A Call for Scientific Literacy: The Claims for Public Understanding

by Alfred I. Tauber

OF THE VARIOUS recommendations already submitted here about scientific independence, about increases in research budgets, about intellectual property being protected, about scientific development being a key human right, the professionalization of science, and all the rest, I think the priority of public education is the most critical one. Without an educated public none of the rest can, or will follow. Colin Blakemore made the point that a little bit of education has in fact been quite dangerous; my answer to that observation is that we need more education. In fact, we require a strategy that follows two paths: The first has to do with scientific literacy per se, that is, to educate the public of the current views of the natural sciences and medicine that have direct bearing on forming a picture of reality and understanding human nature. The second path, the social one, so to speak, pertains to educating the public to understand science's function in culture and its dependence on social choices. This is the aspect I will be concentrating on in these remarks, but underlying each of these issues, is a deeper agenda that guides my argument.

Modern science, its founders and patrons recognized that the issue of mapping the independent domain of knowledge proper was crucial, given the rise of political agendas concerned with how science could be used to serve particular social and economic interests. And it was in the recognition of science's power that its early institutionalization was structured to guarantee its independence from meddling politicians, who in turn extracted the promise that scientists would remain uninvolved in political interests. As patient spectators, the "common" people would reap the material harvest.

But as science continues to amass further sophistication and complexity, and its products continue to dramatically change human lives, citizens will be increasingly concerned that science is too significant to be left to scientists alone. Further, as an important corollary, its purported benefits will be increasingly scrutinized. Governments' growing presence in regulating the laboratory, protecting human subjects, examining research budgets, and monitoring investigators reflect the demand by society to control the course of research. Science studies have fueled the opinion that science is very much like any other social activity and that it is governed by the same general cultural rules that direct other complex cultural institutions, e.g., Pickering (1992).

Science does have legitimate claims to rationality and objectivity in pursuit of its narrowly articulated objectives, and these objectives hold important promise for human welfare. But when scientists engage in public debate on social questions where public policy is to be decided, their authority is subject to different rules of inquiry. On virtually any controversial social question, from abortion to waste control, we witness scientific testimony aligned on both sides of the issue. Argument is usually pitched between opposing experts, and citizens watch the spectacle of a contest concerning whose data are more valid or on what basis such data might be enlisted. Skepticism about scientific certainty, or, at the very least, about bona fide knowledge, opens the door to decisions determined by criteria other than what are normally construed as "scientific". These decisions may of course be determined by moral, legal or frankly political rationales, and the scientist then becomes a bit player in a larger social drama.

The scientist's adjudicating role is also undermined by mistrust about science in regard to how well scientific answers might offer solutions to complex social problems. While I suspect this apprehension is growing increasingly dominant, its precise value is not easy to assign. Most will recognize a common image of the practicing scientist, locked in his laboratory, isolated from social trials and tribulations, and divorced from the concerns of a turbulent outside world. After all, in the search for "truth" and "reality", a scientist is ostensibly isolated from the messy decisions about how the fruits of his labor are to be applied (whether in warfare, medicine, or technology-at-large) or from the possible dire consequences of his discoveries for individuals or for the environment. In this view, in science's lofty laboratories, only unperturbed truth-seekers explore nature's secrets, oblivious to the political, social, and economic needs of the supporting culture.

Some critics, such as Theodore Roszak, have deplored the moral consequences of this posture, whose description, although widely held, must incidentally be regarded as caricature (Roszak 1972, p. 169). His vision sees the scientist's political overtures as no more than an undisguised effort to exert a particular ideology. In other words, the sc4entist has a dual persona: on the one hand, divorced from the world, the product of her labor is nevertheless expected to percolate through its technological application to benefit society. Objectivity then assumes a particular social value. So from this alienating perspective the scientist emerges out of the laboratory to engage in public debate on public matters, where she is viewed as a trespasser, one who would impose her own Faustian vision upon her fellow citizens. This Dr. Strangelove image – and the disparity it represents between how the non-scientist sees the scientist and how the scientist sees herself — is disturbing, to say the least.

There are, to be sure, such diabolical characters among scientists, but by and large they are straw men constructed by various lobbies for their own purposes. Once the polarization of scientist/citizen is abandoned, all of us, scientists and lay persons alike, turn out to be aligned on the political spectrum, advocating various positions with varying commitments to scientific arguments for support. In these debates, however, the uses of science in the social context cannot be neutral. The neutrality of science depends on regarding nature as holding no value. Values are rooted in human needs and desires; whereas nature, stripped of qualities, teleology, and meaning, is left secularized, value-neutral, disenchanted. But when the findings of science are used in social debate, its neutrality is lost because human values are then imposed onto what, left isolated, might otherwise claim objectivity.

The crucial distinction for this discussion is between "what ought to be" and "what is". The attempt to free facts from value originated in the effort to liberate science from its medieval theological roots, and it remains the linchpin for scientists pleading autonomy under the guise of "objectivity", as well as for critics who decry the violation of neutrality of science, which obviously serves particular social agendas. But as Robert Proctor has cogently observed:

[N]eutrality and objectivity are not the same thing. Neutrality refers to whether science takes a stand; objectivity, to whether science merits claims to reliability. The two need not have anything to do with each other. Certain sciences may be completely "objective" — that is, valid — and yet designed to serve certain political interests. Geologists know more about oil-bearing shales than about many other rocks, but the knowledge is thereby no less reliable....

The appropriate critique of these sciences is not that they are not "objective" but that they are partial, or narrow, or directed towards ends which one opposes. In general, knowledge is no less objective (that is true, or reliable) being in the service of interests. (Proctor 1991, p. 10)

Since World War II, an increasingly critical political chorus has heightened awareness of this objectivity-neutrality problem. Despite the reiterated disavowals of a value-laden science, critics have exposed this innocent view for what it is. Citizens maintaining a vigilant watch over science's aspirations and successes no longer accept as gospel the claims and promises of a growing scientific lobby. Recently, critics successfully halted the SSC, the exemplar of Big Science, in what some regard as anti-scientific conservatism (costing the United States leadership in elementary particle physics), and others see as appropriate constraint of a ravenously imperialistic Science. The SSC debate seems to have been a different kind of activism than, for instance, the attacks on what has been perceived as unbridled technology (e.g., nuclear power or environmental pollutants). The distinction between science and its product, technology, has previously afforded scientists the "space" to pursue their research in the interests of advancing

knowledge, leaving its application to another public forum. But science no longer enjoys such latitude.

Controversies surrounding public policy concerning investment in major scientific projects that are touted as the penultimate, if not the ultimate, climax of scientific development are largely connected to three recent assessments: First, the disappointment in similar programs of the past, such as Nixon's "War on Cancer" and other overly optimistic projects, promising to deliver solutions that were unrealistic. The political response has been a growing concern that resources should be more carefully allocated toward directed application and more modestly achievable goals. Second, science and its uses are not easily separated, so we must be careful in controlling the very genesis of new industries. This potential limit on the growth of science has led some critics to propose that indeed there are forms of "forbidden knowledge" (Shattuck 1996). And finally, perhaps the catch-all of a new prudence, the widespread recognition that the positivist ideals of the scientific method have been weakened means that the progress and application of science must be viewed with more circumspection (Kitcher 1993).

Daily we witness how science functions as a political force. Consider, for instance, how scientists must vie with other interest groups to garner public support. Detractors have attempted to depict the proponents of such projects as the SSC as self-aggrandizing competitors in a political arena for scarce economic resources. Science then becomes another project for debate, just like subsidies for milk, pork barrel patronage for public works, or special tax breaks for struggling industries. In this context, scientists occupy no sacrosanct position and must pit their lobbyists against those of other interest groups similarly seeking government support. The same rules apply, and the same utilitarian factors determine the outcome. On these playing fields, science is just another participant in contemporary power politics. That is the price of science's successes and the controversy of some of its applications.

But there are other ramifications. The scientist's authority is continually attacked, not solely for her scientific claims, but, more often than not, for her presumed ideological stance. The scientist will increasingly be placed in the interesting role of social activist under the cloak of his or her professional credentials as scientific questions which are posed and the answers formulated become central to the public debate about human and social character. Of course, such controversy will also expose the vulnerability of scientific knowledge, that is, its provisional and tentative character. And those who see science as a normative activity may find it painful to see it dragged into the trenches of current political warfare, and thus bloodied by contests within its own ranks as one group of scientific experts is pitted against another. As scientists, we expect

debate amongst ourselves about data and theory; in the public forum, we are often exposed as less certain (and thus less authoritative) than we might wish.

So while the scientific ethos pervades into every sphere of Western society, the very success of science has resulted in counterattacks to its program. The so-called Science Wars have seemingly grown in intensity over the past decade. In academic circles the assault is generally led by humanists who see science as somehow disenchanting the world, giving us a blindly materialistic, deterministic view of nature and ourselves. Intelligent people, in my own university, oppose science on this basis, seeing it as imperialistic, and even hegemonic, as its influence grows. There are attacks from religious fundamentalists, who throughout the world regard science as the voice of a particular secularized, Western orientation that risks the place of their own belief systems. Then there are the ideologues who oppose science because of its particular rationality. Radical constructivists, feminists, and certain Marxists see science as simply another ideology in competition with their own.

I believe that we must seek some kind of accommodation with these groups and initiate dialogue which maintains a pluralistic attitude. We need to say to the humanists, "science is not in itself disenchanting; science has aesthetic and ethical dimensions which are important in defining our humanity and understanding the world and ourselves. Meaning is a product of different faculties, and science is only one of several." To the religionists, we must have them consider, although I am not sanguine that they will listen!, that "science explores 'reality' in a particular way, but it is not the only way to know The Real, nor does it exclude religious belief. There is room for both approaches and we are then challenged with finding their meeting points." To the ideologues, I must admit, I have little to say other than a plea for tolerance and pluralism, which ultimately is to their own benefit.

I admit that none of these counter-arguments will hold sway, and I then must acknowledge that my most pronounced fears are directed to science's "friends". For as powerful as these opposing forces might be, I am most alarmed by the politicians and industrialists who would seek to use science for their own agenda. The independence of science is crucial to its health, so that any attempts to guide the direction of science by political or economic controls must be seen as part of a political process – insidious, necessary, and thus particularly difficult to analyze, forecast and direct. The surreptitious use of science for various political agendas has a noxious history in this century, and to those forces we need be particularly attuned.

Science Influences Culture; Culture Influences Science

Political challenges are to be expected, for science does not exist in some sacrosanct, insulated enclave in our culture. Indeed, science and culture exist in a complex dialectical relationship, which might be schematized as a set of parallel vectors connecting two domains that are too often regarded as distinct — science and culture. One of these vectors points from science to culture, describing how science has become a crucial constitutive component of culture, deeply influencing our world view. The ethical implications of that influence are profound, and perhaps no better articulated than in disconcerting our human nature as biologically determined. The other vector describes how we appreciate the ways in which culture, to varying degrees, both frames scientific inquiry and practice and also determines its social support and its development as a social activity.

Our discussion is just one chapter in a more general debate begun after World War II concerning the place of science in society, but I am doing so with the overarching sense that "science" and "society" cannot be neatly divided, for the two domains intimately influence each other. My comments might have been titled, "The Demise of the Two Cultures", which brings to mind C.P. Snow and another era (Snow 1959). When Snow published his essay, he was preoccupied with the disjunction of intellectual life. The growing autonomy of science, residing in its technicality and esoterica, seemed to be unchecked and unchallengeable. Although he was arguing a different agenda, the contrast between then and now is striking, for Snow wrote at a time when science was generally regarded as some distant colony, aloof if not markedly separate from the rest of culture. I, on the other hand, see science as fully contextualized to the point that it is fighting to regain its "sense of self". The pendulum has swung wildly in the past four decades. Science cannot be given the status of some autonomous social activity, or even of a possession that enriches the mother country. Science has become constitutive to our very selves, interpreting through its own refractions issues heretofore left to religion, ethics, and philosophy. For instance, evolutionary explanations are now offered to elucidate complex social behavior like altruism or the economics of commerce (de Waal 1996; Ridley 1997); biological, universal, criteria are sought for what is "beautiful: (Rentschler et al. 1988); some innate (programmed) belief in the divine has been postulated (Wilson 1978); indeed, the very way we think and the cognitive basis of language are now heatedly debated as a biological phenomena, best understood in the context of evolutionary pressures, and so on. The cautionary caveat, to borrow from Marshall McLuhan, is that the medium — in this case science — is becoming the message.

Scientific consciousness dominates Western culture, not only in the practicalities of our everyday lives, but with respect to our most basic notions of reality and objectivity. Science also influences how we regard ourselves — that is, as animal creatures, rational thinkers, or elements

of the entire cosmos. In short, science has shaped the West's world view, and increasingly the rest of mankind's. I am less concerned here with the practical ways in which the science of the future will influence our lives than I am in the manner in which we humans use science to define ourselves. This latter concern reflects our attempts to define human nature biologically. For instance, is IQ racially correlated and therefore based on inherent biological differences? Does homosexuality arise as a result of a gene or a cluster of genes and is it therefore biologically determined? To what degree is schizophrenia, or any other mental illness, genetically determined, and by extension, is behavior or personality neuronally hard wired — and thus genetic?

These questions do not simply reside in the domain of science, but have surreptitiously crossed over into the domain of human values where moral orientations and human prejudice heavily influence how these matters are framed and discussed. This transition from ostensible "objective" scientific evaluation to social "opinion" has been made effortlessly in current polemics about the environment, education, race, abortion, homosexuality, mental illness, criminal deviance, or any number of other social questions that have sought biological models of explanation. At the most basic level, the very possibility that science has answers to such questions already frames the kinds of responses that will be offered.

The adage that the "answer is implicit in the question" holds powerful sway in current debate. Undoubtedly, science is a powerful ally invoked to support or challenge the ideological position of the advocates of one position or another in social policy debates. If, indeed, we seek to be rational in adjudicating complicated social questions, it is expected that we would invoke the most sophisticated and informed scientific opinion to derive the best solution. But debates are on-going about how, or even whether, biology should be used to formulate the so-called "human sciences". To what degree biology defines human nature — for example, the degree of genetic determinism that might program complex human behavior — has a profound influence on ethics. In effect, the question is: to what extent are people "responsible" for their behavior if biology tells them that they are but their genes, not autonomous free moral agents? In fact, we might well ask, what is the status of a psychology that is reduced to aberrant biochemistry? How do we judge and punish the criminally insane? What is addiction? What are the educational "rights" of dyslexics? Is homosexuality "normal"? What, indeed, is normal? Indeed, an answer to this basic question remains elusive (Canguilhem 1989).

It is impossible to totally separate current scientific appraisals from the rational construction of social choices and mandates. The epistemological and moral debates are intertwined, supporting each other in obvious and not so obvious ways. It consequently seems apparent that the boundaries of science arise from a complex interplay of social conventions, both

within the scientific community (however it is defined) and outside it, from its surrounding culture.

Scientists have become willing actors in this social drama. They often find themselves choosing a line of inquiry that posits an ideological endpoint with profound social ramifications. Thus, for example, the Human Genome Project (HGP) may ostensibly receive financial and political support in order to develop better technology for nucleotide sequencing and information processing, or to construct genetic maps, or to serve as the foundation for advances in basic molecular biology. But it is also enlisted to identify genes for various "social diseases" such as alcoholism or violent behavior. Thus the HGP has been trumpeted as both a Holy Grail and a Rosetta Stone by many camps, not all of which share the same agenda.

The issue in the case of the HGP is to what extent a molecular approach is applicable to describing human behavior. The answer to that question in large measure reflects strong extracurricular influences. Science has an undeniable authority when it remains within a narrow domain of inquiry, but extending the results of the HGP to social policy provides a vivid illustration of science's profound influence on culture. The nagging question remains: to what extent we should allow science such authority, when its findings are projected or applied in domains so widely outside its purview? Perhaps the basic question concerning the future of science pertains to where the boundary between the laboratory and its surrounding culture is drawn. While guarding its own integrity and independence, science seeks to inform and influence the political agenda of social policy.

But this is only one of the two vectors governing science's place in culture. Society has a reciprocal influence on science.

Current science studies emphasize that science can no longer be regarded as a circumscribed, self-contained intellectual or social activity. Natural sciences reside firmly and intimately within their supporting culture. Science not only penetrates society, but also is molded by culture. As Bruno Latour describes the phenomenon, science is "blended", by which he means to emphasize how artificial it is to attempt to separate "science" — as insulated and circumscribed — from the myriad other social activities (political, economic, educational, etc.) which support and guide its practice (Latour 1993). Perhaps the most important point is that the study of nature and the study of society are inextricably linked, because not only are they interwoven in a trivial social sense, but because their belief systems are interdependent as well. Science studies scholars debate the extent of this interdependence, the so-called "boundary problem: (Gieryn 1995; Tauber 1997). Some maintain that there is a strong degree of autonomy for science; others argue that it

makes no sense to speak of nature (as science examines it) and culture (as historians, philosophers, or sociologists practice their studies) as independent domains.

The Question of Boundaries

The question of science's boundaries and the legitimacy of its authority rests on its claims to objectivity. On the one hand, the "internalist" approach argues that science grows from its local, immanent concerns; that it is subject to and governed by rational discourse; and that the world it examines may be discerned objectively by the scientific hypothetico-deductive method. The project of comprehending nature is thus viewed as essentially logical. This is what Michel Callon calls the model of "Science as Rational Knowledge" (Callon 1995). It implicitly relies on the realist view of nature, in which science enunciates a sophisticated and formalized dialogue between man and nature. In this view, science is fundamentally a normative exercise in which extrinsic social influences — be they political, ideological, or economic — are minimized in the pursuit of truth.

This approach has been challenged both historically and philosophically. From these perspectives, science emerges as a vast, intricate network of social practices. It is thus erroneous (or perhaps just superficial) to regard science as having its own domain, or as cautiously venturing forth from its insularity against a potentially intrusive public. In this view, science continuously sells itself, promoting the benefits of its progress for technology and medicine. For example, virtually every high school biology textbook now states that the improved health and longevity of Western citizens are due largely to scientific insights regarding nutrition, sanitation, and infectious diseases. But the march of science hardly rests on its laurels. Daily, dramatic television and photo-journalistic accounts present "Science at Work" at the frontiers of knowledge. Whether through photos of distant galaxies, or the pinpoint accuracy of missile bombing, or the *in vitro* fertilization of a postmenopausal woman, Francis Bacon's espousal of science's promise to improve society is constantly reiterated. To propel that message, the boundaries of science currently extend well beyond the laboratory into the copy rooms of news agencies and the studios of television networks. No longer solely the business of scientists, scientific findings and disputes find their way into lay culture to become integrated within society as a whole (Gieryn 1995). Beyond publicizing scientific progress, these public relations forays are designed to stake out a social role for science that translates into power, resources, and authority.

There are at least two aspects to science's politics. On the one hand, various political groups use science to advance their own agenda. Because science is regarded as a form of

knowledge that has special claims to legitimacy, those who advocate policies on the basis of scientific "facts" have more authority than those who do not. And if both sides of a social debate embrace scientific "facts", then the political jury must decide which position embraces the better science or is supported by the better scientist. In short, the Nobel laureate as politician is a potent figure. This adjudicatory role of science is hardly a new issue. Beneath the current sociological dissection of the local fights for dominance in the evolution of scientific knowledge reside the observations of the first architects of science. Four hundred years ago, Francis Bacon astutely recognized that scientific knowledge confers social power. As purveyors of this power, scientists may be regarded as political instruments, be they in monarchial, totalitarian, or democratic societies.

The other aspect of science's politics is the promotion of its own self-interests as a social institution. As the scientific community has grown in the twentieth century, scientists and their support industries have increasingly been characterized as an interest group advocating their method and product for their own economic purposes. Thus, a delicate political balance is constantly being struck between science being used by society and the institution of science seeking its own self-aggrandizement. Given the tugs and pushes on science, it is perhaps not surprising that questions concerning the process and nature of scientific knowledge are often raised.

The Production of Scientific Knowledge

This analysis brings me to the fundamental sociological question: how is truth found — or, as some would say, invented? This issue has been approached in two ways, one assuming a normative attitude, the other embracing relativism. These two perspectives, essentialism and constructivism, form the axis of the sociology of knowledge and serve to separate the forces pitted against each other in the battles about the political standing of science and its role in adjudicating social questions. Essentialists maintain the possibility and analytic advantage of identifying the unique and invariant qualities that set science apart from other occupations, and thus explain its singular achievements. Constructivists deny any such demarcation and instead maintain that science, like other intellectual disciplines, is contextually contingent, driven by the pragmatic interests of its supporting political culture. Some constructivists extend the argument by contending that science uses a rationality designed for its own hegemonic ends, and thus would enlist a radical self-reflexive sociology as part of a far-reaching ideological battle over the very nature of knowledge itself (e.g., Woolgar 1988a, 1988b). The struggles of the Science Wars then extend from the more mundane issues of how much money governments should budget for research to highly iconoclastic attacks on the foundations of knowledge (for review of these

issues see Hollis and Lukes 1982, Cole 1992, Holton 1993, Gross et al. 1996, Ross 1996, Barnes et al. 1996).

Few would dispute the constructivist's claims regarding the inter-contextualization of science into its supporting culture. But the constructivists have generated heated debate when their arguments seem finally to reduce science to politics. Those who regard science as a normative enterprise reject critics' assertions that theoretical scientific formulations are heavily determined by ideological orientations or that science is no more than a rhetorical enterprise, in which persuasion is used to overwhelm the opposition. What is at stake is not only the definition of "truth" but also the definition of science itself.

The implications of this debate go well beyond characterizing science as a form of knowledge. When science is applied to the social domain, it shifts from its epistemological function (knowing nature) to a role in a different arena, one heavily laden with value judgements, cultural history, and political forces. In this context, science becomes invested in the moral domain. In other words, the boundary between "what is" and "what ought to be" — between ontology and ethics — is continually blurred as science assumes a greater and greater dominance in discussions of how human biological character might determine social behavior. Perhaps the intellectual basis of the Science Wars resides in this shift. Contemporary historians and sociologists of science have shown in their investigations of scientific practice that "what is: (i.e., the reality as described by science) cannot be understood independently from how that reality was examined or produced in the laboratory. So after shifting the focus from ontology ("what is") to epistemology ("how we know what we know"), these two questions are conflated, so that "what is" becomes an epistemological matter. The constructivist's reading undermines the authority of science to make ontological truth claims by exposing the contingency of those claims. And consequently, the next step of applying such claims — by which moral choices might rationally be made — is also undermined. If science is only one of a broad range of systems of rational endeavor, if it is likewise fraught with human frailties, then the scientist loses not only her epistemological authority but, more pointedly, her moral authority. The social consequences would be revolutionary, possibly seismic, if radical constructivism were to succeed in fatally undermining the epistemological standing of science.

This underlying issue of the radical constructivist critique arouses the most hostility among defenders of science, who argue that perverse uses of science represent a political usurpation of what should (and can) be an autonomous, if not value-neutral, endeavor. Some constructivist critics counter that as often as not a particular research strategy has, within its very foundations, an ideological basis that, although usually left unstated (or unrecognized) by the

scientist, has broad social ramifications beyond its narrow research agenda. A case in point is the support genetic reductionism gives to a particular kind of biological determinism. So when critics rail against the HGP, they do so not only because of misgivings about its scientific strategy, but also because they perceive that it consists of more than the stated direct purpose of mapping and sequencing our genes. The detractors' general concern is that biology, under the guise of genetic reductionism — the view that holds that all biological (and social) behavior is ultimately determined by our genetic constitution — prescribes a particularly noxious deterministic orientation toward human nature (Tauber and Sarkar 1992, 1993).

This is an ideological argument, resting on a complex array of philosophical orientations. To advocate resolution of contingent and complicated interactions of environment and heredity – when such a determination is impossible — reveals only opinion, not scientific knowledge. The stakes are high, for the vision adopted seeks to determine the way we regard ourselves both individually and collectively. So, the polemics swirling around the HGP — those ethical and philosophical issues that eclipse the technical questions of how to effectively map genes or process the enormous quantity of data — may be fairly regarded as an example of science's political persona. This case example illustrates that science is not simply prescribed by laboratory-based activity seeking (what William James called) "stubborn facts", but also includes two clearly declared political activities: The HGP is both a lobby to accrue government support for molecular biology and genetics, as well as a philosophical debate about the merits of genetic reductionism. These latter two activist identities collaborate to frame public social policy in two venues: political and financial support for a particular branch of science, and the application of a particular philosophical orientation to social issues. This seems to be an exemplar of science stretching its domain. Those who seek to understand the social construction of knowledge may well reap a rich harvest here.

Conclusion

The autonomy of science is being eroded as a result of a growing public awareness that science as practiced is not a free-standing enterprise, but is socially based and subject to the needs and values of its supporting culture. This public domain of science refers not only to the renewal and support that our society gives scientific institutions, but also to the recognition that science serves in a political culture, supporting diverse economic and social interests.

In other words, science is highly politicized. From this perspective, the relevant issue, beyond defining the social origins of knowledge, is the requirement for a philosophy that focuses on the forms of power in and around the sciences: "Why do we know what we know and why

don't we know what we don't know? What should we know and what shouldn't we know? How might we know differently?" (Proctor 1991, p. 13). In short, a political philosophy of science is emerging (see, e.g., Rouse 1987,Longino 1990), which in some fashion must attempt to resolve three differing views of science and society that while competing with one another, also resonate together in offering differing perspectives of a most complex association. As Scott Gilbert has elaborated, these relationships are: (1) science (or at least its truth claims) is independent of society, (2) science is politics by other means, and (3) science plays a critical role in defining our culture and world view (Gilbert 1997). Given its centrality in defining human nature and cultural practice, biology, perhaps more than any other branch of science, will command a domineering status in how these varying views shape our understanding of those activities we call "science" and "culture".

It is, after all, naive to regard science as somehow isolated from its supporting culture. Science cannot be confined to its investigative concerns, for its boundaries cannot be firmly drawn. While guarding its own domain, science seeks to inform and influence the political agenda of social policy as a reasonable extension of its knowledge. The epistemological and the moral domains are therefore not easily separated because we integrate them as informed opinion on a complex continuum between our search for "what is" and our aspirations for "what ought to be". On the social playing field, these two philosophical goals meet somewhere beyond their theoretical origins and thereafter cannot be divided again. Science is inexorably drawn between these two poles, which should make us pause and consider anew how a politics of science might emerge. The character of science in this broadened view remains a critical question for the future, which, from this perspective, is no longer just a laboratory effort, but a complex social institution that impacts upon other cultural activities.

Despite cautionary provisos, we still seek authority, if not certainty, in our public debates. So in the very act of defining ourselves, the scientific view, with its strong claims to objectivity, is used to displace and out-weigh other modes of discourse. The dialectic is of course bidirectional because our social and ethical ideologies may also color scientific interpretations of the nature of human psychology and social behavior. But of the two vectors, we more clearly appreciate the influence of science on culture, and as the authority of science has grown, its influence on the epistemology of the human sciences has increased in parallel, and from this position, we witness biological theory applied to the moral domain. For example, if homosexuality is regarded as biologically determined (a scientific judgment), and if biological determinism translates into psychological and social determinism (the conclusion of a human science), then how might we regard such behavior as criminal (a final moral determination)? To

make homosexuality a crime, one must either use criteria other than science's (e.g., religious or ethical) or attempt to undermine and refute the science used to reach this unwanted conclusion. Increasingly, the course of employing other kinds of knowledge or rationalities becomes less tenable, and social debate is contested on scientific grounds where the objectivity/ neutrality distinction must be carefully scrutinized.

This complex dialectic of science affecting our moral stance and our moral views subtly directing science is, at its heart, the problem of placing science within its cultural context. The basic question concerning the future of science is where to draw the boundary between science and other social activities and applied moral judgments. This question is perhaps less epistemological than ethical, for that decision is based on choice, and

choice is grounded on value, and value is a moral category — informed by understanding. An educated public is our best assurance that science will be protected, promoted, and understood in its full complexity — for what it offers and for what it cannot provide.

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DISCUSSION

BALABAN: I almost want to say that there's nothing more to be said because you also gave the recommendation which we're asking you all to think about — to have a recommendation as a summary of some of the discussions you're having.

JACOB: Sokal, a professor of physics at Cornell, published an article in a review of post modernism, using all the proper words but meaning nothing. The paper was accepted and he eventually disclosed the fact that he was just joking. He wanted just to show that these people were telling about science things which they just didn't understand. Because in this discussion between the postmodernist and the scientist, which you mention, it seems to be forgotten that science works and can be judged on its predictive value when this seems at best a secondary argument in the debate.

TAUBER: I am delighted you brought up the Sokal affair. Obviously the radical constructivists have a very important ideological agenda. They at times admit that what they want to do is dislodge rationality, the hegemonic rule of rationality. Those radical constructivists are doing a disservice to the constructivist program. The constructivist program, in fact, I believe, is quite

valid. What does it say? Basically it argues that scientific inquiry is not insulated from language, from its metaphysical foundations, from its political and economic resources. In its dependence on the broader culture, science is socially constructed — in a very trivial sense but also in a very profound sense. That lesson is something which actually emerged as a reaction to positivism. The logical positivists were basically dethroned, overthrown, by Kuhn, Polanyi, and Lakatos, by other philosophers of science of the 1960s and 1970s who said, "Look, this is not entirely rational what's going on. You're telling yourselves stories because you need to rationalize what in fact occurred. If you look at the historical record it's quite different".

Scientists don't know philosophy, scientists don't know history. They don't need to know it in order to progress. But if we're going to understand what science is in its broadest historical and philosophical context, then we need to understand that it's a very human affair, socially constructed from many diverse sources. It's a lesson that scientists need to be aware of too, but the best scientists are not, because if they were too concerned about these social (extraneous) factors, nothing would get done. Sokal did a disservice to the constructivists. And the problem, of course, is that the two sides are talking past each other. What we need to do is talk together.

WOLPERT: Nobody who does science cannot think that it's a social process when getting a paper reviewed or dealing with your colleagues. We know it's a social process. What we're talking about, what's important, is the results of science. I ask you to give me one example in the whole of biology in the last fifty years which is a social construct and isn't really related to reality. Do you really want to tell me that chemistry is a social construct?

TAUBER: I will tell you the following, Lewis, and I'm delighted as usual that you bring up your point.

WOLPERT: Just to be even more militant. Philosophy of science has contributed zero to the understanding of the scientific process this century. I'd love a counter example.

TAUBER: Let me answer the first rabid comment. I will try to de-escalate the rhetoric. Philosophy of science has not contributed to science, Lewis. It has not contributed to what occurs in the laboratory. Philosophy of science never wanted to do that. Philosophy of science simply wanted to use science as part of its agenda of understanding epistemology, understanding the process by which we might comprehend the world. So you're confusing two different agendas. It's a basic category error, but you make it all the time. I just can't hope to convince you, but I don't want the rest of the group to be confused.

Regarding social constructivism, I refer you to my paper for a full discussion. But here let me say that the Human Genome Project is hardly scientific in a narrow sense. To a large degree it is an ideological scientific program. It argues a genetic reductionism, namely, if in fact we have a

blueprint, a genetic blueprint, we will have an important, if not critical, Rosetta Stone or Holy Grail to give us a new biology. I'd venture to say, as a physician, as an immunologist, as a philosopher, that such a claim is ideological and represents a political agenda. The molecular biologists are seeking to control biology by their own criteria, and their influence in Europe, Japan, and America critically determines the kinds of projects that are being funded. But I can say to you that integrative biology, the kind of work that I suspect Colin is very attuned to, is the kind of biology that we need to be pushing, at least in balancing the genetic determinism that is being propagated now. I mentioned earlier to John Maddox the history of sickle cell anemia where the gene has been identified for fifty years and the epigenetic effects of that gene are still not understood. Now, that's not to say that we will not have a cure for sickle cell anemia. We will as soon as we take that gene and have the technology to put it into blood precursors. But that's another question. The kind of biology I would argue that is needed to balance radical reductionism is an integrative complex-based biology. One which is integrated, let's say, by the whole organism. Be that as it may, understanding the issues surrounding the HGP is an example of a constructionist analysis.

SPIER: For more examples of the way in which science is constructed: People actually supply money into cancer research funds. A lot of research is done on the biology of cancer because it's a socially deemable good in that sense. Why is it that we mainly look at therapy rather than at prophylaxis? The pharmaceutical companies love us to make drugs. They don't love us to make vaccines, and there's a fairly obvious reason why that should be the case. This is exacerbated at the NIH budget which is something like sixteen billion, of which about half a billion goes to prophylaxis. That is a socially constructed way in which biological research is oriented. But let me come back to social construction. It is socially constructed whether we like it or not. It's just part of the observation of what it is we do and the way we come to do what we do.

I'd like to come back to the philosophy of science and I like your idea in essence of finding the global version of it. I actually go somewhat further than you do and say that everybody in any society uses the scientific method to know where they are and where they're at any one point in time. They're using it every which way. It is not a property of scientists. Scientists use the scientific method mainly to make money out of it because they get their livelihoods from it and they tend to be employed by the society to do those things which are particularly difficult, with either the very small, or the very large, or the very complex or the very sort of things that are part of our human biology. So we get the difficult jobs, which is why we're paid to employ this method. But that doesn't mean to say that other people are not, in fact, using the scientific method to come to terms with what they're going to have at breakfast or where their

coat is hanging in the cupboard. I mean they actually use science to determine those things. And I would go even further and I would say that in the animal world too there is evidence that animals test their concepts of reality by a variety of techniques of sensory perception or whatever and make determinations and hypotheses and test those hypotheses just as we do. They may do it consciously. So I would actually say that what we do in science goes much further and has much deeper roots, much more fundamental roots than the kind of intellectual super-structure the philosophers might seek to place first on us.

MADDOX: Since we are talking frankly, I've been uneasy ever since. Because I do think that Lewis is right when he says that the constructionists are indeed deeply skeptical of science. They don't want it about anymore. And I say this ... but it's what they say. I think it's also doing no great service to science or even understanding of the problems: to contrast those starkly, the human genome project as wholesome as it were, the whole animal business or even to suggest that the human genome project is necessarily genetic determinism.

You and I were talking earlier about the folly of genetic determinism, by which I meant that it is ridiculous to suppose that because the gene has been identified everything is known about the consequences of the presence of that gene in the human genome. And indeed on the contrary, I think it's a very interesting program that will have to be mounted soon to discover exactly how it is that external influences, external to the genome actually affect the development of personality. And so in that sort of sense I think one shouldn't polarize that argument too much. It is not a polarized argument, but maybe you didn't mean to.

TAUBER: I wanted to make a point, and I polarized on purpose to make the point that there is a certain philosophical, if you will, orientation about the kinds of questions that are going to be asked in the laboratory. I think the Human Genome Project in its original mandate asked a very reductionist, even deterministic, kind of question. Michael assured me last night that, in fact, it is expanding and he almost quelled my worry.