

New Directions in Interdisciplinarity: Broad, Deep, and Critical

Disciplines *discipline* knowledge:

- making claims liable for adjudication
- producing expertise
- defining truth

In circumscribing the various domains of knowledge, disciplines create regions of comparability, marking off epistemology from politics and one epistemology from another. By creating regions of epistemological propriety, they set the terms *quid jure* (by what right?), identifying who speaks authoritatively on a subject. By marking off one field from another, and all fields from the uninformed, disciplines produce expertise. (It is, after all, a contradiction in terms to be an expert in everything.) Finally, the peculiar efficacy of (scientific) truth depends on disciplinarity. Truth as that which can be demonstrated on demand requires that knowledge be created outside of history in discrete, repeatable units. Scientific papers report propositions and reference methods, not socio-historical context.

Aristotle launched us on the trajectory ending in disciplinarity. Plato divided his investigations by personal names (*Euthyphro*, *Phaedrus*, *Theatetus*), occasionally by social roles (*Statesman*, *Sophist*) or political phenomena (*Republic*, *Laws*). In contrast, Aristotle introduced a taxonomy that foreshadows those presently used to manage knowledge: logic (*Categories*, *Prior and Posterior Analytics*), physics (including not just the *Physics* but also *On the Heavens*, *Meteorology*, *On the Soul*, *On the Parts of Animals* and more), and ethics (including the *Nicomachean Ethics*, *Politics*, *Rhetoric*, and even to some extent the *Metaphysics*). The question is whether the modern knowledge management scheme that began with Aristotle is adequate for the age of Google. (We think not.) If not, perhaps an undisciplined discourse more evocative of Plato can help us constitute new, more relevant, inter- and trans-disciplinary forms of knowledge — using “interdisciplinarity” in a generic sense to cover inter-, multi-, cross-, trans-, and other extra-disciplinary formations.

The Complementarity Thesis

Both science and society now recognize that disciplinarity and interdisciplinarity are not mutually exclusive but complementary. Hence the widespread appeal even within disciplinary formations for interdisciplinary efforts. The two are nevertheless also strongly opposed, since otherwise these efforts would be unnecessary.

The complementarity of disciplinarity and interdisciplinarity was adumbrated by Martin Heidegger in a mid-1950s essay, where he noted the mysterious way that science depends on both disciplinarity and interdisciplinarity. “Specialization is ... a necessary consequence ... of the coming to be of modern science.” Nevertheless, disciplinary compartmentalization does not just “split the science off from one another”; it also “yields a border traffic between them” (Heidegger 1977, pp. 170-171). Disciplinarity is the basis of the divide and conquer strategy of modern natural science. Identify a particular phenomenon (such as the mechanical interactions of inelastic bodies), develop

a specialized method for analyzing that phenomenon (the mathematical representation of force and mass found in classical mechanics), and then extend this method across the object-area until it is exhausted or reveals the need for a new object-area definition and associated method (as with chemical bonds and interactions).

This analytical, disciplinary approach has advanced our understanding of nature and contributed to the development of technological power. Disciplinary knowledge has improved human welfare, increased human abilities both to produce and consume, vastly lengthened our life spans, and created opportunities for exploring outer and inner space. At the same time, according to Heidegger, the disciplinary formations of modern science set the stage for further interdisciplinary interactions — and thereby new disciplinary formations. Physics and geology made possible geophysics; chemistry and biology made possible biochemistry and molecular biology. Indeed, in the way that interdisciplinarity usually functions, it does not so much counter disciplinarity as advance it. But note that this form of interdisciplinarity, rather than promoting global views, creates additional and ever more regional ontologies. It has become apparent, however, that the complexity of many problems — from social anomie to climate change — calls for global views, even at the cost of more nuanced epistemological analysis.

It is not necessary to accept Heidegger's argument concerning the ontological foundations of the disciplines in order to admit the empirical fact that their interactions tend to generate more disciplines, and that in consequence there exists a need for some kind of discipline-transcending reflection — a reflection that nevertheless struggles for realization. Steve Fuller, who styles himself an “ideologue of interdisciplinarity,” rejects any and all ontological justifications. According to Fuller, the disciplines are no more than socially rigidified forms of what were once interdisciplines or worldviews — worldviews that characteristically included a strong social movement component (Fuller and Collier 2003). For instance, classical modern physics, which has become a narrow, self-interested, knowledge-producing social institution subdivided many times over into mechanics, nuclear physics, quantum physics, astrophysics, high energy physics, and more, in its original 17th century form as “mechanical philosophy” claimed to offer a comprehensive understanding of the world, not simply a regionalized ontology. For Fuller, interdisciplinarity and disciplinarity thus remain complementary, with interdisciplinarity in desperate need of recovery as a free ranging, heroic ideal that might bring scientific knowledge to bear in human affairs.

Another way to characterize such a heroic ideal would be as interdisciplinarity that is both broad and deep.

In the 20th century, however, cognitive productivity in both disciplinary and interdisciplinary forms is becoming problematic, if not counterproductive. Knowledge production today has a tendency to swamp knowledge use systems at both individual and institutional levels. Overwhelmed by knowledge, we find it increasingly difficult to make good decisions — or, Hamlet-like, any decision at all. Psychological studies have well established that choice behavior is complicated by the expansion of choice options, and the same seems likely with regard to cognitive inputs. Nor is this a problem for ivory tower intellectuals alone. Try buying a television: one now has the option of buying SD, ED, HD-Ready, or HDTVs in one of five main varieties (CRT, LCD, Plasma, Front Projection, or Rear Projection) — this in addition to considerations of size and brand,

over-the-air, cable, or satellite, etc. And as the science writer Malcolm Gladwell (2005) has reported in one example of the oversupply of information: for physicians, increases in knowledge about patients can actually lead to more rather than fewer errors in diagnosis. Additionally, while politicians, when faced with difficult problems, often call for more research as a way to stall for time, society is increasingly unable to fully fund all the knowledge producers it has trained. PhDs become cab drivers, arguably a poor allocation of intellectual resources. Institutions such as the U.S. National Science Foundation now reject higher and higher numbers of grant applications and support those they do fund at progressively diminished percentages of their original requests. Overproduction has bred absurdities such as astronomers who each night download gigabytes of data, only to store them in data bases that no one has the time to analyze.

Moreover, the knowledge society is increasingly characterized by a disconnect between knowledge production and knowledge utilization. This disconnect is in part the result of the sheer volume of information being produced. Disciplines pursue more and more specialization and detail, crowding out awareness of ends or purposes. Interdisciplinary efforts are often characterized as shallow, but this is true only in comparison with the “stove-pipe” narrowness of depth in disciplinary detail and specialization. It is equally the case that the disciplines are unable to offer any width and breadth of contextualization. Moreover, no epistemological justification is offered for why we should prioritize the vertical as compared to the horizontal dimensions of knowledge. In what sense does a PhD know something more or more valuable than a person with three masters? As important as disciplinary depth is knowledge of the overall topographic landscape of human affairs.

But how is this topography to be mapped? This is a question that requires a reconfigured version of the humanities to explore. Granted, the dream of a grand unification of (scientific) knowledge has properly been abandoned. In its stead, a crowded, fast-paced, high-tech world sponsors simultaneous interactions across an indefinite and shifting range of perspectives in search of nuggets of cognitive utility.

The epistemological existentialism of the Internet provides one salient example. Hotlinks embedded within texts radiate in all directions, exchanging disciplinary boundaries for a hyper-multidisciplinarity. Instant access to infinite amounts of information, combined with the lack of a vetting system for identifying authoritative knowledge, has promoted a new type of knowledge gathering and analysis: surfing. Surfing has been dismissed as a distracted, superficial, and indolent activity in contrast with the serious, sustained focus of traditional learning. But in an age of chronic over-information, knowledge consumers must learn how to perform information triage. While not yet part of either undergraduate curriculum or graduate training, in a world where no one has time to read a book cover to cover, surfing is a skill that even specialists must master.

Might there not be a form of interdisciplinarity that complements the advancement of disciplinarity by circumscribing disciplinarity, assisting both producers and users of knowledge to draw insights from constrained disciplinary formations? Might there not be a type of interdisciplinarity that trains us to take quick dips into bodies of knowledge, extracting the knowledge necessary for particular circumstances, without becoming hostage to the incitements of surfing — disciplining our desires as well as our epistemological methods? As the pursuit of infinite knowledge begins to lose its *raison*

d'être, should there not be a form of interdisciplinarity — call it “critical interdisciplinarity” — that focuses on the recognition of limits, defining how much or how little information is needed to address a challenge at hand?

Predisciplinarity and the Rise of the University

Before interdisciplinarity in either the disciplinary-producing or disciplinary-circumscribing senses could manifest itself, disciplinarity itself had to take on its peculiarly modern form. Any assessment of interdisciplinarity — multi- and trans-, non-critical and critical — will benefit from an appreciation of this background.

Prior to the modern period, learning exhibited a kind of unity that might be called predisciplinary. Aristotle, it is true, introduced distinctions between logic, physics, and ethics; but these were never of a kind to raise the possibility of cross-disciplinary formations such as “physical ethics.” During the Middle Ages the division of the *artes liberales* into grammar, rhetoric, dialectic (the trivium), arithmetic, geometry, astronomy, and music (the quadrivium) ensured that the education of “free men” included all the knowledge and skills needed to exercise their social roles. Insofar as it existed, disciplinary specialization was present more in the “servile arts” of artisans and tradesmen. Not even teachers of the liberal arts became specialists in their different branches, since the idea of, for example, possessing arithmetic without grammar would have been considered a deformation of the mind. In the monastery schools the unfettered pursuit of knowledge was viewed skeptically, criticized as *curiositas*, and therefore subject to disciplinization in a premodern behavioral sense. Only at the end of the Middle Ages, as the infinite pursuit of disciplinary knowledge took on the character of a spiritual activity, would Renaissance men become necessary to cross boundaries and synthesize diverse areas of learning.

The rise of the universities — Bologna in 1088, Salamanca in 1218 — did not initially alter premodern predisciplinarity. Modern disciplinization really began outside the universities in such institutions as the Royal Society and other “invisible colleges.” For example, in the United States before the mid-19th century all college degrees were what would now be called general studies degrees. The modern research university was a phenomenon of the post-Civil War period, developing in response to the varied challenges facing a dynamic American society.

Spurred by industrialization, urbanization, and expansion along the western frontier, traditional predisciplinary structures of higher education broke down. Collegiate study (previously limited to the East Coast) had been dominated by recitations of Greek and Latin texts and lectures in natural philosophy and political economy — with no electives or laboratory courses. The overwhelming emphasis was on the preservation and transmission of established traditions and insights rather than on the creation of new knowledge. College education prepared gentlemen for politics, law, and theology.

Such an education was rendered obsolete by the forces of urbanization and industrialization. To a remarkable degree it was an academic revolution from above, led by a small number of visionaries. In 1869 Harvard President Charles William Eliot introduced the concept of the major and the elective system for undergraduates, creating an internal educational market where students could vote with their feet for the most useful classes. This in turn encouraged further curricular innovation and academic specialization, expressed by the progressive differentiation of undergraduate majors. In

1876 Johns Hopkins University adopted and adapted Germanic notions of advanced specialization and research in the form of the PhD degree. At the same time, the development of industrial chemistry — first in Germany, soon throughout Europe and the United States — marked the transition to an economy dependent on scientific research. The highest development of the tinkerer tradition in the person of Thomas Edison (1847-1931) also marked its eclipse as industry, invention, and science lurched toward integration.

New categories of knowledge were created. Natural philosophy divided into physics, chemistry, and mathematics, while natural history became biology and developed an experimental component that challenged the traditional emphasis on description and taxonomy. The social sciences of sociology, psychology, economics, and political science arose to address the new social conditions, applying a scientific and distinctively empirical approach to the problems of industrialized society. Professional associations such as the American Association for the Advancement of Science (founded in 1849, in imitation of the British Association for the Advancement of Science, which had been founded the decade before) quickly emerged across the disciplines, establishing standards for accreditation and scholarship.

The disciplines that became known as the humanities — philosophy, classical and modern languages, history, art history, religion studies — formed a rump of knowledge, left over after the extraction of the other new specialties. The term itself was an adaptation from the Renaissance *studia humanitatus*, when humanist scholars looked to ancient thinkers such as Plato and Cicero for inspiration and guidance. A few of the latter day epigone protested the rise of specialization and disciplinarity and the new emphasis on research, but in general the humanities accommodated themselves to the novel paradigms of knowledge. Abandoning traditional ideas of expounding a perennial philosophy, fields such as literature and philosophy now trained their own specialists to develop new insights. Having given over the study of nature to the physical sciences, and the empirical aspects of the study of culture to the social sciences, the humanities were left with conducting meta-analyses or promoting a general approach of *l'art pour l'art*.

20th Century Interdisciplinary Education and Research

The closest the humanities could come to defending the traditional nature of the humanities was to defend interdisciplinarity. In her classic study *Interdisciplinarity: History, Theory, and Practice* (1990), Julie Thompson Klein distinguished a number of types of border traffic between the disciplines that emerged from the early middle 20th century: multidisciplinary, crossdisciplinarity, transdisciplinarity. She further identified two distinct roots of 20th century interdisciplinarity: educational reform (a more humanities oriented version) and scientific advancement.

Beginning in the 1920s, U.S. institutions of higher education sought, by the development of general studies curricula, to counter the specialization they had created in the form of the major. The election of a major — within which courses were largely predetermined — was to be complemented by a set of core courses providing liberal education in a post-medieval sense. Under the influence of the Enlightenment, the conception of liberal arts had been transformed from passing on traditions to an upcoming elite who were already liberated from servile labor to liberating all minds from the superstitions and prejudices of tradition itself. Thus it turned out that the sciences, as

those disciplines that commonly challenge received religious and political beliefs, came to have a central place in the new multi-disciplinary educational core, along with those parts of the social sciences and the humanities that could be interpreted as part of such a progressive program. In any case, this core of ostensibly predisciplinary courses themselves became steadily more disciplinary, and were increasingly viewed as something to be “gotten out of the way” before turning to the proper task of specialization.

Beginning in the 1930s, initially as a feature of the unity of science movement, scientific researchers proposed to interweave and hybridize the scientific disciplines into multi- and cross-disciplinary formations in order to extend their ability to pursue more complex research programs. Interdisciplinary efforts within the sciences were further intensified by the rise of mission-oriented “big science” (Price 1963) 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 was further intensified by efforts to address social problems such as poverty, war, hunger, overpopulation, and environmental degradation. Recognition that none of these human problems are amenable to strict disciplinary approaches also led the physical sciences to cross borders with the social sciences — and vice versa. Social systems thinking emerged from systems science and systems engineering as one proposal for a grand interdisciplinary synthesis to replace older ideological syntheses such as those of Marxism or Thomism. Other factors promoting scientific interdisciplinarity included 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 soon pursued their own distinctive forms of interdisciplinarity. Area studies (American Studies, Latin American Studies, Asian Studies) prospered, and were soon complemented by Black Studies, Womens Studies, Popular Culture Studies, and more. The humanities saw the wholesale borrowing of methodologies as hermeneutics, phenomenology, structuralism, post-structuralism, and deconstruction flowed across the liberal arts and to a lesser degree into the social sciences. But by and large, just as in the physical sciences, the result was more new disciplinary formations from what began as interdisciplinary exchanges. The various area studies programs became institutionalized in departments and degrees, which were complemented by their professional associations and scholarly journals.

Whether as educational curricula or research programs, all efforts at interdisciplinarity have tended to evolve into narrow disciplines. Moreover, they have tended to originate from rather restricted border crossings. Despite a plethora of interdisciplinary work, for instance, there have been remarkably few efforts to bring the sciences and the humanities together in a sustained manner. Instead, it has been much more common for one science to be crossed with another, or for one compartment of the humanities to open a window into another humanities compartment. 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 humans on the moon have been spectacularly successful in meeting very specific mission-goals, but with little or no attention to the broader questions these successes raise. On the side of the humanities, the traditional belief in a perennial philosophy was abandoned; philosophers, historians, and literary critics became specialists who developed new knowledge. Non-perennial and reputedly non-ideological syntheses such as poststructuralism or postmodernism were the most that seemed possible.

On the educational side the achievements were less dramatic, but the failures were just as glaring. The merger of periodical and broadcast journalism (with some advertising) into communications studies advanced technical competence at the same time that it marginalized the political and philosophic roots of these fields. And the general education movement remained the abused stepchild of higher education, consisting of spot check requirements often resented by students.

The Disciplinary Archipelago and Its Future

To reiterate: The paradox of a century of interdisciplinarity effulgence is that no attempt at interdisciplinarity has produced a viable understanding of or on-going counterpoint to specialization. Instead, each effort at interdisciplinarity has served as preamble to further disciplinary specialization and production. Narrow interdisciplinarity has begotten still more narrow disciplines; weak interdisciplinarity has failed to break out of its academic confines. Despite the tremendous explosion of knowledge, there is not yet any discipline or interdiscipline that defines its task in terms of understanding the relation between the disciplines, or that systematically questions relations between the regional ontologies of the academy, the social institutions of technoscience, and the inchoate but quite decisive struggles to define the good life that define our time.

The fact/value distinction appears to be the best that can be done in the public sphere. While values are either marginalized or politicized, the numbers of knowledge workers continue to multiply, and to become increasingly efficient in producing information. Hundreds of thousands of bachelor degrees and tens of thousands of doctorates are awarded each year just within the United States — a number now surpassed by China. The annual federal support of science in the U.S. is approaching \$150 billion, with twice as much supplied by the private sector. A skyrocketing stream of publications floods the infosphere in hardcopy, electronic, and various other media. As more than one social commentator has noted, we are the most information and knowledge-intensive society in history (see Machlup 1962, Rubin *et al.* 1986, and Castells 2000). To utilize Albert Borgmann's (1999) insightful distinction, information about reality (science) and information for reality (engineering) have morphed into the cyber age where information now functions *as* reality. But the information society has no program for how to live with or within this overloaded information space, other than to assume some type of automatic synthesis (perhaps by means of Adam Smith's invisible hand or G.F.W. Hegel's cunning of reason), or the subjective construction of meaning.

Three fields that have been sensitive to these questions, bridging the sciences and the humanities and involving the general public, are environmental studies and science, technology, and society (STS) studies, and the policy sciences. All of these fields have

nevertheless struggled with the gravitational pull of disciplinary specialization. Environmental studies has difficulty distinguishing itself from environmental science, which in turn strives to define itself as *reicht* science; STS studies oscillate between history and sociology, picking up philosophy on one swing, politics or economics on another. One stream within the policy sciences has offered its own distinctive gestures toward what might contribute to a critical interdisciplinarity: some of the most telling critiques of knowledge culture have come from this domain, as in the work of Daniel Sarewitz (1996), Donald Stokes (1997), Sarewitz, Roger Pielke, and Radford Byerly (2000), David Guston (2000), Steve Fuller (2000), and Philip Kitcher (2001). But the core of the received view — as established by Vannevar Bush's *Science: The Endless Frontier* (1945) — continues to be strongly reiterated: we may not know when or where, but new knowledge is of inherent benefit, adding to the reservoir from which economic and social development proceeds.

A few isolated analyses point in more radical directions. Studies by Nicholas Rescher (1984 and 1987) and Roger Shattuck (1996) have questioned any simple commitment to continuing knowledge production and unfettered information availability. More recent work by Klein (1996 and 2005) and Jens Høyrup (2000) make the case for exploring new forms of interdisciplinarity. Alan Lightman, Sarewitz, and Christina Desser (2003) offer a broad overview of the challenges raised by the knowledge-technology interface. Work by President's Council on Bioethics (see, e.g., 2003) has further disturbed scientists and social critics alike by its conflation of science, philosophy, and policy advising (see Briggie, 2006).

Conjoined, these sources suggest that the modernist disciplinary research philosophy is bumping up against epistemological, political, and metaphysical limits. As previously noted, the epistemological limits of this research philosophy are evident in the increasingly synthetic nature of both societal problems and our information architecture. Our lives are now interwoven at the local, regional, and global scales; most of the problems that are isolable and thus susceptible to a laboratory methodology have been addressed. The central contradiction we face is that laboratory conditions cannot mimic the only partially controlled and random events of historical life.

The political limits of disciplinary knowledge are found in the insistent demand that publicly funded research and education clearly show their connections to community needs. Since the end of the Cold War pressures have steadily increased for science to demonstrate its results. The Governmental Performance Results Act (GPRA) of 1993 formalized the requirement that knowledge production have a tangible outcome. While GPRA applied to government agencies generally, the National Science Foundation's institution of a second criterion of "broader impact" in addition to "intellectual merit" in 1997 explicitly announced the need for researchers to consider the societal impacts of their research on the front end. Review committees, unsure how to integrate impact with merit, have been able to give it no more than nominal attention (Holbrook, 2005). Then, too, the terrorist potentials of dual-use advancements cast their own growing shadows.

The metaphysical limits of disciplinary knowledge lie in the as yet largely unarticulated sense that current and projected research has or will cross what ought to remain as proper if not inviolable limits. Disciplinary blinders have thus far supported prescinding from the cultural and civilizational clash that such knowledge provokes. This may not continue. Many of the most scientifically exciting future advances —

cloning, the radical expansion of the human life span, the creation of human-machine-animal chimeras — raise issues that touch on metaphysical and theological questions concerning whether there should be a limit to human activities.

Despite and because of its brilliance and continuing success, the productive jungle of the disciplinary archipelago is threatened by both informational and political floods, themselves tokens of fundamental shifts in the cultural climate. Attempts to build or rebuild levees to preserve pure research in isolation from epistemological, political, and metaphysical exigencies are unlikely to succeed for long. What strategies can we devise to address these new conditions for knowledge? An alternative system of dikes and outlets that might help us simultaneously preserve and connect the multiple islands with their rich cognitive diversity? Or can and should we, perhaps, slow the rise of information that threatens to inundate us all?

Toward a Critical Interdisciplinarity: Theoretical and Practical Steps

Knowledge experiments are needed that try to respond to the new conditions of contemporary knowledge production. Out of a number of examples we mention two efforts that we have been involved in.

New Directions: Science, Humanities, Policy consists of a series of case study experiments in interdisciplinary research and education. Created in 2001, *New Directions* treats knowledge as tied to places rather than persons or social roles and institutions. Its case studies have been funded by public science agencies (e.g., NASA, NSF) who are interested in better understanding how to integrate ethics and values with science for better decision making. The six original *New Directions* case studies were based on the theme of water (including salmon restoration in Oregon, and hydrological modeling in Salt Lake City). More recently, case studies have focused on the theme of Cities and Rivers – leading to NSF-funded workshop on St. Petersburg, Russia and the Neva River (June 2004), and New Orleans and the Mississippi River in the wake of Katrina (March 2006) (<http://ndsciencehumanitiespolicy.org>).

Progress has consisted in the growth of the group's understanding concerning the intellectual and institutional challenges facing knowledge production in the 21st century. Three themes have emerged:

- How does scientific and technical knowledge relate to place?
- How can the humanities become more policy-relevant?
- What are the different forms of interdisciplinarity, and how can interdisciplinarity promote better connections between knowledge production and use?

Outcomes include the development of the Humanities Policy (H/P) website (<http://humanitiespolicy.unt.edu/>), where an interdisciplinary group of researchers articulate and seek to test the idea that the humanities have real contributions to make to policy debates on issues positioned at the interface of science, technology, and values. Other products include our “Toward Philosophy of Science Policy,” a special supplement of *Philosophy Today* (Frodeman and Mitcham, 2004), and this essay. *New Directions* is also participating in the creation of a field station for interdisciplinary work in environmental science, philosophy, and policy at Cape Horn, Chile, in collaboration with the Omora Foundation (<http://www.phil.unt.edu/chile/>). The Cape Horn region contains one of the last intact temperate forests of the world, is characterized by a high degree of

biological and cultural diversity, and is the home of the world's newest UNESCO Biosphere Reserve. Threats to the region include economic pressures such as salmon farming, tourism, construction of travel routes through the Cape Horn Archipelago, timbering, and mining. Human influences on Cape Horn (including water quality and quantity) will have effects on the local, regional, and global scales.

A second concrete effort was the recent publishing of the multi-volume *Encyclopedia of Science, Technology, and Ethics* (2005). The term "encyclopedia" comes from the Greek and references the classical conception of *paideia* as character formation that came to include the liberal arts of logic, grammar, rhetoric, arithmetic, geometry, astronomy, and music. As achievements in these fields accumulated and became more extensive, explicit efforts were naturally undertaken to summarize them. The oldest extant work in this type of encyclopedia goes back to the first century CE.

The work with which the term is most commonly associated, the Enlightenment *Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers* (1751-1772) marked a three-fold change in the encyclopedia idea. First, the French encyclopedia was written to educate the many as well as the few, that is, to popularize or democratize knowledge. Second, the knowledge summarized in the French encyclopedia included technical craft traditions as well as learned or intellectual knowledge, thus building a bridge between theory and practice. Third, the French encyclopedia proposed not simply to summarize existing cultural achievements but to produce new ones. As the modern project of knowledge production took hold the encyclopedic idea became a kind of counter movement to the creation of more and more specialized knowledge in the physical sciences, the social sciences, the humanities, and the arts. Projects that exemplified efforts at synthesis range from G.W.F. Hegel's *Encyclopedia of the Philosophical Sciences* (1817) to Otto Neurath, Rudolf Carnap, Charles W. Morris's *International Encyclopedia of the Unified Sciences* (1938-1969).

The *Encyclopedia of Science, Technology, and Ethics* (*ESTE*) draws on all three of these traditions. *ESTE* summarizes emerging bodies of knowledge bearing on the co-construction of an ethical, scientific, and technological world; promotes new collaborative efforts in this field of thinking and acting; and stimulates new cross-fertilizations and syntheses between science, technology, and ethics.

Conclusion

The description of a movement from predisciplinarity to disciplinarity, followed by attempts at interdisciplinary education and research, is not meant to be a full account of a complex historical process. Rather, this essay seeks to illustrate the kind of critical interdisciplinarity needed to circumscribe a disciplinary overproduction that is itself too often stimulated by interdisciplinarity. The aim is to draw out pertinent knowledge for public affairs. Critical interdisciplinarity seeks to take the effort involved in mastering or going deep into any one discipline and spread it over a number of disciplines, going just as deep in a discipline as is necessary or appropriate to grasp the essentials. Was this not the model of the well-educated non-specialist, the amateur (root meaning: lover), or the dilettante (root meaning: appreciator)? This approach to interdisciplinarity seeks to define a kind of knowledge — a broad knowledge that possesses its own special type of depth.

Interdisciplinarity must be given a scope as wide as knowledge itself, spanning the entire space from the natural sciences to the humanities. While its breadth will of course include the social sciences, the insistent focus needs to be on the fundamentally humanistic question of what counts as *pertinent* knowledge. Knowledge for what? We need not merely to describe the role of values within science and society — the role of the social sciences — but also to assess these values, working with society as it struggles to address questions of social and environmental justice, human freedom and responsibility, and the proper roles of the public and private sectors.

Theoretical and institutional structures are needed that promote an ongoing dialogue between the sciences and the humanities. *New Directions* is one gesture in this direction. This dialogue will promote a critical assessment of unfettered information production that has ignored the concern for pertinence, and has dismissed the need for time and place to reflect upon the larger significance of knowledge. As part of the task, this will involve questioning the iconic status of scientific curiosity. Too often, curiosity has become a means for restricting critical assessment of the role of knowledge in society, shielding practitioners from the need to give an account of the significance of their research.

But if knowledge is to be genuinely interdisciplinary it needs to do more than simply reach across campus. Interdisciplinarity must also pursue its own distinctly interdisciplinary depth, moving beyond the academy into dialogue with the public sector, the private sector, and community and stakeholder including religious groups. Our academic research portfolio must include an account of how to effectively integrate knowledge within the decision-making context faced by governments, business people, and citizens. Critical interdisciplinarity requires a horizontal and vertical axis. The contemporary knowledge society represents a multi-dimensional challenge, involving not only the horizontal axis that stretches across the physical sciences, social sciences, and humanities, but also a vertical axis where academic research is self-consciously integrated into the multiple contexts of contemporary life.

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