THE INTELLECTUAL ELECTRIC FENCE[1]

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The world is increasingly a place of interactions. The world's major problems of population, environmental pollution, ecological destruction, ozone holes, acid rain, hazardous materials that must be stored for thousands of years while they decay, short-falls in water quantity and quality, global loss of agricultural soils, and biotic impoverishment (just a few examples) transcend the capabilities of one discipline. The present structure of the educational system is toward depth in a particular discipline rather than in breadth in a variety of disciplines as one ascends the educational ladder from secondary school to a B.S., M. S., and finally to the Ph.D. Reductionist science is the norm and integrative science is the exception, although less so than it was a decade or two ago.

This separation is regrettable because almost every activity of human society (except perhaps such passive activities as meditation) has an environmental impact. The per capita energy use in developed countries, as well as use of other natural resources, is markedly higher than it is in developing countries. On the other hand, rate of population increase is at unprecedented levels in many of the developing countries and appears unlikely to stabilize as a consequence of societal efforts until well into the next century, if then. There is always the possibility of large-scale human deaths due to disease, malnutrition, hazardous water supplies, etc. The Union of Concerned Scientists (Cambridge, Ma., 1992) issued a "World Scientists Warning to Humanity" indicating that the present rates of population increase and environmental destruction cannot continue without severe impact on human society. The fact that this was signed by over 100 Nobel laureates and over 1,600 members of the U.S. National Academy of Sciences and its counterparts in other countries indicates that mainstream science believes there is substantive evidence to support this view. Additionally, the officers of the Royal Society of London and the U.S. National Academy of Sciences (1992) released a report with essentially the same view.

Why, with all the environmental crises in the world requiring the interaction of two or more disciplines, has interaction and integration not occurred in the educational system and in the larger world more frequently than it has? The root cause is the intellectual electric fence which each discipline uses to prevent defection from the discipline and to repel invasion from other disciplinary tribes. From the moment a student enrolls in an institution of higher learning, there are "jolts" to keep her/him within the tribal boundaries of the chosen discipline.

The most powerful of these deterrents are the prerequisite courses, without which a B.S. or B.A. is unattainable. These are so numerous and so carefully structured that it is virtually impossible for a student to develop substantive literacy in any other professional field, except on labeled "the minor." If a student strays too far outside the disciplinary boundaries, mild to severe penalties occur. The worst of these is not having the necessary prerequisites for graduation, which is a penalty in both money and time because it may require an extra semester or even an entire academic year to fulfill the needed requirements. Not only are money and time lost, but this delay might raise questions about the student's sincere interest in a particular discipline when he/she applies for graduate school in the same discipline or for a position in that discipline.

In graduate school, the penalties for straying outside disciplinary boundaries are continued by requiring additional courses, most with a strong disciplinary orientation. Graduate students share offices with other students in the same discipline and may not be encouraged to attend seminars in other disciplines that are attended by students and faculty from a variety of disciplines. Finally, preliminary examinations and final examinations for the Ph.D. are committee examinations of the candidate by tribal "elders" (i.e., staunch disciplinarians) who decide whether a candidate qualifies to be an apprentice elder.

A number of barriers or intellectual electric fences are designed to reinforce disciplinary purity and to avoid or reduce substantive relationships with other disciplines. A powerful barrier is a series of tribal languages (which the uncharitable might call disciplinary jargon) not intelligible to the uninitiated. The jargon does serve a useful purpose within the discipline to convey much information in a few words if a large, common-knowledge

base is shared by all members. It does inhibit exchange with disciplinary tribes that do not share the common-knowledge base and, therefore, are mystified by the jargon. Implementers of disciplinary language "purity" are the editors of, and the reviewers for, tribal journals who exclude publication of research that does not emphasize the disciplinary language. Manuscripts intelligible to a wide variety of disciplines are generally designated as "shallow" and as "lacking knowledge of the field." Since professional status is usually determined within a discipline, failure to conform to these requirements can have serious, sometimes fatal effects on professional careers.

Tribal languages and the journals that reinforce them are by no means the only isolating mechanisms with which the intellectual fence is charged! Disciplines on a university campus have a patchy distribution, each discipline occupying a particular spatial patch. On those rare occasions when space shortages or other problems prevent a high degree of geographic integrity for a particular discipline, the least senior members or the departmental outcasts are housed in areas predominately occupied by another discipline. The graduate students and faculty are encouraged to gather for reinforcing rituals, such as departmental seminars and the like. Seminars given by world-class outside speakers are poorly attended at some institutions because the faculty feel the seminar is not on a topic "in my field," which translates into "not my specialty." This is particularly incongruous when uttered by people with a Doctor of Philosophy degree.

Another important segregation occurs at the major annual meeting of a particular discipline, either nationally or internationally. This is the intellectual equivalent to the aggregation of some species at a particular breeding ground each year where the attributes of the species that will be dominant in the population are determined. This intellectual isolation is, in some important aspects, analogous to genetic isolation where outbreeding is discouraged. Thus, a species that is actually capable of successfully mating with another species does not do so for behavioral rather than genetic reasons.

Practically everyone in academe needs money in order to foster intellectual renewal through research. In the past, most of the gatekeepers (i.e., people who decide who will be funded and who will not) were selected by discipline and represented a relatively homogeneous group in the sense that, while they might not have the same areas of specialization, they were all within a discipline or subdisciple. The gatekeepers have the power to exclude applicants by denying access to funding – the surest way to impair a professional career. Without funding, a researcher cannot have postdoctoral fellows, graduate students on research assistantships, technicians or other assistants, substantive computer time, major travel funding for meetings, or even the money to pay for page charges for publications and to buy reprints to honor requests from colleagues. Those so afflicted are less able to exchange ideas with colleagues at other institutions, either personally at professional meetings or through exchange of reprints.

Ironically, however, extramural funding is becoming one of the major factors facilitating interdisciplinary activities. Comprehensive research universities are sensitive to shifts in funding priorities and sources of funding. Without extramural funding, their research programs would be a pale shadow of their present activity level, the graduate programs would be severely attenuated, their faculty would cease to win the accolades and honors that have a major effect on university ranking, and last, but far from least, a major source of income through overhead would be lost. Furthermore, since major problems that transcend the capabilities of a single discipline routinely generate major funding far in excess of the typical grant for a "lone wolf" investigator, these shifts in funding have not gone unnoticed by comprehensive universities dependent upon extramural funding. In a real sense, faculty research fitness requires skill in foraging for resources, and this influence upon individual professional survival, strongly coupled with institutional academic stature, has seriously weakened the intellectual electric fences that were so successfully maintained by the disciplines for many decades.

I hasten to add the caveat that the barriers to interdisciplinary interactions are not entirely bad. For example, quality control is much easier when the attributes of the "product" are crisply identified. A comparable robust quality control system for interdisciplinary activities has yet to emerge, although professional organizations, such as the Society for Environmental Professionals, have a certifying process that exercises quality control at a society level, but only for those who voluntarily apply for certification. Additionally, the basic quality control process should be at the degree-granting institutions. An additional caveat is that reductionism and specialization within a discipline will continue to be as essential in the academic system as it has in the past. However, maintaining disciplinary integrity should no longer be permitted to impede interactions among the disciplines or exercise penalties on those individuals who choose to study problems that transcend the capabilities of a single discipline.

The thrust toward interdisciplinary activities is now too well underway to be stopped. In the last 15 years, numbers of interdisciplinary journals have appeared on the international scene, such as *Environmental Toxicology and Chemistry* (combining environmental toxicology and environmental fate of chemicals), *Ecotoxicology* (combining ecology and environmental toxicology), *Ecological Economics*, and *Integrated*

Management. Research investigators, frustrated by the fact that their interdisciplinary research is not a "good fit" with the disciplinary orientation of most journals and the fact that the reviewers are more suited to comment on the quality of a manuscript in only one area, have finally found that it takes less energy to launch a new journal more suited to their needs than to fight the established system. Thus, the intellectual electric fence has been weakened further by the inability of the classical journals to deny publication of manuscripts that lack disciplinary purity. Again, the quality control system for interdisciplinary activities is far from perfect, and some journal space must be expended because the readers do not share the same information base to the extent that they do in a specialized or strongly disciplinary journal. However, this is a transient problem since the number of persons working in the interfaces between and among the disciplines is increasing markedly.

The most serious weakening of the intellectual electric fence will probably result from the events discussed in the Virginia Tech President's Symposium on Environmental Literacy. The environmental literacy movement is an inevitable result of the information age. For policy- and decision-makers, information is of greatest value if it can be integrated with a variety of other information to make policy and decisions about complex, multivariate systems. Almost every major global problem, and practically all regional and national problems, comfortably fit within this category. Because we are in a global market and because society depends on both an ecological and a technological life support system, environmental literacy (or knowing something about how the natural world works) is of importance to all disciplines. It is interesting that the impetus for this appears to have come primarily from outside the academic system because of the need of corporations active in the international marketplace to have management employees who can make decisions based on information from more than one discipline. Therefore, students in economics must understand ecological restoration, and those in biology must understand economics. Natural resource managers must understand both the benefits and limitations of waste treatment technology; engineers must understand the nature of the receiving systems (i.e., natural systems) into which their wastes are discharged. Additionally, the political and cultural aspects of all decisions must be given serious consideration. These are but a few of the illustrative examples of the wide array of information that is routinely involved in landscape level natural resource planning and management.

However, students cannot become environmentally literate if the faculty is not. Therefore, along with all the other changes occurring in teaching methods, course structure, student preparation, and the like, faculty members must become environmentally literate in the context of their basic disciplines. Although environmental literacy appears to focus on the environment, in fact, its primary focus is interdisciplinary; and, if carried out properly, it will not focus entirely on environmental matters but rather on a suite of information of which the environment is one component. If this movement is successful, even though it may be altered considerably by feedback loops that modify the original plan, it may be the single most important factor weakening the intellectual electric fence. After all, today's students are tomorrow's gatekeepers and are the ones who will decide how potent the barriers to interdisciplinary activities should be and, more importantly, what the new boundaries should be.

As a person who has repeatedly ventured beyond the boundaries of my original discipline of biology, I welcome this expansion of intellectual horizons. At the same time, I am apprehensive that the intellectual quality control system, which was and is one of the major contributions of a disciplinary orientation, does not yet have a counterpart in the rapidly developing interdisciplinary system. This is probably an unwarranted fear because, if the will to develop a robust quality control system exits, it should not be any more difficult for it to develop.

It is worth remembering that, in the early days of science, it was not uncommon for astronomers, biologists, geologists, chemists, and a variety of other disciplines, including those in the humanities, to exchange ideas on a common ground such as the British eating clubs. The enormous increase in both numbers of professionals in the various categories and a concomitant increase in amount of information and literature weakened the interactions among the disciplines that was once take for granted by scholars. We should, therefore, remember that we are not abandoning the disciplines in re-establishing the interactions among and between them, but rather returning to an earlier mode of information exchange that pre-dates the intellectual electric fence.