, *The Elegant Universe*, attempts to reconcile two theories regarding the physical universe — quantum mechanics and general relativity — by proposing the controversial idea known as "superstring theory." Greene has lectured on physics in more than twenty countries, and has lectured with such renowned physicists as Stephen Hawking and Edward Witten. He served as director of the Theoretical Advanced Study Institute in 1996 and is on the editorial boards of major publications in theoretical physics.
- **Katherine Fulton.** A member of Hybrid Vigor's board of directors, Fulton, a principal with Global Business Network, leads scenario, strategy and change projects. She has worked with leading organizations in both the private and public sectors, representing such diverse areas as publishing, financial services, education, health care, social services, telecommunications, broadcasting, consumer products, and philanthropy. She has also taught scenario planning at Harvard University's executive programs. She has been the recipient of a Nieman Fellowship for journalists, and her innovative teaching has been featured in *Time* magazine.
- **Michael Lerner, Ph.D.** Dr. Lerner is a former Yale professor and recipient of a MacArthur Foundation "Genius" Fellowship. Lerner is also the co-founder of the Commonweal Cancer Help Program and the Smith Farm — both cutting-edge health and environmental help centers. His work with Commonweal was featured in Bill Moyer's award-winning PBS series "Healing and the Mind." He is the author of what is now considered the classic text in the field, *Choices in Healing: Integrating the Best of Conventional and Complimentary Approaches to Cancer*.
- **Bruce McEwen, Ph.D.** Dr. McEwen is the Alfred E. Mirsky Professor at Rockefeller University and head of the Harold and Margaret Milliken Hatch Laboratory of Neuroendocrinology. Dr. McEwen is heralded for making major scientific contributions to the field of neuroscience. His research on the mechanisms underlying the actions of stress and sex hormones on the brain has helped to create a new understanding of how the brain changes in structure and function in adult life as well as during development.
- **Richard Miller.** A member of Hybrid Vigor's board of directors, Miller began his career at the Institute for the Future as a researcher for the U.S. Government's Advanced Research Projects Agency. Here he participated in some of the earliest technical design and development of computer based messaging (today's ubiquitous "e-mail") and computer conferencing using the distributed data network called ARPAnet, the precursor to today's Internet. Miller then co-founded Infomedia Corporation, where he was responsible for development and operations of Infomedia's computer messaging, conferencing and information services, and later Telematica, Inc., a consultancy specializing in electronic messaging. In 2000, Miller co-founded Breo Ventures LLC, a venture accelerator firm and consultancy.
- **Margaret Somerville, Ph.D.** Dr. Somerville is a professor in both the Faculty of Law and the Faculty of Medicine at McGill University, Montreal. As the Gale Professor of Law, she is the first woman in Canada to hold a named Chair in Law. She is the founding director of the McGill Centre

for Medicine, Ethics and Law, and plays an active role in the global development of bioethics and the study of the wider legal and ethical aspects of medicine and science. Dr. Somerville is also the co-editor of a new book called *Transdisciplinarity: reCreating Integrated Knowledge*.

- **Richard Zare, Ph.D.** Dr. Zare is the Marguerite Blake Wilbur Professor in Natural Science at Stanford University. He has previously served on the National Science Board for six years, the last two of those years as its Chairman. He was also a council member of the U.S. National Academy of Sciences. Among many other distinctions, Dr. Zare has earned: the ACS Award in Analytical Chemistry, Harvard University's Centennial Medal, NASA's Exceptional Scientific Achievement Award, the National Medal of Science, and the distinction of California Scientist of the Year. Most recently, he is a co-founder of Stanford's Bio-X Program for Bioengineering, Biomedicine and Biosciences.

EDITORIAL CONSULTANTS

Hybrid Vigor has assembled a team of top science authors to investigate and chronicle research topics for the Institute's publications and conferences. In addition to Hybrid Vigor's president and executive director, Denise Caruso, a veteran technology journalist and analyst, they include:

- **Judith Goldhaber.** For more than 30 years (1961-93), Goldhaber worked as a writer and editor at the University of California's Lawrence Berkeley National Laboratory (LBNL), writing about science and technology for newspapers, magazines, television, and for LBNL's nontechnical publications. The Lawrence Berkeley Laboratory is a multidisciplinary scientific research institution managed by the University of California for the U.S. Department of Energy. During this period, Goldhaber published over 1,000 articles under her own byline or in the form of press releases.

- **Steven Johnson.** Named by *Newsweek* as one of the "50 People Who Matter Most on the Internet," Johnson is the co-founder and editor-in-chief of FEED, the Web's leading independent magazine. He is also the author of *Interface Culture: How New Technology Transforms the Way We Create and Communicate*. The book has been hailed by *Upside* as "a masterwork," and *Salon Magazine* has called it one of the two best technology books of 1997. Johnson is currently working on a new book, tentatively called *Emergence*. Drawing upon a number of disciplines, it is an exploration of self-organizing behavior in cities, brains, software, and media.

- **Pamela McCorduck.** McCorduck is the author/co-author of eight published books. Among her books are *Machines Who Think*, a history of artificial intelligence; *The Universal Machine*, a study of the worldwide impact of the computer; *Aaron's Code*, an inquiry into the future of art and artificial intelligence; and *The Futures Of Women*, a series of scenarios about women in the year 2015. Her work has been translated into all the major European and Asian languages. In addition to her books, McCorduck has published some 50 articles in journals, and she has appeared on network television news and documentary programs.

- **Oliver Morton.** Morton is currently a contributing editor at *WIRED* and a contributing author to *The New Yorker*, *Discover*, *Newsweek International*, and *Talk*; to the journals *Nature* and *Science*; to the newspapers *The Financial Times* and *The Wall Street Journal*; and, to the magazines *New Scientist*, where he has a regular column, and *Prospect*, where he is a member of the advisory board. He is also the managing editor of *The Daily Davos*, a *Newsweek* website covering the World Economic Forum's annual meetings. Morton is also currently writing a book, *Mapping Mars*, to be published by St. Martin's Press in 2001. Morton has previously been the editor-in-chief of *Wired UK*, and as special features editor and the youngest science and technology editor to serve at *The Economist*.

- **Bruce Sterling.** Sterling has written eight science fiction novels, three short story collections and a nonfiction book called *The Hacker Crackdown: Law And Disorder On The Electronic Frontier*. Sterling has also written regular columns on popular science for *The Magazine of Fantasy and Science Fiction*, *Interzone*, and *Science Fiction Eye*. He has been featured in *WIRED*, *The*

Wall Street Journal, World Art, Time, Newsweek, Details, Nature, The New York Times, and Der Spiegel. In 1999, Sterling launched a movement called Viridian Green to combat global warming, challenging designers and hackers who created the digital revolution to start a cultural movement that views CO2-emitting designs as outré. The Viridian mailing list, which is comprised in nearly equal measure of dire environmental news and enthusiastically supported design contests for various green products, is distributed electronically to several thousand subscribers.

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