SOCIAL EPISTEMOLOGY, 1990, VOL.4, NO. 2, 215–227

A dialectical discussion on the nature of disciplines and disciplinarity

The antithesis [[DISCIPLINES AS CULTURES had been the title suggested by the author]]

HENRY BAUER

1 Introduction

Intellectual disciplines are not simply different domains of knowledge. That is to say, chemistry and history (for instance) differ not just because the one comprises knowledge about matter and the other knowledge about the course of events: chemists and historians differ in many ways. Thus they may mean different things when they appear to be saying the same thing, for example that something is 'known'—they differ characteristically over epistemic matters, over the possibility of attaining a degree of certainty; they differ over practical matters, for instance over what a desirable curriculum is; and they differ even in voting behavior, social habits, and religious beliefs.

The nature and extent of these differences make it apposite to regard the various intellectual disciplines as distinct cultures: chemists and historians are not the same sorts of people working at the same sorts of tasks with only the specific objects of work being different, as collectors of coins might differ from collectors of stamps, say: rather, chemists and historians differ much as do Germans and Frenchmen, whose differences of language are part-and-parcel of different intellectual, political, religious, and social habits.

The metaphor of culture is fruitful in several ways. Typical divisions or disputes in academia can be understood as resulting from involuntary, unrecognized misunderstandings and from xenophobia and not from willfully malicious wrongheadedness or blatant departmental self-interest. Again, the nature of interdisciplinary work has close parallels in interactions of national cultures. And intriguing questions follow: To what extent are these cultural disciplinary differences inevitable corollaries of seeking knowledge about different sorts of things? Can a single epistemology be valid for all fields?

2 Some differences among disciplines

It has often been remarked that physicists hold reductionist views much more commonly than do biologists; or that scientists as a whole are more commonly reductionists than are historians, philosophers, or theologians. Again, sociologists commonly emphasize the degree to which knowledge is a human construction, not necessarily reflecting any objective, external reality; whereas scientists take knowledge

Author: Henry H. Bauer, Department of Chemistry, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0212, USA.

0269-1728/90 $3.00 01990 Taylor & Francis Ltd.

to be something that objectively describes the real world and that is independent or human biases or wishes. Or, 'even the concept of "truth" is completely different in the legal sense than . . . in the scientific sense. Scientists (and engineers) believe implicitly in certain absolute truths, and further believe that given enough time and effort the ultimate truth can be found . . . For the attorney . . . there often is no absolutely determinable truth' (Bromberg 1984).

Polya (1954) has given a whimsical illustration of how inductive thinking varies by field: the mathematician, having carefully noted that each of the first 99 numbers are less than 100, infers that *all* numbers are; the physicist, noting that 60 is divisible by 1, 2, 3, 4, 5 and 6, chooses a few more at random - 10, 20 and 30 - and concludes that 60 is divisible by *all* numbers; the engineer notes that, among the odd numbers, 3, 5, 7, 11 and 13 are all acknowledged to be primes, thinks that 1 really ought to be considered a prime also, and concludes that 9, the exception, is an experimental error.

Roe (1952) found significant differences in verbal, spatial, and mathematical abilities among physical and social scientists. Biologists and experimental physicists used visual imagery more—and much more adeptly—than did social scientists or theoretical physicists (Roe 1952: 42, 146–149). That Einstein's thinking was predominantly visual (characteristically so for his cultural milieu (Miller 1988)) may be an exception that underscores this generalization, for Einstein's opinions were—from the 1920s to his death—in opposition to those of almost all his contemporaries (over quantum mechanics in particular).

Theory is valued quite variously in comparison with data in different disciplines. In some sciences—those in which data are hard to come by—much speculation is published around each tiny bit of evidence: in paleoanthropology, say, or 'especially in a field like astronomy . . . a whole house of thought is erected with very few facts' (Hively 1988); when it comes to testing theories, astronomers are used to a slow accumulation of data that leaves things inconclusive for long periods, whereas physicists look to crucial experiments to decide among hypotheses in one fell swoop (Sturrock 1987). In physics, Nobel prizes have been awarded about twice as often for experimental novelties as for theoretical ones; but in chemistry, experimentalists have been so honored five or six times more often than have theorists.[1] Within a single science, experimentalists and theoreticians typically differ over the importance of finding that experiment and theory give the same answer. My first research was to measure quantum yields for photolysis of organic iodides, and I was taught—implicitly as much as explicitly—that accurate experimentation was paramount, that satisfactory theoretical interpretation would indubitably follow if—and only if—my results were sufficiently precise and reproducible; one of my peers, on the other hand, did *ab initio* calculations of dipole moments, and his calculations were highly praised even though they matched experimental data *less well* than had previous calculations: he learned, in contrast to me, but also implicitly more than explicitly, that theoretical insight and mathematical ingenuity were paramount and that agreement with experiment would follow once the theory was complete.

Expertise in method, by contrast to success in making substantive discoveries, is also valued quite variously. In chemistry, experts in a given technique are pejoratively said be 'turning the crank' as they apply the technique to an endless succession different substances; in social science, those who are expert with computers are highly prized as they publish analyses of successions of datasets.

Practitioners of the various disciplines differ over many aspects of pedagogy. Thus textbooks in the sciences refer to the scientific method—if at all—only briefly, whereas

introductory texts in psychology invariably incorporate a substantial discussion of it (Burnham 1987). Most humanists and social scientists believe that classes should b relatively small, but historians like large classes (Adams 1988). Humanists but not scientists believe that undergraduates should take many upper-level courses. Graduate students in the sciences are treated as apprentices (or 'pairs-of-hands', or 'slaves') whereas in mathematics and in the humanities they are regarded as independent (albeit fledgling) scholars. The term 'ABD' (i.e. 'All But Dissertation') is not entirely pejorative in the humanities—people so describe themselves, in written *vitae* as well as in conversation, without evident embarrassment—whereas in the sciences it would be so opprobrious a term that one never takes the occasion to use it.

The practice and implications of citation vary from field to field. Trained as a chemist, I believed implicitly that by citing something in the literature—something not generally known to be superseded or wrong—I would not be taking responsibility for deficiencies in the cited work. But when I adopted that approach to citation in a sociohistorical study of pseudo-science (Bauer 1984), relying on the only available published accounts of certain matters, I was criticized by an historian of science and by an art historian: according to them, I should have sought—as historians are trained to do—to uncover other and preferably first-hand accounts.[2]

Eponymy is not widespread in the humanities or in the social sciences—certainly not by comparison with the sciences, where all sorts of things are eponymized: elements and minerals, constants and units, biological species, craters on the moon, reactions of organic compounds, experimental techniques; there are Hall, Josephson, and many others' 'effects'; Boyle's, Charles', and many others' laws; there is a Faraday Society, Bunsengesellschaft, and other associations; Max-Planck and other institutes; *Dalton Transactions, Langmuir, Perkin Transactions,* and other journals.

When scientists lecture, they usually speak rather spontaneously—they use few notes and they use them unobtrusively. Historians and philosophers, by contrast, tend to follow closely a fully-written-out text which they often read quite overtly. And the reactions of audiences also differ: I have heard chemists praised for delivering exquisitely polished talks with no notes other than their slides, and I have heard philosophers criticized for doing the same thing, for not having taken the time to 'work up' their talks in proper written form. Historians may occasionally show slides of buildings, documents, or the like, and philosophers or linguists may write some words or phrases or symbols on the board; but scientists tend to be incessantly writing things for the audience or showing slides of formulae, equations and patterns—they even perform demonstration experiments or pass samples of things around the audience.

In discussion after their lecture, philosophers or historians will commonly be heard to say something like 'As the paper argues . . .', referring to their own talk as though it has some independent existence of its author. By contrast, scientists respond as though they feel personally responsible for the actual truth of the points they have expounded.

Librarians know how differently practitioners of the various disciplines regard books and periodicals (and perhaps librarians). Chemists pre-eminently demand immediate access to all issues of every journal and fight fiercely to prevent any circulation outside the library of old or new, bound or unbound issues; but chemists hardly care at all about books. Engineers and humanists, on the other hand, cannot understand the fuss that chemists make about journals and are much more concerned that the library have a complete collection of standard monographs and works of reference (of which there are far more in these fields than in chemistry).

Most of the differences mentioned so far have easily conceived connections with the

disparate intellectual natures of the different disciplines: one can suggest plausible reasons for them in terms of how chemists or historians or sociologists pursue their scholarly work. What may not be so evident are corollaries that follow from the human tendency to generalize: what one learns in studying quantum yields, say, tends to be generalized as applying to all of chemistry, and even to all of science: thus I was trained —implicitly and subconsciously—to think that experimental accuracy and reproducibility are the essence of 'the scientific method', whereas my colleague who calculated dipole moments was trained to regard theoretical insight as the essence of 'the scientific method'. Inherent in one's disciplinary training, then, is implicit learning of *different generalizations* in the various disciplines about such things as the value of experiment in relation to theory, the definition of scientific method, the possibility of inductively achieving absolutely reliable knowledge, and the like.

Those contradictory learned generalizations provide rich ground for misunderstandings and disagreements among the disciplines. The situation is aggravated by the existence of cultural differences that are not even related in any obvious manner to the intellectual contents of the various fields: there are notable differences among disciplines that might seem to be no more than matters of style or manners. Why, for example, should humanists and scientists, mathematicians and artists and social scientists express themselves so very differently (Martin 1988) when they write evaluations of colleagues? Why do professors of English care so much about being offered honoraria for evaluating candidates for tenure in other universities—to the extent that the Association of Departments of English passed a formal resolution urging the practice—whereas most scientists and some humanists and social scientists are surprised to hear that anyone expects to be paid for doing that?

Cultural differences of this latter sort are responsible for much ill-feeling: thus professors of English can easily be called greedy mercenaries for demanding honoraria where others do not; yet there is hardly a causal connection between being greedy and professing English—it must be that there is something rather different *about performing evaluations for tenure* in English by contrast with most other disciplines; and in order to avoid mutual misunderstandings, it becomes important to discover what that might be; and what might be the reasons for the other cultural differences among disciplines.

Can it really be somehow inherent in the intellectual dimensions of the fields that international societies and journals should be so much more common in the sciences than in the social sciences or the humanities? That in the social sciences but not the sciences one finds a goodly number of regional associations and journals, for instant a Southern Sociological Association? Why should interviewing of candidates for faculty positions—and even for Department Headships—be so commonly carried out at conventions in the humanities but not in the sciences?

Again, scientists *qua* scientists are not usually anxious about their societal standing, whereas social scientists are overtly self-conscious about it: psychologists or sociologists frequently say, 'As a professional' or 'As a professional social scientist' or the like, whereas from scientists one would hear simply, 'As a geologist'.

Disputes over priority are common only in the sciences, where there is a corollary undertone of everyone seeking to be first (in point of time) with something (even anything). Scientists seem also to be the most workaholic: cultivational reading or travel, or collegial interaction over morning or afternoon tea or coffee, tend to be regarded in scientific circles, far more than in non-scientific ones, as 'goofing off' (unless, of course, it happens to be sanctioned under the aegis of a Gordon Conference). Here again, however, the sciences are not monolithic: eminent physicists seem to feel

more pressed for time than eminent biologists (or than social scientists); and they become eminent at an earlier age; and they give up research for administration at an earlier age (Roe 1952: 42, 45).

Even forms of address seem to vary by discipline: historians, literary critics, or linguists may be written of as (say) Peter Hamline Smithsen, whereas scientists would simply refer to Smithsen (unless there is more than one such in the field, when one might distinguish P. Smithsen from T. Smithsen, say). Customs of that sort could hardly be demanded by the intellectual necessities of scholarship in the disparate fields, yet the differences are there; as, indeed, are differences in political and religious behavior and belief.

A comprehensive survey of political opinion and behavior revealed that 'No other variable . . . differentiates politically among American academics as effectively as their professional fields' (Ladd and Lipset 1972). Physicists are considerably more liberal on the average than are other scientists, being comparable in that respect to artists and humanists. The most extremely liberal are the social scientists, but there are marked distinctions by discipline and subdiscipline within those fields: economists and political scientists are conservative by comparison with anthropologists, sociologists, or psychologists; among the latter, social psychologists are the most liberal, experimental psychologists the most conservative, with clinicians in between (Ladd and Lipset 1975). Such differences run similarly in Britain as in the US (Halsey and Trow 1971) and are not explicable on the basis of differences in class origin, gender, or religious affiliation (Ladd and Lipset 1972; 1975: 121, 344); despite the fact that religious affiliation, for example, varies notably across disciplines. Thus chemical engineers practice a religion more frequently than do physicists, zoologists, or geologists (Vaughan *et al.* 1966); and (in the US in the early 1970s) some 45% of clinical psychologists had a Jewish background by contrast with only 14–17% of experimental and social psychologists (Ladd and Lipset 1972: 344).

Divorce rates (in the US during the 1940s and 1950s) were markedly different (Roe 1952: 57) among physicists (5%), biologists (15%), and social scientists (41%), as was family background, including the experience of losing a parent while one is still a child (Roe 1952: 68, 85, 87). Authoritarian attitudes are more common among scientists, artists, and humanists than among social scientists; and more common among faculties of education than among faculties of agriculture or engineering (Struening and Lehman 1969).

3 *Disciplines as cultures*

Evidently, those who work in the various intellectual disciplines differ characteristically even on matters that are not obviously related to the substantive intellectual content that nominally defines their field. That makes it apposite to view the disciplines as culturally rather than just intellectually different: the distinctions among them show up on many types of issues and not only on the single, ostensibly defining characteristic of what the particular focus of scholarly concern happens to be. Thus physicists are not only more knowledgable about such things as nuclear structure than are (most) biologists, the physicists are also (only on average, of course) more reductionist, more politically left-wing, and more likely to feel pressed for time: the *culture* of physics seems to have implications that go far beyond understanding the properties of matter at its most fundamental level.

That point was made long ago, of course, notably in Snow's (1963) characterization of 'the two cultures'; but the appositeness of 'culture' became rather obscured by polemics over 'two', particularly as Snow was taken to be denigrating the literary in comparison with the scientific culture. Moreover, Snow used the metaphor of 'culture' without explication or justification; though some of his remarks indicate clearly enough that he fully recognized its implications: 'Without thinking about it, they respond alike. That is what a culture means'; the attempt to communicate across cultures is 'as though listening to a foreign language of which one only knows a few words'; 'the reason for the existence of the two cultures . . . is rooted in social histories . . . personal histories . . . the inner dynamic of the different kinds of mental activities'; we are 'more than we think children of our time, place and training'. In any case, the wide currency[3] gained by Snow's usage indicates that something about it is widely admitted to be appropriate and useful.

Snow spoke of 'two' cultures because he was concerned with national policy-making and with the roles of scientists and technologists in that, and 'two' seemed to him the significant number in that respect. But Snow acknowledged the existence of many such cultures and explicitly referred to a third and a fourth. Other writers have emphasized whatever number seemed germane to them (Lafore 1964; Adams 1988; Martin 1988). Irrespective of count, these usages underscore how useful is the metaphor of 'culture' which reminds us that complex, organically related sets of characteristics are at issue and not one-dimensional categorization by the subjects of nominal intellectual concern. For the purpose of the present discussion, disciplines are emphasized as the criterion for distinguishing cultures because the underlying concerns have to do largely with the role of science as a pursuit of knowledge and with what goes on in academia where the disciplines are acknowledged to be salient, being institutionalized as departments.

Of course there are subcultures and overlaps among cultures. In some respects, for example, experimental physicists are more like biologists than like theoretical physicists, though overall they have more in common with the latter (Roe 1956); the 'scientific' culture needs, for some purposes, to be divided into those that are financially supported by government, by industry, and by universities, respectively (Charles 1988). But far from making the metaphor dubious, this need for flexibility or ambiguity in categorizing disciplinary cultures actually underscores the appositeness of the metaphor, for such flexibility is characteristic of how 'culture' is understood in its more usual contexts: thus the Japanese culture is at the same time one instance of an oriental or Asian culture, as well as an instance of a developed economic culture by contrast with undeveloped, under-developed, or less-developed ones; and it contains within itself a traditional as well as a youth culture, and also several ethnic and religious cultures, and others.

So too does the metaphor of culture appropriately accommodate the fact that things change: the relationships among the ingredients of cultures are not fixed. The salience and role of economic, linguistic, religious, and other factors change at various times and for various reasons, and, consequently, so also do the relationships among them; and so different nations become more congruent or less congruent as the salient features of their cultures change. Just so with intellectual cultures: though there has been predominant fragmentation for some centuries, there have also been amalgamations— biology may have fragmented in profusion, yet molecular biology has moved close to chemistry; science, as a whole hand-in-hand with religion until the 'Scientific Revolution', then became its competitor, and now holds dominant sway; in the USA,

the social sciences and their practitioners act largely as advocates of societal change whereas in the USSR they are largely committed to the *status quo* (Ladd and Lipset (1972)).

To speak of disciplines as cultures underscores that the various domains of knowledge differ much more profoundly than just as different 'departments' of knowledge, similar in all respects but one. The metaphor emphasizes that there are rich stories to be told about the disciplines; that it should not be taken for granted that they all have the same cognitive goals, let alone the same values—albeit they all claim to be engaged in 'the search for truth'. The metaphor emphasizes that cooperation among the disciplines, in schools or colleges, say, should not be assumed to be natural; and that interdisciplinary activity faces difficulties on more scores than one.

Though Snow's use of 'culture' has been widely adopted, its ramifications seem not to be widely recognized: in particular, that the myriad details of cultural differences are somehow inherent rather than happenstance. This lack of recognition may stem from the paucity of meaningful interactions among disciplines, interactions in which the cultural distinctions would become evident. They tend to become obvious, however, to those who administer intellectual endeavors in more than a single discipline.[4]

Now, failure to understand the nature of cultural differences can be damaging. For example, British visitors or emigrants to Australia or the USA are often dismayed that certain things are done so inappropriately and incorrectly in those countries. That dismay follows from a one-dimensional view, namely that those countries differ from Britain only in geographical location: the similarity of language and ethnicity produces for the naive the illusion that all significant things should be significantly the same. Yet the same Britishers who believe that Australians do so many things the wrong way can often find the Japanese way of life charming: not expecting similarity, they are able to enjoy differences, or at least not be so offended by them. In the same way it can be damaging that intellectual disciplines are commonly thought to differ in only one dimension, that of the nominal field of inquiry: the unsuspected cultural differences can then stimulate much passionate dissension when they come to the surface, because they are not only unsuspected but also, therefore, not understood. To understand, it is said, may be to excuse; at least it can provide good reasons for excusing.

4 The analogy of *language*

Just as languages differ not only as language but because they are embedded in the cultures of their speakers—geography, history and religion—so too do intellectual disciplines differ culturally because their epistemic features are embedded in practices that include necessities and traditions. Foreigners have difficulty in understanding what the Austrian means by '*gemuetlich*' because that concept draws on several aspects of the Austrian way of life, for example the coffee-house tradition; again, Germans have difficulty comprehending why something 'is not cricket' not because they have no concept of fairness as such but because the concept of 'fair play' has acquired so much subtlety and nuance over a century in which cricket matches were a significant part of public life in the British Empire and Commonwealth.

Similarly, the chemist's use of 'objective' is not fully comprehensible by the sociologist who has not experienced the force of nature in inexorably determining what happens in a reaction vessel; equally is the sociologist's description of

knowledge as ‘constructed’ opaque to the chemist who has not experienced the search for truth in a

discipline that has no single paradigm and in which data for a very special set of circumstances is *not* easily merged with the existing body of knowledge in the whole field. Chemists may be surprised to find that 'stable' can mean something different to them than to physicists (Hoffman 1987); or that astronomers call all elements heavier than helium 'metals'. 'Graduate student', 'instructor', 'grant', and innumerable other terms carry importantly diverse significance in the various disciplines—but we are not commonly sensitive to that, with the result that interdisciplinary misunderstandings are rife.

The analogy with language becomes particularly provocative when one considers the nature of interdisciplinary activity. For instance, it has often been noticed how dramatic a change it is when the learner of a new language becomes able to think directly in that language: one can see something similar when a chemist, say, begins to understand how sociologists can talk about the construction of knowledge. Again, the failure of Esperanto and the other, even lesser known artificial languages (Ido, Interlingua, Novial, Occidental, Volapuek), in other words 'languages' divorced from culture and from literature, is analogous to the failure of the grandiloquent attempts occasionally made to construct general systems encompassing all knowledge. Yet again, that 'interdisciplinary' activities so often seem superficial, interdisciplinary in only a semantic sense, uninformed by the richly nuanced understanding present in the individual disciplines, may be analogous to those who speak the words of several languages without realizing how inappropriately they use or mix them;[5] a claimed polymath (Bauer 1984) may only be like Mezzofanti, who knew 58 languages but nothing worthwhile to say in any of them (Shaw 1945).

5 Applying the metaphor

Things happen in academia that seem inconsistent with the behavior of people disinterestedly dedicated to the pursuit of truth. For example, when in an interdisciplinary meeting a philosopher confessed to a modicum of cognitive realism, sociologists on the platform and in the audience snickered and agitated their eyebrows;[6] or, when an eminent social scientist was proposed for membership in the National Academy, a mathematician campaigned against admitting a practitioner of pseudo-science.[7] The most appropriate way to understand such events may be through analogy with the mutual ignorance and xenophobia that separate national cultures. Thus naive occidentals can be shocked at the 'bad manners' of orientals who deliberately make noise while eating, can laugh at forms of greeting other than shaking hands, and pity 'heathens' who need salvation: naively, they fail to recognize that their own manners and beliefs, just as much as those of the strangers, are intricately interwoven features of their culture that have grown in association with, and at least partly because of, particulars of climate and weather, political and social histories, and intellectual and religious traditions. And just so may naive mathematicians fail to recognize that methods of research, choice of problems, evaluation of quality and the like *must* be different in social science than in mathematics; so too may naive sociologists fail to recognize that they themselves are *culturally constrained* from being receptive to realist notions, whereas the culture of philosophers *necessarily* has room for realists as well as non-realists.

A one-dimensional view gives scant opportunity for reasoned discourse let alone for reconciliation of different viewpoints. If sociology and mathematics were both pursuits

of the same sort of truth, merely about different topics, then mathematicians indeed could only regard as pseudo-science in sociology what they know would be pseudo-science in mathematics. So too if the USA and the USSR were different only in that one is capitalist and the other communist, then they would inevitably have to regard one another as implacable, eternal, natural enemies. By contrast, a cultural multi-dimensional view opens possibilities: since the USA and the USSR share the human desires to live and to reproduce, perhaps the differences in economic approach (as in language) can be accepted simply as different rather than as wrongheaded or evil; especially if they can be understood as *necessarily* different in view of the different geographies and histories. Similarly, it is one thing to seek mathematical knowledge or truth, in a culture based on strict categorization and definitions, where one can choose and delimit variables and domains at will; it is another thing to seek knowledge about human behavior, where categories are only postulates, definitions are subject to change, and one rarely controls any variables but must simply observe what circumstance brings about. Good mathematicians and good sociologists *must* differ in many ways, including in their aesthetic and substantive evaluation of the quality of research and including what they mean by 'truth', 'search' or 'research', and much else.

Commonly, certain types of disputes in universities are said to result from 'departmental self-interest'; but again, rather than informed, narrow selfishness, such instances may just reflect differences between cultures that are naively ignorant of one another. Thus when humanists seek to mandate that the BS and BA curricula require students to take a high proportion of upper-level course-work, incredulous scientists have been known to ascribe this to concern over shrinking enrolments in upper-level humanities courses and the humanists' fear that more of them might have to teach freshman and sophomore courses.[8] But, in reality, disagreement here stems from the fact that the role and significance of upper-level courses are entirely different in those two cultures.[9] Science curricula are tightly structured, and upper-level courses require chains of prerequisites, so that undergraduate curricula for science majors *cannot* include too high a proportion of upper-level classes. In the humanities and the social sciences, by contrast, upper-level courses typically have no prerequisites;[10] however, students enrolled in them are expected to demonstrate intellectual sophistication that is rarely expected of science students before they enter upon research.

Such typical disagreements as over curriculum illustrate how the different cultures talk past one another, not recognizing that they mean different things by the same words—in that instance, not only by 'upper-level courses' but also by 'sophistication' or 'originality' as applied to undergraduates. Saliently in comparing disciplines, 'the search for truth' implies—that is to say, *means*—quite different things in the various fields. 'Truth' itself means something different to lawyers and to scientists, as already mentioned (Bromberg 1981); it means something different again for historians, too (Harrison 1987). 'Search' also has disparate meanings, though that is often obscured because so many cultures speak of 'the scientific method' as though it were a single thing, when actually there exists no satisfactory definition of it (Bauer 1987)—or, more definitions than there are individual sciences; to give just one instance, that statistics is variously used (Good 1988) clearly indicates different beliefs about what 'scientific methods' entails in reliability, reproducibility and ability to distinguish between competing hypotheses.

One consequence of their belief in a single 'scientific method' is that scientists are prone to assume that, having learned it, they are then competent to investigate any subject at all—when in fact what they have learned is an approach that happens to be

particularly suited to some speciality within one of the sciences, say the elucidation of photochemical reactions or the calculation of molecular parameters. A notorious example is the penchant of eminent physicists who take up parapsychology to be fooled by fraudulent psychics (Hyman 1986): the physicists believe such investigations to call for careful examination of phenomena, which of course is true of investigations in physics; whereas psychologists, magicians, and stage mentalists know that such investigations call for careful control and observation of the claimed psychics. Again, physicists—being trained to find single causes for particular events—are prone to ascribe biological extinctions to interplanetary collisions, whereas paleontologists look at the many factors that influence ecologies and, furthermore, recognize that even the 'extinctions' themselves may not be single events—and the opposing sides have even been known to describe themselves as being competently scientific by contrast with their opponents (Browne 1988).

The cultural metaphor underscores that there is nothing 'mere' about even 'rote' knowledge. The view applied so widely in American education, that intellectual skills can be learned or taught without integral connection with any particular subject matter (or much of it), has been incisively discredited often enough (see, for example; Hirsch 1987; Mitchell 1981) in detailed discourse. Its vacuity is evident as soon as one views learning as becoming acculturated. Thus a child who learns the multiplication table learns much else at the same time: that some people believe the learning to be worthwhile; that certain questions have quite definite answers; that accuracy matters; that one often has to accept on faith that a certain thing is worth learning; that acquired knowledge can bring satisfaction; and that calculators or computers may be conveniences and tools rather than needs. That some or many of these things are learned implicitly and not explicitly is, of course, precisely consonant with the metaphor of acculturation.

Viewing interdisciplinary activity as the interaction of distinct cultures is fruitful in a number of ways (to be explored in detail elsewhere). For example, it is often said that the prime barrier to interdisciplinary work is institutional, specifically in universities the existence of departments that jealously guard their turfs; yet in reality departments are but natural, tangible results of ultimately intellectual differences, and the mere creation of extra-departmental entities of multidisciplinary units, or even the abolition of departments altogether, has often enough proved to be insufficient to bring about robust interdisciplinary activity.

6 Conclusions and questions

The burden of this essay is that differences among intellectual disciplines are far more multifaceted than is usually recognized; that this lack of recognition abets serious misunderstandings and disputes; that viewing disciplines as cultures can open further possibilities of understanding and for cooperation in education as well as in research.

Perforce, the adduced illustrations of cultural differences have been unsystematic and largely anecdotal: there does not exist as yet a systematic anthropology of knowledge. One conclusion, then, is that systematic exploration of the range of characteristics displayed by the disciplinary cultures would be a fruitful undertaking. One would like to know, for instance, how strong is the implicit pressure on physicists to become reductionist—and how that compares with biologists or social scientists. And is there any causal (albeit probabilistic) connection between this and the high

proportion of physicists who hold left-wing political views? Or, could there exist a land or a world in which eponymy is more common in the humanities than in the sciences?

Reasons for some of the political, social, and behavioral differences among practitioners of different disciplines have been suggested (see, for example, Roe 1952: 46, 149; Burnham 1987: 111; Ladd and Lipset 1972; 1975: xi, 56, 68, 116--117, 121); and it can be tempting to offer more of such plausible speculation. For instance, since science deals with nature-given categories and phenomena, scientists when lecturing care much about what 'facts' they expound and relatively little about the subtlety or precision of the language in which they expound—so, unlike humanists, they do not read from fully written texts, and they respond to comments not with 'As the paper argues. . .' but in terms of 'Yes' or 'No' or 'We don't know yet'. Again, scientists simply cannot empathize with a domain of knowledge in which students can choose which courses to take, and in what sequence, for in studying science a certain definite sequence—and, moreover, a reductionist one—seems to have been preordained by nature; and, because in science there is always (at least potentially) a definite answer, it is natural for scientists readily to believe that all questions have definite answers, correct ones, including psychological and social matters. Because science deals in discrete nature-given facts, eponymy can be so widespread in comparison with the humanities and the social sciences where there is no nature-given discreteness. And so forth and so on.

Plausible as such speculations may be, however, the metaphor of 'culture' warns that apparently simple and overt differences, for which simple explanations can seem obvious, may reflect complexly interwoven arrays of cause and of happenstance, of logical cause and of historical contingency. (And here again there is a useful analogy with languages: people have gone badly astray in comparing different languages only on the basis of the apparent similarity of certain words, ignoring how languages have actually changed and what can be learned from deeper characteristics of languages such as grammar and syntax.) There would seem enough to be done short of explaining cultural differences, simply in systematically and comprehensively describing disciplinary cultures. Such studies should rather quickly bear practical fruits by enabling those trained in the various disciplines to cooperate with fewer misunderstandings stemming from unsuspected but characteristic differences of opinion. A better understanding of the cultures would represent a gain for the sociology of knowledge and will eventually lead to a deeper understanding of the cultural differences; and that might be relevant to epistemology, since the differences discussed here raise questions about the possible universality of any theory of or approach to knowledge, be it 'the scientific method' or a symbolic logic or even a purely philosophic epistemology.

Notes

1. I characterized prizes as for experimental or for theoretical work using the lists for 1901-1982 in P. Wilhelm (1983).
2. Personal communications from I. Bernard Cohen (28 June 1985) and Lewis M. Greenberg (telephone, 3 November 1984).
3. Readers of *Science*, *Nature*, and many other periodicals need only to look for it to find many examples of the usage; for instance in Arthur Kornberg's address to AAAS, abstracted on the editorial page of *Chemical & Engineering News* (9 March 1987): 'chemistry and biology are two distinct cultures and the rift between them is serious, generally unappreciated, and counterproductive'.
4. C. P. Snow worked in the British Civil Service on matters related to science and technology; Adams was Dean and later Vice-President in a major university; Martin was Dean of a large College of Arts and Sciences.

5. The author is not aware of any written discussions, but there is a rich folklore, for instance about the refugees from Europe during World War II, who spoke 'Emigranto' in English-speaking countries. Typical problems involved not only differences in grammar but also differences between dictionary and common usage. Words that have more than one meaning in one language but not in the other led to whimsical situations: a German refugee in Australia wished to buy some almonds; unable to make the clerk understand his accent, he pointed emphatically to the undersides of his jaw, for in German the same word serves for 'tonsils' as well as for 'almonds'.
6. At the closing Plenary Session of the Conference on History, Philosophy, and Social Studies of Biology, Blacksburg, VA, 16–20 June 1987.
7. The cultural significance of this situation was commented upon by Sherman (1987).
8. The author experienced discussions about this at both Virginia Polytechnic Institute and State University and at the University of Kentucky.
9. Westheimer, for example in his Priestley Medal Address (Westheimer 1988) traces much of the problem with American education to this: 'Perhaps if administrators and nonscientists fully appreciated the vertical nature of education in science, we could begin to straighten out our educational system'. By 'vertical', Westheimer means the hierarchic structure of courses in which earlier ones are prerequisites for later ones.
10. Knowledge of even so clear a fact is not commonly shared among the disciplinary cultures. When I ventured this generalizations in an oral presentation, an erudite colleague with experience in technology and social science protested at this slur against the social sciences and asked whether I had actually made any counts. Here are a few from the VPI & SU catalog: of 22 senior-level courses (4000 numbers locally) in history, only one has a specific course as a prerequisite and only another two require that students have studied *any* history before; similarly in sociology. Of 14 senior-level courses in chemistry, by contrast, only one has *no* prerequisite course in chemistry (but that one did prerequisites in electrical engineering or computer science), and the others all have *specific* courses as prerequisites; similarly in geology. I did not pursue the counting beyond this sample of four disciplines.
11. These ideas were presented orally at the Luncheon Forum of the Center for the Study of Science in Society, VPI & SU, in the fall of 1987, and were then circulated in written form. I am most grateful for the many helpful comments that came from more of my colleagues than can efficiently be mentioned by name.

References

ADAMS, H. *The Academic Tribes*, 2nd edn, University of Illinois Press, Urbana, IL. (1988), p. 163.

BAUER, H. H. *Beyond Velikovsky: The History of a Public Controversy*, University of Illinois Press, Urbana. IL. (1984).

BAUER, H. H. *Journal of Scientific Exploration* 1: 119 (1987).

BROMBERG, J. P. *Chemical & Engineering News* 27 February: 4, 116 (1984).

BROWNE, M. W. *New York Times* 19 January: C1 (1988).

BURNHAM, J. C. *How Superstition Won and Science Lost*, Rutgers University Press, New Brunswick, (1987) p. 112 and note 69 on p. 299.

CHARLES, D. *Science* 240: 874 (1988).

GOOD, I. J. in *Kotz-Johnson Encyclopedia* of *Statistical Sciences* 8: 291 (1988).

HALSEY, A. H. and TROW, M. *The British Academics*, Faber, London (1971).

HARRISON, E. *Nature* 329: 213 (1987).

HIRSCH, JR., E. D. *Cultural Literacy*, Houghton-Mifflin, New York (1987).

HIVELY, W. *American Scientist* 76: 13 (Jan.-Feb. 1988).

HOFFMAN, R. *American Scientist* 75: 619 (1987).

HYMAN, R. *Proceedings IEEE* 74: 823 (1986).

LADD, JR., E. C. and LIPSET, S. M. *Science* 176: 1091 (1972).

LADD, JR., E. C. and LIPSET, S. M. *The Divided Academy*, McGraw-Hill, New York (1975), pp. 116, 21.

LAFORE, L. *Science* 145: 790 (1964).

MITCHELL, R. *The Graves of Academe*, Little, Brown & Co., Boston (1981); and in the periodical *The Underground Grammarian* (P.O. Box 203, Glassboro NJ 08028).

MARTIN, J. *To Rise above Principle: The Memoirs of an Unreconstructed Dean*, University of Illinois Press, Urbana, IL (1988), pp. 116–120.

MILLER, A. I. *University of Lowell Magazine* 3(1): 8 (Spring 1988).

POLYA, G. *Induction and Analogy in Mathematics*, Princeton University Press, Princeton, NJ (1954), p.11.

ROE, A. *The Making of a Scientist*, Dodd, Mead & Co., New York (1952), p. 162, and Chap. XV.

ROE, A. *The Psychology of Occupations*, Wiley, New York (1956), p. 216.

SHAW, G. B. *Back to Methuselah*, Oxford University Press, London (1945), p. *xxvii*.

SHERMAN. J. H. JR., *Research & Development* September: 122 (1987).

SNOW, C. P. *The Two Cultures: And a Second Look*, Cambridge University Press, Cambridge (1963).

STRUENING, E. L. and LEHMANN, S. In PERRUCCI, R. and GERSTL, J. E. (eds), *The Engineers and the Social System*, Wiley, New York (1969).
STURROCK, P. A. *Journal of Scientific Exploration* 1: 75 (1987).
VAUGHAN, T. R., SMITH, D. H. and SJOBERG, G. *Social Forces* 44: 519 (1966).
WESTHEIMER, F. H. *Chemical & Engineering News* 4 July: 32 (1988).
WILHEIM, P. *The Nobel Prize*, Teknowledge, London (1983).

[[This scan of the original publication does not reproduce precisely the arrangement of words within lines]]