"QUESTIONING INTERDISCIPLINARITY"

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Specialization is ... a necessary consequence, and indeed the positive consequence, of the coming to be of modern science. The delimiting of object-areas, the compartmentalizing of these into special provinces, does not split the sciences off from one another, but rather it first yields a border traffic between them by means of which boundary areas are marked out. These areas are the source of a special impetus that produces new formulations of questions that are often decisive. We know this fact. The reason for it remains enigmatic, as enigmatic as the entire essence of modern science.

Martin Heidegger, "Science and Reflection" (1977 [1954]), pp. 170-171.

Martin Heidegger was one of the most influential philosophers of the 20th century. In a short essay arguing the need for reflection on the inner dynamics of contemporary science, Heidegger points out the mysterious way in which science depends on both disciplinarity and interdisciplinarity. Disciplinarity is the very basis of the divide and conquer strategy of modern natural science. Identify a particular type of phenomenon (such as the classical physics of mechanical interactions between material bodies), develop a specialized method for analyzing the phenomenon (such as the mathematical representation of force and mass), and then proceed to extend this method throughout the subject-area until it is exhausted or runs up against the need for a new subject-area definition and method (such as chemical interactions).

There can be little doubt that the analytical, disciplinary approach has focused attention on discrete scientific problems and contributed to the development of technological responses. Nor can there be doubt that such a techno-production reductionist approach has advanced human welfare appreciably, enhancing human comfort, lengthening life spans, creating opportunities for exploring components of the earth system. However, it has also become apparent in the last half century that

pressures on what scientists now call the biosphere and its embedded human systems call for synthesis as much as analysis, that the problems characteristic of a crowded high-tech world require the exploration of interactions among complex phenomena and an understanding of the interstices of knowledge. Increasingly, science and society recognize that disciplinarity and interdisciplinarity are not mutually exclusive, but mutually reinforcing.

Indeed, as Heidegger also notes, the disciplinary formations of modern natural science do not so much separate the various sciences from each other as prepare the way for what have come to be called interdisciplinary interactions, which are equally as important as the disciplines themselves - and the source of new disciplinary formations. This means that interdisciplinarity is commonly not so much a counter to disciplinarity as a means for advancing it. Our question concerns whether there might not be other forms of interdisciplinarity, forms that not so much advance as circumscribe disciplinarity.

Interdisciplinarity Education and Research as Sources of Disciplinarity

Discussion of the need for interdisciplinary research - as well as research into interdisciplinarity - was not discovered by Heidegger. In her authoritative study Interdisciplinarity: History, Theory, and Practice (1990), Julie Thompson Klein distinguishes a number of types of border traffic between the disciplines: multidisciplinairty, crossdisciplinarity, transdisciplinarity. She also identifies two distinct roots of interdisciplinarity: educational reforms and scientific advancement.

Beginning in the 1920s, institutions of higher education sought to counter the specialization they had created through the institution of the major by developing general studies curricula. In the 17th century and before, for instance, all university degrees were what we could now call general studies degrees. Beginning in the 1930s, scientific researchers proposed to interweave and hybridize the scientific disciplines in order to extend their abilities to pursue more complex research programs. Interdisciplinary movements within the sciences were markedly intensified by the rise of mission-oriented "big science" (Price, 1963), which was associated with the explosion of science funding during and after World War II. The research and development of radar, the atomic bomb, and other military projects could not be undertaken by any one scientific discipline, but required the coordinated interaction of such diverse disciplines as electrical and mechanical engineering, physics and chemistry.

During the latter half of the 20th century scientific interdisciplinarity has been intensified by efforts to address "real-world" problems such as poverty, war, hunger, overpopulation, overconsumption, and environmental degradation. Recognition that none of these human problems are amenable to strict disciplinary approaches has led the physical sciences to cross borders with the social sciences and vice versa. Other related factors promoting scientific interdisciplinarity include the rise of the computer as the subject of a specialized interdisciplinary science of electronic logic machines and as a tool for all the sciences, the emergence of relational sciences such as ecology, and the thematizing of chaos and complexity as distinct interdisciplinary research programs.

Following the physical sciences and engineering, the social sciences and the humanities have pursued their own forms of interdisciplinarity. Area studies (American Studies, Latin American Studies, Asian Studies) have prospered, and have been complemented by Black Studies, Women's Studies, Popular Culture Studies, and more. There has also been the wholesale borrowing of humanistic methodologies - hermeneutics, phenomenology, structuralism, and post-structuralism - across these disciplines. But by and large, just as in the physical sciences, the result has been the manifestation of new disciplinary formations from what start out as interdisciplinary exchanges. The various area studies programs have, for instance, become institutionalized in departments and degrees, which are complemented by their professional associations and scholarly journals.

Whether as educational curricula or research programs these efforts at interdisciplinarity have, in fact, tended not only to become narrow disciplines but actually to originate from rather restricted border crossings. Despite a plethora of interdisciplinary work, for instance, there have been few sustained efforts to bring the sciences and the humanities together. Instead, the more common thing has been for one science to be crossed with another, or for one compartment in the humanities to open a window into another compartment in the humanities, in both cases for rather restricted ends. On the research side: biophysics has not really united biology and physics but created another and even more narrow discipline; the same goes for fields like biochemistry and paleoclimatology. Interdisciplinary teams of scientists and engineers formed to create nuclear weapons or land a human being on the moon have been spectacularly successful in meeting very specific mission-goals, but only at the cost of raising broader questions for society. On the

educational side the achievements may have been less dramatic, but the failures are just as real. The merger of periodical and broadcast journalism (with some advertising) into communications studies has advanced technical competence in fields of complementary skills, but only to be institutionalized in new departmental configurations. The general education movement has remained a shallow requirement, often resented by students, in most academic curricula.

Indeed, interdisciplinary efforts themselves may be characterized as shallow rather than deep, insofar as they have not stepped outside the disciplinary matrix to involve representatives of the public or common good. Indeed, there has been little serious questioning of a manifold of presumptions underlying disciplinarity, such as the basic need to complement intense disciplinary specialization with light acquaintance of many disciplines (by means of general education curricula) or to extend disciplinary compass and harness disciplinary utility when faced with socially set problems (through interdisciplinary research). The only interdisciplinary fields that have to any significant extent attempted to bridge the sciences and the humanities and to involve the general public are arguably environmental studies (see, e.g., Soulé and Press 1998) and science, technology, and society (STS) studies (Cutcliffe 2000).

Thus, to reiterate, the paradox in a century of interdisciplinarity effulgence is that each attempt at interdisciplinarity has tended to produce not any true general understanding or counterpoint to specialization so much as the presentation of another immanent specialization. Narrow interdisciplinarity has begat more narrow disciplines; shallow interdisciplinarity has perforce remained on the surface.

The Information Explosion and Its Discontents

Following Heidegger, again, we see that the development of the disciplines as well as the current limited border traffic between them promotes some basic assumptions concerning knowledge. Science is our paradigmatic way of knowing; in its classical formulation science rests on the production of knowledge from regionalized ontologies. The various scientific disciplines thus yield not so much knowledge about the world in any traditional sense as information about a well-delimited domain that can typically be modeled in the laboratory. The requirements of the laboratory experiment - setting up a closed system within which observers control all variables, methodically modifying one at a time - are mirrored in the structure of the disciplines. For all the difference in content

between disciplines, the resulting information remains structurally the same, that is, information reports structured around scientific laws or theoretically defined ontologies. Despite the tremendous explosion of knowledge, there is no "discipline" that takes as its provenance understanding the relation between the disciplines.

Hundreds of thousands of bachelor degrees and tens of thousands of doctorates are awarded each year; the annual federal support of science approaching $100 billion (with twice as much coming from private sources); and a sky-rocketing stream of publications floods the infosphere in hardcopy, electronic, and various other media. As more than one social commentator has repeated, we are increasingly the most information and knowledge-intensive society in history (see Machlup 1962, Rubin et al. 1986, and Castells 1996). To utilize Albert Borgmann's (1999) prescient distinction, information about reality (science) and information for reality (engineering) have morphed into information as reality. But the information society appears to have little or no program for how to live in or with this information rich possibility space other than to affirm some automatic synthesis (perhaps by means of Adam Smith's "invisible hand" or G.W.F. Hegel's "cunning of reason") and the personal construction of meaning.

In the specific area of science policy, it is true, voices have been raised to question some aspects of the received view (see, e.g., Sarewitz, 1996; Guston, 2000). But the establishment response has been to marginalize such pragmatic criticisms. Indeed, the core of the received view - one key nodal point in the articulation of which was certainly Vannevar Bush's Science: The Endless Frontier (1945) - has been strongly reiterated by Nobel Prize winner and President of the California Institute of Technology David Baltimore (2000) and editor of Science Donald Kennedy (2001), among others. We may not know when or where, but new discoveries add to the reservoir of knowledge from which economic and social development proceeds.

A few isolated analyses point in rather more radical directions. Provocative studies by Nicholas Rescher (1984 and 1987) and Roger Shattuck (1996), for instance, challenge any simple commitment to continuing knowledge production and unfettered information availability. Julie Thompson Klein's Crossing Boundaries: Knowledge, Disciplinarities, and Interdisciplinarities (1996) and Jens Høyrup's Human Sciences: Reappraising the Humanities through History and Philosophy (2000) make insightful cases for exploring new forms of

interdisciplinarity. Together such efforts suggest that our traditional research philosophy is running up against both epistemological and political limits.

The epistemological limits of our traditional research philosophy are evident in the increasingly complex nature of both information and societal problems: our lives are becoming more interwoven on global scales, and many of the problems that are most easily isolated have already been addressed. The political limits of this increased information production are found in the public's increasingly insistent demand that publicly funded research and education clearly show their connections to community needs. Although the repeated call for interdisciplinarity in education and research is often an effort to respond to such problems, in many instances the interdisciplinarity that emerges does little to address such issues since it leads ultimately only to more and more refined disciplinarity.

Toward a New Interdisciplinarity: Going Wide and Deep

It is our suggestion, then, that new forms of interdisciplinarity are called for to respond to the epistemological and political limits of disciplinarity. These two new approaches to interdisciplinarity may conveniently be described as wide and deep. The former would attempt to bridge the sciences and the humanities, the latter to involve the non-disciplinary public. There are both theoretical and practical arguments for each.

From the perspective of theory, to give interdisciplinarity a wider scope, one that spans the sciences and the humanities, may well begin to address the epistemological limit by reopening negotiations about what counts as information or knowledge. In the first instance, a dialogue between science and the humanities holds some promise of a critical reassessment of any unfettered information production that ignores concern for pertinence or runs over the need for sufficient time and place to assimilate or reflect upon its larger significance. Not just scientific information, but ethics and metaphysics and theology might once again be allowed to play a role in culture beyond the simply reactive. Deepening interdisciplinary exchanges by promoting more significant public participation in science policy decision making would have similar implications.

Speaking more practically, wide and deep interdisciplinarity offers the possibility of promoting true scientific and technological literacy. Too often the means to scientific literacy is thought to be getting the

non-scientists to sit down and listen to scientists tell them about the way things really are. But effective pedagogy depends on students taking a more active and collaborative approach to their learning - with the scientists learning from the non-scientists as well. True learning, as all good teachers know, is a two-way street. Only insofar as this two-way street should be able to incorporate the other in the two forms of other scholars (from the humanities) and other people (non-scholars, the public) can a street become both a polity of the common good and a culture of more than political diversity.

To some extent the need for wide and deep interdisciplinarity--that is, interdisciplinarity reaching out across the science-humanities and science--public divides has been recognized by the Human Genome Project. From the beginning, built into the federal funding of human genome research has been a commitment to use 5% of the public support to promote research into the Ethical, Legal, and Social Implications (the ELSI program) of genome research. There is no use in producing more genetic information if that information is not understood by the public that funds it and may possibly benefit from it. Even if this 5% of funding devoted to ELSI modestly slowed down the mapping and sequencing of the human genome, it may reasonably be argued, it opened up space for that humanities and public reflection that ultimately makes scientific progress more substantive and sustainable than would otherwise be the case. Indeed, given some of the problems that are arising with regard to genetic testing and therapies, it may well be that an even greater percentage of funds should have been devoted to humanities and public dialogue - and even that a little of the dialogue should have been reflexive, exercising some influence on research priorities within the Human Genome Project itself. ELSI has been pretty much a one-way street, from the genome project to society but not from society back into the human genome project.

The bottom line is that wide and deep interdisciplinarity does not lend itself to subordination to the disciplinary imperative that appears to guide the modern knowledge-producing project. Asking questions about interdisciplinarity may point toward a new type of questioning interdisciplinarity. Wide and deep interdisciplinarity may offer a new way to begin to reinscribe disciplinarity within the larger human culture from which it originally arose, and over against which it has ever more insistently placed itself across the course of the 20th century - a theme

that deserves further exploration than has been attempted in this preliminary article.

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