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ABSTRACT

Presented is a discussion of the state of the art of internalist and externalist positions within the literature of sociology and philosophy of science. The research utilizes interviews with scientists from a variety of disciplines in the agricultural sciences, a review of publications, research educational guidelines, and formal organization of each discipline. The limitations of both the internal and external positions are suggested as being subject to change by each scientist, discipline, and institution. (Author/SA)

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Sources of Influence on Problem Choice in the Agricultural Sciences: 'The New Atlantis' Revisted

by

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ABSTRACT

SOURCES OF INFLUENCE ON PROBLEM CHOICE IN THE SCIENCES: 'THE NEW ATLANTIS' REVISITED

Sociologists of science have intensely debated whether science is an autonomous institution or a product of the social environment in which it is constructed. This paper reviews recent developments of the internalist and externalist positions within the literature of sociology and philosophy of science. Evidence is presented for both internal and external sources of influence on research problem formulation in the sciences. The research utilizes in-depth semi-structured interviews with key informants in the agricultural sciences and a review of publications, research educational guidelines, and formal organization of each agricultural science. The paper concludes with a discussion of the limitations of both the internal and external positions and suggests these positions be viewed as a dialectic constantly being 'resolved' by each scientist, discipline, and institution.

SOURCES OF INFLUENCE ON PROBLEM CHOICE IN THE SCIENCES: 'THE NEW ATLANTIS' REVISITED

Sociologists of science have heatedly debated whether science is an autonomous institution or a product of the social environment in which it is constructed. Until recently it appeared that the debate was to be resolved in favor of the so called 'internalist' position. Of late, however, the issue has reemerged and promises to change substantially our way of thinking about the sciences. In this paper we examine recent developments of the internalist and externalist positions within the sociology and philosophy of science literature. Next, we present evidence of internal and external factors that influence research problem choices in the sciences utilizing data obtained through in-depth interviews with agricultural scientists. From this evidence we conclude that the internal/external dichotomy may have outlived its usefulness.

The Internal/External Debate

In brief the internalist position[1] centers around the assertion that science as an institution is autonomous. Science has attempted to maintain its prejudice against prejudice[2] and thereby create knowledge free from the constraints of human circumstance. Therefore, attempts to direct science are regarded as likely to produce erroneous results and retard scientific progress. The infamous Lysenko affair is frequently pointed to as an example of what can happen if the state attempts to direct scientific affairs.[3] Moreover, internalists generally argue that decisions regarding project funding should be essentially the result of a peer examination, and that issues of science policy should be made by scientists.

Internalists thus tacitly accept the Popperian, positivist, or even Cartesian philosophy of science as an accurate account of the way in which science is carried out.[4] Indeed, Zuckerman[5] suggests that the imperfect correspondence in theory choice between 'scientists' actual behavior' and 'epistemological prescriptions of how they should behave' may be due to a gap between philosophical concepts and sociological indicators. Of particular importance is the fundamental acceptance by internalists of the notion that scientific knowledge is an accurate representation of the world and hence not subject to external manipulation. The larger social world only impinges upon the world of science to the extent that non-scientific criteria are employed in the allocation of research funds[6] or in terms of the broadest features of research policy. When exceptions are found, they are taken as merely evidence of paradigmatic immaturity.[7] Furthermore, Gaston argued that 'whether a country organizes its scientific research policy and funding in a centralized or decentralized method is the interesting dimension of the social organization of science.'[8]

As a result, internalists have tended to focus on 'science indicators' such as citation analysis and other similarly 'objective' techniques for the study of science. Both the larger socio-cultural context of scientific research and the day-to-day affairs of work-life in the laboratory have received short shrift from the internalists. Indeed, the internalists have followed Merton's dictum to develop 'theories of the middle range.'[9] Predictably, internalists tend to conclude that,

> Recent case studies of problem choice often find in actual practice what methodological dogma has long maintained should be the case: that scientists define some problems as pertinent, and others as uninteresting or even illegitimate, primarily on

the basis of theoretical commitments and other assumption structures.[10]

In contrast, the externalist position asserts that science is a product of the social environment in which it is constructed. Taken in an extreme vulgar Marxist perspective, science becomes merely an ideology concealing class interests. Scientific claims to objective knowledge are summarily dismissed as a mode for concealing the interests of the ruling class.

A more recent, and more moderate, formulation of the externalist position[11] asserts that science shares some but not all of the ideologies prevailing at a given time. Furthermore, it is claimed that these ideologies affect a number of aspects of science. Initially, it is maintained that they affect the form of organization of the sciences. The division of the sciences into broad areas as well as into specific disciplines is said to be societally determined. Secondly, it is suggested that economic factors play a role in determining topics to be studied and their degree of depth. On this point externalists are in substantial agreement with the internalists. However, unlike the internalists, they are less likely to see the state as a neutral body mediating the interests of various classes. Instead, they view the state as the servant of class interests.

It is also argued by externalists that societies determine the degree of permissable deviation from the established scientific orthodoxy. This is particularly true in the social sciences where an official doctrine may prevail. The natural sciences, however, are by no means immune to this kind of manipulation.[12]

The reward system is also influenced by the society at large. While the publication of journal articles and the receipt of scientific awards may accurately reflect the reward system among elite scientists, for peripheral scientists both nationally and internationally, other factors such as pay, prestige, ability to attract research funds, and administrative scope may be of far greater importance.[13] This is particularly true in third world countries where competition at the international level is unlikely, if not impossible.

It has also been suggested by externalists that the society at large influences, and often determines, the choice of research problem. As one biologist has noted[14] the increase in scale of scientific activities and the advent of direct state funding has tended to turn researchers into opportunistic research enterpreneurs. This, of course, is of little consequence if it serves merely to direct scientists to research problems of social significance. However, 'the danger is that a man may come to identify his scholarly function with the specific goals of certain sectors of the power structure.'[15]

Finally, externalists argue that the society may influence scientific research styles or orientations. This is perhaps the most subtle way in which scientific research is influenced by the larger society. Specifically, it is argued that the society at large may influence the kinds of instrumentation used, the locale in which research takes place, the design of experiments, and the way in which research results are reported. Thus, this assertion squarely challenges the internalist position that science is essentially an autonomous activity.

Recently, the externalist position has been bolstered by two related changes: the decline of the belief in the unity of science and the changing role of science in society. Let us briefly examine each of these societal shifts.

<u>The problem of the unity of science</u>. The internalist position initially rested on the argument that while one may have the choice of doing X or Y first,

eventually both must be accomplished. This was asserted since both were considered to be part of the same jigsaw puzzle. In contrast it was argued that external influences would result in a development of 'things' that were not part of the scientific puzzle at all.

The work of Thomas Kuhn[16] dealt a near death blow to the unity of science position. This was ironic in that Kuhn's work was a contribution to the International Encyclopedia of Unified Science. Perfect knowledge was no longer viewed by either scientists or those who study them as a valid goal. Then it could be argued that knowledge of some aspects of the world must be developed at the expense of others. Therefore, decisions as to what to study must be social decisions rather than technical ones. Moreover, one might have many separate sciences developing out of many cultural systems. This is not to say that such scientists would produce contradictory results, but that they would deal with different aspects of the natural world. The complementarity principle[17] has lent strong support to this position.

The changing role of science in society. It is naive to assume that the structure of modern science should have remained unchanged since its inception in the 17th century. Indeed, as the status of science changed from that of a peripheral to that of a core institution, so has its role in the larger society. During its formational period, science was clearly seen as a liberating force, freeing humanity from the bonds of tradition and scholasticism.[18] The scientist, like the atomistic entrepreneur of Adam Smith, could do what he felt was important, with full assurance that his work would be guided by an equally invisible hand (of nature?), and become a building block in the cathedral of knowledge.

With the development of the corporate form, science become corporatized. Big science began to replace little science.[19] Rather than master craftsmen working in their own house, scientists became employees--first of the state (in agriculture) and later of industry. Moreover, this shift from Cartesian to Baconian science[20] changed the very nature of scientific knowledge: 'the dominant mode of production of scientific knowledge has become that of knowledge-as-commodity, as a marketable good with a cash value.'[21] In addition the copyright and patent laws have contributed to this commodification.

The increase in scale, the development of scientific 'manpower,' and the increasing centrality of the relations between science and the state have forced the external influences on science into the public (and sociological) eye. Not only have questions of science policy become defineable and, hence, a matter for debate, but both the state and the large corporations have become increasingly reliant upon scientific knowledge to bolster and maintain their legitimacy.[22] Moreover, both have taken an active role in the suppression of research results they considered contrary to their interests.[23]

These developments have lent support to the externalist position precisely because science itself, as an institution, has become less autonomous. Indeed, it can now be argued that the claim of scientific autonomy has become an ideology designed (much like the calls by the giant corporations for 'free enterprise') to further certain class interests.

In the study reported below, we examine the agricultural sciences, a group of disciplines that are self-consciously 'applied' or 'mission-oriented.' The agricultural sciences were chosen in part because of their unique position in the development of the sciences in the U.S. and the tremendous variation in the nature and degree of internal and external influences upon them. Since their inception, these sciences have been committed to both the accumulation of scientific knowledge and the pragmatic goal of increased productivity.[24] As such, they permit us to study a wider spectrum of scientists[25] and to examine the internalist and externalist positions in a new light.[26] As will become apparent below, the two positions are best viewed not as diametrically opposed but as a dialectic constantly being 'resolved' by each scientist, discipline, and institution.

Method

To examine the internal and external sources of influence on the development of the agricultural sciences, this study utilized 1) semi-structured interviews with key informants in the agricultural sciences, and 2) a review of the publications, research and educational guidelines, and formal organization of each agricultural science.

The interviews contributed a particularly heterogeneous and detailed qualitative information base for assessing the processes and factors related to scientists' problem formulation and the development of the disciplines. Through open ended questions the interview schedule provided information on the informant's current research, influential people in problem formulation, theoretical orientations, important considerations for choice of research, topics within their discipline that are consistently avoided and the reasons, the perceived audience of their research, sources of financial support, frequency of interaction with scientists and non-scientists and opinions about each scientist's discipline.

The population for the interviews consisted of agricultural scientists in the fields of Agronomy (crop and soil), Animal Sciences, Biochemistry, Genetics, Horticulture, Agricultural Engineering, Entomology, Forestry, Nutrition, Food Science, and Phytopathology. In-depth interviews, were conducted at several agricultural colleges. The sampling strategy employed was that of theoretical sampling or dimensional sampling.[27] This strategy maximizes the variation in responses by interviewing persons in very different circumstances. Each interview was concluded by asking the scientist to suggest another interviewee whose research orientation differs from that of the respondent. The use of this approach permits the development of theoretical categories that reflect the views of the practitioners of each of the various sciences, rather than those of the investigators. Theoretical sampling substantially reduces the risk that an artificial symbolic framework is thrust upon the research population. This may be of particular importance in the case of scientists, who are actively engaged in the social production of symbolic frameworks.

In addition to the interviews, recent literature, publications, research and educational guidelines, of each discipline were reviewed. The focus of this review was on state-of-the-discipline articles, critical letters, and other materials that reflect the official views, research emphasis and publication orientation of the disciplines. This provided an additional comparison of the various disciplines, an analysis of the relationship of discipline organization and policies to research problem formulation, and the extent of the influence of internal and external sources on development in each discipline.

Internal Influences on Agricultural Science

A number of internal factors appear to impinge upon the agricultural research process.[28] A particularly important factor is the process by which researchers are socialized. It is commonly assumed that one's major professor in graduate school is the most influential person in shaping research orientations. While this may be true, major professors during post doctoral training, sabbatical leaves, colleagues on the job, and even one's graduate students are frequently mentioned as key figures in research choice and paradigm orientation.

A leading agricultural scientist suggested that the sources of influence may be changing in his field of biochemistry. The selection of a particular paradigm and research direction for the oldest generations of biochemists was probably influenced greatly by the doctoral training.[29] In contrast, the middle age biochemists as well as many of the younger scientists have often been most influenced by their professors during their post doctoral training and sabbatical fellowships. Finally many younger scientists may be additionally influenced by their first job due to limited opportunities to pursue prior training and tight job markets. A young entomologist reflected that both of his current research projects were suggested by department colleagues. A pomologist and an entomologist both indicated that the introductions to their respective research fields was the result of a teaching assignment. Finally a plant pathologist observed that opportunity and job openings are the primary bases on which members in his field choose a particular orientation. While it is true that the particular people most influential in shaping a scientist's research may vary from individual to individual and from discipline to discipline, key fellow scientists remain important internal sources of influence.

Of equal importance, is the content and structure of the training and educational programs. For example the paradigm and research orientations of biochemists are greatly shaped by training in either chemistry or biology. Similarly agricultural meteorologists will employ either physiological or statistical approaches in their attempt to explain the impact of climatological factors on plant growth. In addition, the approach taken in many of the plant and animal sciences may depend upon whether one has received training in genetic or physiology. In entomology it has been suggested that the broader research questions involving genetics and microbiology were avoided because training in the basic sciences has not been emphasized. Indeed, even the development of an ecological perspective appears to be the result of undergraduate and graduate training.

A third area of internal influence is the development of new theoretical orientations and methods. For example, several important research topics have emerged in biochemistry with recent theoretical and methodological breakthroughs, such as determination of the structure of DNA, and techniques for preparing recombinant DNA. Similarly, in the field of animal science, the development of new methods for assessing the nutritive content of feeds opened up substantial new avenues for research. New discoveries and improved methodology have also played an important role in research development and direction in pomology. Here theoretical work on alternative pathways for electron transfer in mitochondria, as well as the availability of inhibitors and techniques for maintaining mitochondria in test tubes, have lead to increased emphasis in this area.

A fourth area of internal influence involves the historical development of the various agricultural disciplines. In the 19th century, it was assumed that agricultural science would develop as an essentially unitary discipline. Pioneering work in the field made it clear that some specialization would be necessary. Over the years the number of specialties has multiplied and each of these specialties has established relatively well-defined discipline boundaries. For example, food scientists, concerned with the development of new food products, have tended to differentiate themselves from nutritionists. Indeed, in many universities nutrition departments are found in the medical college rather than in agriculture. In the area of biochemistry certain areas were avoided, such as organic analysis, not only because they were difficult and complex but also because of the strong historical chemistry tradition in the field. Another example of historical influences on scientific development is found in both entomology and meteorology which developed as disciplines overlapping with agriculture. As a result, in both fields scientists have seen a need to differentiate agricultural questions from other research questions. Historically the two disciplines have addressed this issue in quite different ways. In meteorology, where those concerned with agriculture are in a distinct minority, a separate professional society for agricultural meteorology has been established. In contrast, in entomology where agriculturally oriented 'economic entomologists' far outnumber their liberal arts counterparts, only one professional society now exists. However, a review of the heated debate in their newsletter suggests that the legitimacy of certain research topics is still a real issue to a substantial minority of the membership. Thus, disciplinary boundaries affect the range of acceptable research topics.

Finally at most universities the existing set of disciplinary boundaries are maintained through the process of faculty selection. Generally positions are earmarked for use by a particular department and the determination of specialties within the disciplines is the result of departmental decisions. As a result redirection of research and introduction of major reconceptualization within a discipline occur only slowly.

External Influences on Agricultural Science

Perhaps the most important external influences upon agricultural research orientations are the various commodity groups that financially and politically support selected aspects of agricultural research.[30] While the intimate relationship between agricultural research and the various commodity groups have been documented elsewhere[31], it is important to note that commodity groups are in large part the creature of agricultural research. It is only with the development of highly-integrated, monocultural 'factory farms,' that commodity specific interests have emerged. The more powerful commodity groups tend to encourage research on key problems that broadly effect the 'industry' they represent. They may do so by either supplying funds directly to selected researchers and/or through successful lobbying for additional state or federal money. For example, several California agricultural scientists received funding from state crop advisory boards. One leading pomologist reports that he has received funding from a number of such boards, including the walnut, prune and olive growers. A young entomologist reports that his research on biological control of particular pests had been suggested by his chairman following contact from the fig growers in the state. A senior plant pathologist indicates that his current research was prompted by feedback from farm advisers and that he has received funding from several growers' associations. A viticulturalist suggests the extremely important role that the California Wine Institute and Wine Advisory Board of California have played in research in the field. Until recently the Wine Advisory Board, as well as several other state commodity boards, received research and operating funds through taxes on the sale of the commodities. In Kentucky many agricultural scientists at the Tobacco and Health Research Institute are supported by research funds and research facilities from a tax on Kentucky Tobacco sales similar to California's taxes. Such funding procedures and lobbying efforts may, and frequently do, influence research choices and result in the overfunding of selective research topics.[32] Moreover, the lack of commodity groups in such areas as soil science and rural sociology often puts them at a noticeable disadvantage.

Social movements have also had an impact on the agricultural sciences.[33] In recent years the environmentalist movement has forced the re-examination of the role of chemicals in the production of agricultural goods. With the publication of Rachel Carson's Silent Spring the reductionist character of much agricultural science was substantially challenged. In the intervening years substantial shifts in perspective have occurred. In entomology, integrated pest management employing a variety of insect control techniques, is fast replacing the almost sole reliance on chemical means. Similar changes have occurred within phytopathology, but not without resistance. In the words of one researcher: 'We must make chemical control a science rather than a necessary evil. We must think of chemicals as disease management tools rather than as killers.'[34] In addition, at least one new field, environmental toxicology, has emerged as a result of environmentalist pressure.

Consumer concerns and increasing societal interest in health and nutrition have also influenced the development of the agricultural sciences. According to a young food scientist the consumer movement has led to growing interest in research on food additives and food microbiology. Concurrently, researchers in the field of nutrition report that these same concerns are altering research directions in their discipline.

Agricultural research, unlike more basic research in the biological science must also take into account the changing economic context. For example, until recently virtually all soil classification schemes were created with production uses in mind. Moreover, American agricultural research has tended to focus upon an economic environment in which land, energy and capital were relatively cheap while labor was expensive. As a result, American farmers today tend to have highly capitalized--some would suggest even over-capitalized--operations which employ very heavy doses of fossil fuel energy. With the formation of the OPEC oil cartel and the subsequent rise in oil prices the balance among these factors of production was sharply altered. As a result, not only has energy efficiency become an issue within agricultural engineering, but also in other agricultural disciplines. For example, the increase in shipping costs due to energy consumption has sparked increased interest in post-harvest physiology. If post-harvest deterioration of plant material can be stopped or reduced, then slower and more energy efficient means of transportation may be employed to haul food to market. For example, a pomologist reports that the two hottest topics are 1) research on alternative pathways of electron transfer in mitochondria which may increase shelf life of produce, and 2) research on certain plant hormones which are fundamental in controlling ripening. Similarly, in entomology the increased cost of insecticides (which are nearly always petroleum based) has sparked the search for alternative means of pest control. Finally, the high cost of nitrogen fertilizers has spurred research in biochemistry on nitrogen fixation.

Economics may also play an important role in determining topics that are underresearched, ignored or avoided. For example, an animal scientist reports that his research on double muscling in cattle had been virtually an ignored topic of research, primarily because it was economically unimportant to breeders. A parallel example was provided by a pomologist who indicates that research on the behavior of gases in cellular and intercellular contexts had become an ignored topic thirty or forty years ago. At that time the economic goals of this research had been achieved without a concommitant understanding of the molecular process. Nevertheless the field was abandoned as a major area of inquiry.

Finally, the very pursuit of research may be dependent on funding and therefore susceptible to changing economic conditions. Many of the scientists in the study replied that they would not have pursued their current research if funds had been unavailable. Others went further to indicate that the costs of retooling a laboratory and the current investments in laboratory equipment made radical changes in research problems and orientation difficult, if not impossible. Indeed an agricultural college dean recently lamented that he was the caretaker of a ten year old building filled with obsolete equipment.

The mission orientation of the agricultural sciences also makes them responsive to government regulation of agriculture. For example, recent federal government regulations have required the licensing of pest control applicators and the restriction of a large variety of insecticides. This has led to a marked shift away from chemical control within entomology. Indeed, one department chairman reports that he had experienced substantial difficulty in finding new faculty with an interest in that area. Moreover, those few who still remain staunch advocates of chemical control as the solution to all insect problems have earned several derisive epithets, among them 'spray and pray,' and 'the kill 'em and count 'em boys.'

Government regulations may also spur heated disciplinary debates.[35] For example, environmental and health regulations generally provide legal definitions of toxicity. Many chemicals are only toxic or carcinogenic in enormous dosages (e.g., saccharin). Current regulations require that toxicity be established by feeding rats with the largest dosage physiologically tolerable. While some toxicologists find this definition acceptable, informants tells us that most members of the discipline find it 'unrealistic.' The problem, however, is the lack of an objective standard that might be substituted.

Government may also influence the direction of research through requests for proposals (RFPs). For example, problems involved with dam maintenance led to the formulation of an RFP for the development of foliage tolerant to flooding in reservoirs. Similarly, the Department of Agriculture has recently announced a competitive grants program to develop basic knowledge relating to photosynthesis. The impact of government granting policies appears to be strongest at the most prestigious institutions. While many experiment stations rely primarily on noncompetitive 'Hatch' and state funds, a few receive relatively large proportions of their annual budgets in the form of competitive grants. Indeed, in these institutions faculty salaries may be paid with 'soft money' thereby encouraging faculty to become 'research entrepreneurs.'

The development of instrumentation also plays a significant role in directing the path of scientific investigation. For example, the development of tissue culture techniques and equipment has opened wide new areas of research in a number of disciplines and promises to bypass completely well-established genetic techniques. Similarly in pomology gas chromatography has stimulated increased research on plant hormones. In addition mass spectrometers and lasers have affected research problem choices in biochemistry. Finally nearly all science has been altered by the development of computerized data banks. For example, most agronomists and horticulturists previously recorded the results of field experiments in notebooks. Computerized data storage has permitted both the more rapid processing of statistical data and the use of more complex statistical techniques.

On the other hand, a lack of instrumentation may prohibit the development of certain aspects of a discipline. For example agricultural meteorologists have generally avoided the measurement of wind and turbulence within plant canopies. In large part this has been due to the high cost and maintenance difficulties involved in instrumentation.

In recent years demands for accountability have had the effect of encouraging research administrators to measure productivity more accurately. Counting publications in refereed journals has proven to be a convenient, if flawed, measure of output. A number of our informants suggest that the pressure for publication has narrowed markedly the choice of research problem. For example, little work has been done in forestry on the breeding of improved varieties due to the extremely long reproductive cycles of trees.[36] Similarly, few long term (5 to 10 years) studies of wildlife in their natural habitat have been performed for much the same reasons.

At the personal level, a scientist's non-scientific interests and life style may influence research problem choices. One scientist who engages in a great deal of field research indicates that his choices were greatly influenced by his desires to work outdoors. A plant pathologist also reports that his research interests developed from his hobby of ornamental horticulture.

Finally, the general social and political climate within which researchers operate may have a marked influence upon the kind of research they do. For example, there is some evidence that southeastern experiment stations are more likely to engage in the 'brush fire' research demanded by commodity groups than are stations in other parts of the country. Indeed, the research of entomologists in southeastern experiment stations appears to focus more extensively on chemical means for pest control than that of their counterparts in the rest of the country. It appears quite likely that the focus on chemical control is inversely related to the strength of environmentalist groups.

Implications

It is clear from the evidence presented above that the agricultural sciences are influenced in a wide variety of ways by a diverse array of factors. Some of these influences are clearly disciplinary in character while others represent the demands of outside interests. In light of the internal/external debate, where does this leave us?

Initially, it appears that decisions as to what problem to study are clearly not assignable to any single cause or group of causes. Indeed, virtually all research decisions appear to be the result of a complex of influences, some of which are internal to science and some of which are external. Recent research by Knorr & Knorr[37] on the construction of a scientific research paper appears to further support this conclusion. They note that organizational structure, interpersonal relationships and methodological difficulties, as well as the scientist's disciplinary concerns shaped the problem choice.

Secondly, an extreme internalist view appears to be essentially untenable. The very fact that one cannot study everything simultaneously opens the way for external factors to influence the research process. Not surprisingly, the visibility of these external influences appears to vary inversely with the distance of the research problem from the world of everyday life. Hence, subatomic particle physics, whose objects are, by definition, not directly sensible, is little influenced by the larger social world. In contrast, the social and medical sciences, whose objects are of daily concern to all, are susceptible to a whole range of outside influences. Within the agricultural sciences a similar pattern exists. In this research, basic scientists were more likely to respond with an internalist perspective regarding the influences on their disciplines and on their own research while the more applied fields of agricultural science were more likely to identify external factors influencing their field and problem choice.

Thirdly, an extreme externalist position appears equally untenable. There are certain natural phenomena that are agreed upon regardless of one's political stance or ideology. Put another way, the world is plastic but not infinitely so. Indeed, the mere fact that discussion of competing views is possible demands some common ground.[38]

A fourth point involves the difficulty in making a clear distinction between internal and external influences. For example, while new instruments are developed outside a given science, or even outside science altogether,[39] they are generally associated with methodological approaches and justifications that are fundamentally disciplinary in nature. More subtly, societal concerns (e.g. productivity, efficiency) may become imbedded within the sciences to the degree that they become disciplinary standards by which research is judged.

Finally, the nature of the research methodology in the sociology of science may lead to certain conclusions regarding the internal/external debate. In this research, the in-depth interviews provided evidence for both positions. However, questions regarding who had been most influential in choosing current research problems, how they had begun certain lines of research, how one achieved success in the field and what influenced choice of research orientation were all likely to elicit internalist responses. In contrast, external explanations dominated rationale for the current hot topics and the avoided or ignored topics in each discipline, perceived audience for the research, and perceived considerations important for colleagues' research choices.

These points suggest that the internal/external dichotomy, initially naively accepted from positivism, and overreacted to by its detractors, has outlived its usefulness. Perhaps, even while science differs from other institutions in its commitment to 'public knowledge,'[40] it nevertheless is susceptible--like other institutions--to direction and misdirection by the larger social world. If, as we have suggested above, this is the case, then future studies of science might abandon the dichotomy and attempt, by means of concrete examples, to understand the complex way in which these multiple factors converge to construct that extraordinary social product we call science.

NOTES

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23. Consider, for example, the suppression of information on asbestos exposure by private industry and of information of radiation hazards by the Atomic Energy Commission.

24. C.E. Rosenberg 'Rationalization and Reality in the Shaping of American Agricultural Research, 1875-1914,' Social Studies of Science, Vol. 7 (1977), 401-22.

25. Zuckerman, op. cit., note 1, 82.

26. In contrast, Storer sees the agricultural sciences as deviant. N.W. Storer, 'Science and Scientists in an Agricultural Research Organization,' (Ithaca: Cornell Univ., Ph.D. Dissertation, 1961). This position appears to us to be tenable only if one accepts the 'unity of science' thesis.

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28. Fujimoto and Fiske reported similar findings from their study. However, they use a somewhat different definition of 'internal influences.' I. Fujimoto and E. Fiske, 'What Research Gets Done at a Land Grant College: Internal Factors at Work,' (Davis: University of California, Department of Applied Behavioral Science, 1975, Mimeo).

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31. J. Hightower, Hard Tomatoes, Hard Times, (Cambridge, Massachusetts: Schenckman, 1973). W. Berry, The Unsettling of America, (San Francisco: Sierra Club Books, 1977).

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