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The Anti-Science Phenomenon in Science & Technology Studies

Is there really antagonism against science in STS?

The fact of anti-scientific sentiment

The fact of anti-scientific sentiment has been acknowledged even by as sympathetic a science-studies insider as John Ziman: in contemporary STS, "much ... discourse seems aimed at proving that ... [science] works ... on behalf of certain sinister power groups" (Ziman, 1994: 275).

So far as *outsiders* are concerned, it is of course the most raucous voices in STS that are most noticed: so Gross & Levitt (Gross & Levitt, 1994) even come to equate STS with the radical ideologues of animal-rights activism, feminism, Marxism, and sociological relativism like that of the "strong programme". "Scientists also should confront the sociologists and philosophers at their institutions who are attacking the foundations of science" (Bard, 1996) does not make clear whether it was intended to mean, only those particular ones among those groups that attack science; or whether the over-generalization of Gross & Levitt has been accepted – as certainly seems the case when, commenting on the recently revised national history standards, a leader of the American Physical Society concedes "they did a pretty good job .... I'm really quite astonished that they did as good a job as they did considering the attitude of historians toward science" (Robert Park, cited in Holden, 1996: 351) – not "some historians", just "historians".

Actual events lend support to scientists' perceptions. A few years ago, the American Chemical Society donated $5.3 million for the Smithsonian Institution to mount an exhibit on science in American life intended *inter alia* to stimulate interest in careers in science among girls and children of minority groups – "the largest financial donation for a single exhibit in the history of the Smithsonian" (Ross, 1994: 4–5). No sooner was the exhibit opened than prominent scientists began to express dismay: "Ring the bell of evil, and viewers will automatically blame a scientist" (Nemecek, 1995: 21–22). According to Marcel LaFollette, herself an STS insider, "it

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is ... remarkable then that the ACS itself became the target of so much internal hostility from museum staff. Several historians ... made no secret of their disdain for 'Big Science' and of everything they believed it represented ... they wound up creating a largely negative [exhibit]" (La Follette, 1995: 235–241). LaFollette reports seeing the majority of ACS scientists change from respect for the Smithsonian to disillusion after years of "contentious debate"; "an ACS advisor struggled to maintain his composure while a Smithsonian historian harangued him about the horrors of agricultural chemicals. The curator, determined to press a political argument, seemed smugly unconcerned about the effect of his rudeness." After more than a year of negotiating for changes, the ACS "told the museum that further negotiations would be fruitless" (Chemical & Engineering News, 1995: 40).

The scientific community will not acquire respect for STS when humanists and social scientists demonstrate such intransigence and inability to communicate with leading organizations of science; nor when an assistant professor of sociology at one of the major centers of STS finds space in the *Chronicle of Higher Education* (Kleinman 1995: B1–2) to bleat that "Today's scientists are finding it difficult to deal with the fact that they no longer automatically inherit the near-godlike status that many American scientists were accorded in the years following World War II". It is not easy for one who through actually doing science has learned to base opinion on evidence, to excuse such a sweeping dogmatic over-generalization redolent with jealousy and self-interest; nor the assertion that scientists' response to the recent attacks is "undoubtedly [sic] ... an effort to protect the unique status that science and scientists have enjoyed"; nor the suggestion that not "only certified scientists should have any role ... in making decisions concerning science – including the research methods employed". Ignorance as well as antagonism is displayed when "such high-profile disasters as those at Love Canal and Three Mile Island" are associated with an imagined "right of scientists to work without public scrutiny".

It is a matter of record that leading proponents of constructivism are judged by the scientific community to be ignorant and antagonistic when they claim, for example, that "experiments are rarely decisive in settling scientific controversies" (Collins & Pinch, 1993). In actual fact, of course, experiment or observation – at any rate empirical evidence – is the only way in which scientific disagreements ever do get finally resolved. The shibboleth of "experimenter's regress" stems from studies of controversies made *before they have been finally settled*, for instance as to the detection of gravity waves (Segerstråle, 1994). Permanently settled matters in science – say, the sequence and grouping of elements in the Periodic Table – continue to be agreed to be settled only insofar and for as long as they have adequate empirical justification.

Though the backlash against academic anti-science is associated with Gross & Levitt, they only brought to public attention what had been brewing for some time. In 1988, Lewis Wolpert commented about Woolgar's *Science: The Very Idea* that it "seems a pity that such intelligence has been used to attack science rather than provide badly needed insights into science and its relation to society" (Wolpert, 1988), with an accompanying photo of Woolgar labelled "HOSTILE: The author, Woolgar". An accompanying review of Latour's *The Pasteurization of France* described it as "Starting out as history of science, it gradually becomes science fiction.... this book is great fun to read, once one decides that it has nothing to do with science" (Brock, 1988).

Anti-scientific sentiment in perspective

Societal antagonism toward science waxes and wanes. Though both tendencies are always present, historians have discerned cycles of dominant rationalism and dominant anti-rationalism (or Romanticism) over a

millennium or more of Western civilization. Stephen Brush has explicitly traced cycles of Romanticism and realism since the Scientific Revolution (Brush, 1978). Julius Greenstone finds cycles of rationalism and mysticism in the history of Messianic notions in Judaism (Greenstone, 1972).

The Scientific Revolution in 17th-century Western Europe is often taken as harbinger of the 18th-century Enlightenment in which rationality in all matters became a guiding principle; used, abused, or misused in the service of social revolution, for example, in France. The intellectual "excess of abstraction that marked the end of the Age of Reason" stimulated the reaction of early-19th-century Romanticism with its emphasis on "concreteness and the love of common facts" (Barzun, 1994). The middle and late 19th century then saw a resurgence of "realism" in response to an excess of Romanticism. At the end of the 19th century another predominantly negative response to realism came in *neo-romanticism*; to be followed in turn by a period of *neo-realism* (Brush, 1978).

Periods of rapid scientific advance or dominant rationalism seem often to arouse Romantic notions of an anti- or pseudo-scientific sort (Bauer, 1986–7). Jonathan Swift illustrates (Swift 1726) the intellectual reaction to overweening scientism in the 18th century. Nineteenth-century discoveries in electromagnetism were accompanied by a plethora of electric health-cures and quackery. The realism of natural selection and the tracing of human origins to the animal kingdom came simultaneously with Spiritualism and the enthusiastic investigation of psychic phenomena. The end of the 19th century and the beginning of the 20th saw not only the genuine discoveries of radioactivity and X-rays but also the illusory ones of N-rays and mitogenetic radiation. World War II was followed not only by an avalanche of new science and new technology but also by the advent of flying saucers and renewed interest in cryptozoology and parapsychology. The present, most modern scientific age also harbors New-Age beliefs that counter the cold, hard facts of established science with intuitive, mystical, pantheist concepts; and it also harbors intellectual reaction against scientism, exemplified say by Paul Feyerabend, in which the determination to resist scientism becomes reckless, over-generalizing denigration of anything and everything to do with science.

Early in this post-war period, C. P. Snow pointed to the intellectual chasm that had opened between the scientific and the non-scientific intellectual realms. He was prescient in warning that "incomprehension of science ... gives an unscientific flavour to the whole 'traditional' culture ... that ... is often, much more than we admit, on the point of turning anti-scientific" (Snow, 1964: 17).

That cycles of pro- and anti-science are endemic in society, that antagonism persists even when adulation is dominant, makes it neither necessary nor proper, however, that academic students of science vent animus against it. Indeed, scientists and the wider public believe that academic study should be *dispassionate, disinterested, apolitical.* It does not sit well when activists claim academic freedom to push quite blatantly their political agenda, as the feminist and relativist science-criticizers commonly do.

Incomprehension of science

The "strong programme" and its ilk are fundamentally and irretrievably wrong-headed, if the purpose is to understand science (by contrast to examining the psychology of scientists). The primary "principle" is wrongheaded, that scientific activity should be investigated "neutrally", without prior judgment about the correctness or incorrectness of the science being studied. As happens so often, something that sounds reasonable in the abstract becomes ridiculous when applied to any real case. So far as *science* is concerned, that is substantive knowledge about Nature, it matters crucially whether data or theories fit or don't fit, are operationally right or wrong. A nice illustration of the absurdity that ensues

when "right or wrong" is said not to matter in the assessment of purportedly scientific controversy can be found in the Velikovsky Affair (Bauer, 1984a). The replay of that 1950s controversy in the early 1960s and again in the early 1970s was fueled by social scientists who harped on how badly the individual, Velikovsky, had been treated, asserting that fairness and openness to new ideas was owed in science to anyone, irrespective whether the ideas turned out ultimately to be right or wrong – under which argument scientists would be endlessly doomed to examine the propositions of flat-earthers, 6000-year creationists, and the like just so long as the proponents are articulate and intelligent albeit ignorant (Bauer, 1984b).

A popular exemplar for those who would have science reformed if not entirely re-invented is Barbara McClintock who, according to Evelyn Fox Keller, insists that "one must have the time to look, the patience to 'hear what the material has to say to you,' the openness to 'let it come to you.' Above all, one must have 'a feeling for the organism'" (Fox Keller, 1983: 198). So too, I suggest, must STS have a feeling for the organism that is science if it is to understand science well enough to interpret it to others. In the following paraphrase from Keller (who in places quotes McClintock), I have merely substituted "science", "bit of science", or something similar for "plant" or the like, showing substitutions by underlined italics:

> One must understand how it grows, understand its parts ... science isn't just a piece of plastic, it's something that is constantly being affected by the environment, constantly showing attributes or disabilities in its growth. You have to be aware of all of that .... You need to know science well enough so that if anything changes, ... you [can] look at it and right away you know what this damage you see is from ....
> 'No two bits of science are exactly alike. They're all different, and as a consequence, you have to know that difference,'....
> This intimate knowledge, made possible by years of close association with science ... is a prerequisite for ... perspicacity....
> Good STS cannot proceed without a deep emotional investment on the part of the STSer. It is that emotional investment that provides the motivating force for the endless hours of intense, often grueling, labor....
> ... reason – at least in the conventional sense of the word – is not by itself adequate to describe the vast complexity – even mystery – of science. Scientific activity has a life and order of its own that STSers can only partially fathom. No models we invent can begin to do full justice to the prodigious capacity of science to devise means for guaranteeing its own continuing success. On the contrary, 'anything you can think of you will find.' In comparison with the ingenuity of science, our STS intelligence seems pallid.
> ... It is the overall organization, or orchestration, that enables scientific investigation to meet its needs, whatever they might be, in ways that never cease to surprise us....
> Our surprise is a measure of our tendency to underestimate the flexibility of scientific work.

Scientists and the public expect meta-scientists to have, if not deep knowledge then at least a genuine feeling for the organism that is scientific activity, in its complexity and diversity and nuanced distinctions. To that end, STS should pay some heed to what the more reflective scientists have to say about scientific activity.

A common and pernicious way for STS to exhibit and foster incomprehension of science is to focus on one aspect of it to the exclusion of all else: describing science as "business in disguise", say, or "deconstructing" a celebration of X-ray crystallography as a "succession rite"[1]. That is no more valid than the old-fashioned scientistic showing how scientists seek disinterestedly to serve humankind: both

capture only part of the picture; and the motives of those who look only at the unflattering side of science are at least as suspect as are those of the ones who only flatter.

That sort of one-dimensional, externalist commentary requires no technical knowledge of science itself; which raises the question, how much or how little does an interpreter need to know to be able to speak validly and significantly? Maybe STS should follow the example of history of science: define itself as a field of graduate study open only to people who already have degrees in science? But much more immersion in science than that is needed before one has an authentic feel for it. Undergraduate courses in science typically focus, necessarily, on the reliable stock of textbook science rather than on the uncertainties encountered in *frontier* science (Bauer, 1986; Bauer, 1992). Practicing scientists encounter the realities of knowledge-seeking only when they do research themselves, and only then do they get the personal experience that may lead to a balanced understanding of the shadings of reliability and unreliability that characterize, to very different extents, different bits of '"scientific knowledge". Ideally, then, those practicing STS would themselves have had significant experience of doing scientific research. Failing that, however, they should at least pay considerable heed to those few outstanding scientists who thereafter devoted years of effort to becoming competent also in STS. Perhaps the most telling criticism that could be made of the anti-scientistic extremists in STS is that they ignore the veritable, authoritative insights about science that permeate the work of Michael Polanyi and John Ziman.

Might one not adopt as a criterion of validity in "science studies" that the result not seem absurdly wrongheaded to thoughtful, philosophically minded practicing scientists? A not inconsiderable quantity of spoken and published STS would not pass muster under that criterion. Many examples of such wrongheaded absurdities are cited by Gross & Levitt (Gross & Levitt, 1994). Among those that have astonished me personally: Steven Shapin saying that scientists don't value their technicians, and Andrew Pickering seeing no compelling reason to exclude the possibility of the future discovery of a chemical element between hydrogen and helium[2]. Anthropologists should have learned from the Mead Affair that the natives ought to be explicitly consulted before accepting conclusions arrived at by anthropologists (Freeman, 1983). STS includes the anthropology of science and suffers the same hazard, that outsiders can be wildly, absurdly wrong in their conclusions.

Hypocrisy: preaching vs. practice

When push comes to shove, though, much of the antagonism toward science in STS seems to lack the courage of its convictions, or rather the conviction of its assertions. The slipperiness is illustrated by a recent sidebar quote in *Science*:

> In the numerous conversations I have had with scientists about social constructivism, gravity is invariably brought forward as the great counterexample showing that science is not culturally constructed. A rock falls to earth regardless of the dominant language or ruling class. *Yet even the pervasiveness of this example indicates that it is culturally encoded ... marked by a certain cultural position because it presupposes that mathematics and physics are the core sciences rather than, say, biology and ecology.* (Science 269 (11 August 1995): 860; emphasis added)

But the argument over "culturally constructed", so far as scientists are concerned, is purely whether or not the behavior of bodies is accurately described under the theory of gravity. That's all. No more than that. But also certainly not less. That a scientists' choices of example in arguments with non-scientists are culturally influenced is an entirely other matter,

irrelevant to the central issue. What the "core sciences" might be seen to be is also an entirely other matter – not quite incidentally, one that is of little or no interest to working scientists, most of whom are preoccupied with their technical tasks and could not care less what somebody or other thinks is the hierarchy of the sciences.

The relativists must indulge in such tricky footwork because otherwise they admit that they have nothing useful to say. If science's pronouncements are mere expressions of ideology or self-interest, then those of the relativists are too. Gross & Levitt have described quite authentically the desire of constructivists and relativists to evade the consequences of their stated beliefs: "[C]onstructivism ... is ... relentlessly mechanistic and reductionist .... all are puppets of the temper of an age .... Only the cultural constructivists themselves (of course) are licensed to escape the intellectual tyranny of this invisible hand.... Typically, in the face of all-out challenges from scientists and philosophers ... they edge away from the strong version of the constructivist claim ... [but with] a different audience, one primed to hear science contextualized, relativized, and revealed as the deformed offspring of capitalist hegemony, the constructivist claws come out once more" (Gross & Levitt 1994: 56–57).

In two long essay-reviews, Paul Forman has given chapter and verse of the retreat from the strong-programme version of their views by prominent constructivists, relativists and feminism-theorists *who fail to acknowledge the implications of that retreat* (Forman, 1995a; Forman, 1995b). Their dilemma is plain enough, of course. To say that science is embedded in a wider society that exerts a certain influence on how it functions is sleep-inducingly uncontroversial; the most naive and scientistic scientist would agree, well aware of where research funds come from, or the persistent efforts of creationists to get into the biology classrooms and textbooks, and so on. Not much notice would ever have been taken had the Edinburghers and their fellow-travelers made that their "programme" and had studied in specific instances how societal influence played out in the elucidation of nevertheless rather reliable scientific knowledge. Historians of science, after all, have long known that external as well as internal factors need to be taken into account for any genuine, complete understanding of how science has wrought. Thomas Kuhn's scenario of "scientific revolutions" complete with "incommensurability" and the like quickly found meaningful resonance with scientists. It is only the most extreme, know-nothing epistemological relativism that the scientific community will not stomach.

The purpose of STS

How did STS come into being?

STS derives from several initiatives that have by no means come fully together.

Concern among scientists that science should purposely contribute to the common welfare was exemplified in 1930s Britain by J. D. Bernal, whose personal political convictions lent a Marxist flavor to the movement in which he was so prominent (Bernal 1954; Goldsmith, 1980; Goldsmith & Mackay, 1966). In the United States, a similar movement but without the overt Marxism led to the founding (and flourishing) after World War II of the *Bulletin of the Atomic Scientists*. The Pugwash conferences were another manifestation of scientists' concern to engage in policy discussion. Some of the presently existing "STS" programs with a strong orientation toward policy studies are direct descendants of these precursors.

Within the humanities one can discern at least two distinct sources of STS. The intellectual impetus is often and plausibly traced to Kuhn's argument for a realistic, historically based philosophical understanding of science (Kuhn, 1962). The subsequent and continuing appearance (though not always the durability!) of multi- or inter-disciplinary centers or departments

– History and Philosophy of Science, or Philosophy and Sociology of Science, and the like – attests the recognition that an adequate understanding of science in its societal context requires that philosophers of science join with historians, sociologists and others in pursuit of explanations for the success of science and of proper criteria for such success. Full-blooded attempts at inter- or multi-disciplinary scholarship and teaching led to the founding of Units or Departments or Centers of what has come to be called "Science Studies" (in Britain) or "STS" (in the United States). Professional associations too reflect these attempts at synthesis, as for example the Society for Social Studies of Science (founded in the 1970s) or the Society for History, Philosophy, and Social Studies of Biology (established in the 1980s). An attempt to survey the intellectual ramifications of policy as well as of academic studies was made by Spiegel-Rösing and de Solla Price in 1977 (Spiegel-Rösing & de Solla Price, 1977).

Contemporaneous with that intellectual initiative was the student-led activism of the 1960s, part of which turned to criticism of science as a culprit (or even the culprit) in certain unsatisfactory aspects of technological society. Innumerable undergraduate courses, sometimes more or less organized into programs, dealt with issues of "science and society": environmental pollution, problems of nuclear energy, and so on[3]. Some of the less policy-oriented STS programs derive from these ancestors.

STS exists, then, for several reasons that are not necessarily compatible: most philosophers and historians and some sociologists, scientists, and others want it to be a predominantly intellectual venture aimed at the most complete possible understanding of the ramifications and implications of science. Some scientists, political scientists, and others are primarily concerned that public policy take adequate account of the insights and capabilities that science and technology in principle afford. Some of the loudest sociologists and revisionist radicals – feminist-theorists, Afrocentrists, neo-Marxists and paleo-Marxists, animal-supremacists – want science to become something other than it is. That last group believes that indoctrination into their viewpoint is a legitimate aspect of teaching; and that, together with other substantive differences, is a source of continuing tension among the disparate entities that gather under the umbrella of "STS".

What should be the purpose of STS?

It is not obvious that STS should serve only the immediate purposes of those who brought it into being. The scientists who moved into policy-discussing did so in the belief that the wider society, indeed humanity as a whole, stands to benefit thereby. The academics who sensed the need for multi-disciplinary work also believe that their endeavors to understand are necessary for the common public good. There is in fact consensus that STS should serve the purposes of the wider public; but as usual, there is dispute over what best serves the public interest.

STS practitioners like other human beings suffer the inevitable conflict of interest that the work they do provides their livelihood. It is always tempting to make one's work as congenial as possible, even as easy as possible. Endemic in academe is a tendency to indulge in excessive navel-gazing and esoteric word-play, both much easier than the pursuit of substantive knowledge. In STS, one of those navel-gazing approaches is to examine always the same aspect of science and merely amass more and more examples: of rhetorical practice, say; or of "science as business"; or of scientists as self-serving or as servants of the capitalist class; and so on. (Within science itself, such repetitive churning out of always the same sort of stuff by means of the same approach or method is pejoratively dismissed as "turning the crank(-handle)".) Those exercises do not further our understanding of actual science in the actual world, in all the complexities and nuances that are of interest to the wider

public including the media and the legislators and regulators.

Practicing scientists and technologists are neither last nor least among the potential audience for STS. I am not alone in having turned to science studies because my work within science led me to curiosity about meta-scientific matters. Why have I found STS frustrating?

For one thing because, in John Ziman's words, "Unfortunately, the 'metascientists' – the historians, philosophers, sociologists, psychologists, economists and political scientists who describe and analyze science and technology from a variety of different points of view – have not yet come up with a coherent account of just how the research process actually works" (Ziman, 1994).

When I was studying chemistry in college, in the late 1940s and early 1950s, I was already interested in "the big picture" or the *whole* picture; but there weren't any history or philosophy of science courses available to me; and what I tried to read of philosophy of science turned me off. In the late '60s and early '70s my curiosity became pressing as I started to wonder why some very interesting topics were apparently ignored by science or treated as beyond the pale. So I came to read about attempts to demarcate science and pseudo-science, and that led to some history of science; and then I was lucky enough to become involved in Virginia Tech's Center for the Study of Science in Society and to learn from direct contact with such people as Joe Pitt, Larry Laudan, Rachel Laudan, David Lux, Arthur Donovan, Karin Knorr, and many, many others. I thought I had come into the right company, of very knowledgeable and insightful people who shared my interest in really understanding everything about how science works: how it has managed to bring us such wide-ranging, reliable, and deep understanding of Nature; how fallible and argumentative human beings could become such over-achievers. I lapped up Thomas Kuhn and Robert Merton and John Ziman and a great deal more.

I joined 4S and attended some of its meetings, and felt rather at home. I'm rather sure that practicing scientists and engineers were explicitly invited to join the Society in those early years. By the late 1970s, 16% of the membership described itself as physical or biological sciences or engineering and another 8% as administrative or general education (Nelkin, 1977).

But after a time, starting maybe a decade ago, I began to feel increasingly dissatisfied. There seemed to be a lack of coherence and progress in "science studies". It was not at all like chemistry, where interesting points are seized upon and built upon and expanded and modified; and where the literature is so well organized and indexed that there is no excuse for ignoring important discoveries or for writing or saying something that has already been shown to be nonsense. One of the most fascinating papers I'd come across was Bernard Barber's dense little "Resistance by Scientists to Scientific Discovery", published in Science in 1961. For years I looked for work that expanded those seminal insights, but without success. In the *Social Sciences Citation Index* as well as the *Science Citation Index* I periodically look for work building upon it and continue to be disappointed[4]. I've had similar disappointment over Gunther Stent's notion of "premature discovery" which seems to have left barely a ripple. I recall what one of our sociologists said early in the life of our Center: that they were interested in science as a source of illustrative examples of social phenomena. But that is the very opposite of what I came to science studies for, namely for insights about what's special about science, what's different about science.

That's one of the circumstances, I believe, that easily turns scientists off STS. Most explicitly the "strong programmers" but to some extent all constructivists and relativists seem intent on showing how every aspect of scientific activity is significantly the same as what humans always do. So particulars and specifics are used to lead to always the same over-generalizations – moreover the same ideological generalizations that the

"analyst" brings to the case a priori. And it is true enough, of course, that all human beings are subject to emotions and self-interest, and part of what they do can be explained that way; but only part. What is uniquely interesting about science is how reliable knowledge has nevertheless been attained – so reliable that human beings of every stripe agree over it. So I appreciate the sociology of Merton and Zuckerman and Derek Price and Jonathan Cole and others who dig into the details of how science works in order to bring forth unexpected, new points of information or understanding. "[T]he whole aim of Mertonian analysis was (and is) to understand that which is socially and cognitively distinct about science compared with other forms of knowledge, such as religious beliefs or art, and which has given science such preeminence in modern society. This ... is the question on which we build a sociology of science, but it is one which the relativists deny any warrant to, since they seek to deconstruct science's very claim to special authority and preeminence over other (non-scientific) forms of knowledge" (Webster, 1991: 30, citing Gieryn, 1982). Scientists want answers, and novelty, stimulant to more and new studies. Harping always on human frailties of scientists not only misses the important points, and the big picture, it also amounts to denigration of science.

My intellectual dissatisfaction with STS has been joined by the perception that scientists and engineers are not – or no longer – welcome. I hear it said that prominent people in science studies have asked, "What do we need scientists for?" That seems to be the implicit message when the Society for Social Studies of Science announces on the Internet that "4S includes (1) scholars in sociology, anthropology, history, philosophy, political science, economics, and psychology; (2) areas of study that fall outside of the traditional academic disciplines such as feminist studies and those addressing science and technology for the public; (3) studies of knowledge, policy, government, R&D, the uses of expertise, technological controversies, technology transfer, rhetorical and literary analyses, and studies of specific technologies". Grist for Gross & Levitt rather than a welcome to practitioners of science and technology.

As well as serving the wider public, STS surely has a responsibility to its own students. Particularly when graduate degrees are offered, some attention ought to be given to potential employment. It seems quite unlikely that many academic positions will open up in the foreseeable future. STS graduates might plausibly look for positions mediating between the technical and the non-technical, policy-making communities – in research management, in assisting with environmental-impact considerations, in advising individual legislators and legislative groups, in science journalism. To mediate successfully calls for empathy, a feeling for the organisms involved. Disrespect for any of the communities concerned is dysfunctional. STS graduates who instinctively denigrate science and technology are unlikely to find – or to keep for any length of time – employment funded by science and technology, which represents the bulk of what is likely to be available.

Disciplinary dilemmas

My frustration with STS may stem in part from the *cultural* sorts of differences made notorious by C. P. Snow. My scientific background makes me want progress in knowledge and understanding – but philosophers do not experience such progress in their own field and consequently do not look for it in philosophy of science or in STS. My chemical background makes me lust for generalizations and interpretations that pull all the data together – but historians are trained to distrust and resist any such lust and will resist it in STS as in history *per se*. My disciplinary background makes me seek *decisive* ways to choose among possible viewpoints – but social and behavioral scientists inhabit "multi-paradigmatic" fields in which the same data

are disparately interpreted in the light of contrary pre-existing theoretical stances, and they see neither need nor possibility for STS to acquire a single overarching paradigm. So what *I* look for in STS is not what many or most non-scientist STS practitioners look for.

These disciplinary distinctions explain, too, how some relativists can hold views that seem to scientists inane. Practitioners of the social sciences have not learned, in their own disciplines, much that is operationally indisputable, readily reproducible, and internationally agreed to; so they cannot easily conceive such a thing to be possible in *any* field. Knowing in their own discipline that ideology governs "knowledge" as well as theory, they presume that must be so in all fields.

That the subject matter of society is so much more complex than that of inert Nature is often said to be the reason why the social sciences are less rigorous (up to now at least) than the natural sciences. But this view is another instance of non-scientists lacking an understanding of science. The natural sciences deal successfully with immensely complicated systems incorporating numerous *simultaneously causal relationships.* In consequence, scientists see no reason of principle why STS should not be able to explain *everything* about science, and they are disappointed when STSers do not even dream of such a thing.

The disciplinary dilemma may be resolvable through recalling that STS should serve the wider public interest; and by recognizing that it is unlikely to thrive if it fails to do so. The wider public really does not care at all about disciplinary approaches or goals. It simply wants *usable* output from us. The communities of scientists and technologists, too, want useful explanations if not advice. What might seem useful to the various outside publics of STS? Surely, that questions of the following sort be addressed in terms understandable by non-specialists[5]:

1. Does it benefit the average person that the nation supports a thriving scientific community? If so, how? If not, why not, since it is so commonly presumed?
   - How much of the national budget should then be spent on basic science?
   - How much on applied science?
   - *Which* sciences should get how much each? Do the social sciences count as sciences for this purpose? Which particular *projects* should get funded?
   - By what mechanism, involving which people, under what criteria, are those decisions best made?
2. Is more scientific research (in other words more money and resources devoted to it) always a good thing?
   - If not, why not? How can you tell when it is and when it is not?
   - Can we speed up research in especially urgent cases, say to find cures for cancer or AIDS? How?
3. The same questions, but from a more local viewpoint, for example a State within the U.S., say the Commonwealth of Virginia:
   - What does it benefit the average person to have a thriving scientific community in Virginia?
   - How much of the Commonwealth's budget should be spent on basic science? On applied science? *Which* science? Which particular projects? By what mechanism, involving which people, under what criteria, are those decisions best made?
   - Is more scientific research in the Commonwealth necessarily a good thing? If not, why not? And when is it and when is it not? Can we speed up research on topics of particular relevance?
   - What are we getting out of present investments in Government-funded cooperative ventures between universities and industry? Out of the "research parks" that universities have striven for?
4. The same questions from the viewpoint of corporate entities:
   - What does it benefit the corporation to

have research thriving (a) within the corporation; (b) in the outside scientific community in (i) the same locality (ii) the same country (iii) the world as a whole?
- How much of the corporation's budget should be spent on research in the general area of the corporation's business?
- How much in-house and how much outside?
- How much of the inside should be "targeted" research and how much unfettered support of basic research?
- How much of the outside should be "targeted" research and how much unfettered support of basic research?
- Which particular projects?
- By what mechanism, involving which people, under what criteria, are those decisions best made?

5. Why has science enjoyed such high prestige?
   - Why have other fields of knowledge not been as useful as science?
   - Could they be made so?
   - What exactly is the difference between science and other fields of knowledge?
6. Why do we hear so much nowadays about misconduct by scientists? Are they less ethical than other professional people? Are scientists less ethical than they should be? What could be done about it?
7. Chemists, biologists, astronomers, and other scientists behave very differently in many respects. What do all "scientists" have in common (if anything)? What do all the sciences have in common (if anything)?
8. How come science is such a mixture of almost totally reliable knowledge and quite fallible knowledge? Can one ever know, about any specific "scientific" claim, how reliable or unreliable *it* is? If so, how?
   - How do ideas and hunches get translated into tested facts?
   - What really happens in such "revolutionary" episodes as the replacement of Newtonian theory by Einsteinian?
   - How can competent scientists sometimes lapse into what others call pseudo-science – as with the Allison effect, cold fusion, or N-rays, for example?
9. What exactly is "pseudo-science"? Is astrology pseudo-science? Is the search for the Loch Ness Monster pseudo-science? If so, why? If not, why not (since many people, including many scientists, do label these things pseudo-science)?
   - Why is there so much fuss about alleged pseudo-science (parapsychology, ufology, alternative medicine) but not about alleged pseudo-psychology or pseudo-sociology or pseudo-philosophy?
10. What makes for greatness in science? What makes for competence in science? Can we train any or every child to become a good scientist?
    - Are the greatest scientists the best people to have as advisers to government? To corporations? To the media?
    - Why do so few great scientists have more than one major advance to their credit?
11. What were the significant factors in the "Scientific Revolution"?
    - Why did it happen in the 17th century in Western Europe? Could it have happened somewhere else or at some other time?
    - Why did science in Mesopotamia, Imperial China, Ancient Greece, *not* "take off"?

A host of questions, at least some of which are of quite pressing social concern. Now consider what disciplinary knowledge or expertise might be needed to answer those questions. Immediately it is clear that none of the recognized academic disciplines *per se* can do the job. Moreover it is clear that they need to drop their specialist jargon *and look at their work from the outside, from a broader perspective*, to do the job. But would

not such "popularization" contaminate or dilute or invalidate the exported disciplinary knowledge?

Not, I think, if each discipline is properly clear about the distinction between its *heuristic beliefs* on the one hand and, on the other hand, *actually reliable knowledge.* Cosmologists, for example, "believe" the Big-Bang theory – because that is currently best suited to further theorizing and observing and experimenting; but that is not the same as asserting that the Big Bang really happened. Prospective gene therapists must proceed on the presumption that ills are pre-determined in our chromosomes; but that does not mean they must, as people, believe that to be really the case. And so on. But each discipline surely also has some *knowledge* that it can export without apology as being *true* (or so close to true that the difference does not matter): that the earth is not flat, say; or that a child's very early experience is of overwhelming importance to its later development; or that adversity cripples some youngsters while stimulating others to independence and achievement.

Surely STS has some knowledge to offer that is like those last examples, pertaining to what is likely to make research thrive and what is likely to throttle it; or to what to do as a society when there are hints or suspicions of risks to the ozone layer and of global warming and the like – about which definite, precise knowledge will not be available in time if those suspicions turn out to have been well founded. That is the sort of thing that the wider public would find useful from STS. In providing it, moreover, we would do well to conceal it if we harbor any doubts about the validity of "naive" realism, for the society that funds our work and wants its fruits has no such doubts.

Under what circumstances is STS likely to thrive?

Science itself, and technology, have long enjoyed high public status and prestige. STS, and the social sciences generally, have not. STS can thrive in the long run only if (1) the opulence academe has enjoyed since the 1950s continues or (2) STS demonstrates its usefulness to the wider public, including the technical community. (1) is already plainly not the case. (2) will not be served by doing as the radical wing of STS seems intent on – ignoring or seeking to denigrate or destroy the popular belief that science has produced a large body of reliable knowledge about how the world works and that it properly enjoys high prestige therefore (Brush, 1995):

> ... the current fashion is to stress the social construction of scientific theories and concepts, and to deny that scientists are actually discovering the truth about the world, or that their efforts to do so have any moral or epistemological superiority to those of pseudoscientists, humanists, and theologians. The historian no longer assumes that scientific research is an admirable activity and scientific progress a benefit to society ...

Readers unfamiliar with recent publications in science studies may not believe that any reputable scholar actually holds such extreme views. If it comes to an overt confrontation between STS and science, science is bound to win. The scientific and technological communities continue to enjoy high, even unquestioned status and prestige among most of the population, who are clear what their standard of living depends on. Practitioners of science and technology are looked to not only for technical advice but also for *policy* advice regarding technical matters: thus Presidential Science Advisors are typically scientists or engineers[6], and the Nobel Peace Prize for 1995 was awarded to a physicist on behalf of the Pugwash Conferences on Science and World Affairs that he and other scientists had been principally responsible for organizing (Marshall, 1995; Selzer, 1995). Those communities also have the ear of the media, and themselves control important parts of the media. Among general magazines of science, Scientific American commands a circulation[7], in its English-language version,

of 627,000. The circulation of *Science* is about 155,000, that of *American Scientist* 103,000, of the *New Scientist* 101,000, *The Scientist* 50,000, *Nature* 31,000, *Issues in Science & Technology* 18,000, the *Bulletin of the Atomic Scientists* 13,000. By contrast, the circulation of *Science, Technology, & Human Values* is about 1900, that of *Minerva* about 800, of *Social Epistemology* less than 200 (that of *Social Studies of Science* was not reported in Ulrich's, nor had it been in the previous edition).

Yet overt confrontation seems to have begun, with the publication of *Higher Superstition* (Gross & Levitt, 1994) in 1994. Much correspondence in *Chemical & Engineering News*[8], from some of the 135,000 members of the American Chemical Society, displayed approval of Gross & Levitt's polemic and dismay that their life's work is being denigrated, for example by the Smithsonian Institution. What the Smithsonian did resulted in "cancellations to the museum's magazine (an important source of revenue), affected donations to other parts of the Smithsonian, prompted a letter-writing campaign to the Institution's new secretary, prompted that same secretary to delay work on several other potentially controversial projects, and threatened to affect the spring 1995 round of congressional hearings on the Smithsonian budget" (La Follette, 1995). The American Physical Society joined the Chemical Society in protesting (Holden, 1994a). Earlier, there had been a storm over the proposed national standards for science education when a late draft "conveyed 'the really bizarre postmodern notion that somehow science is just a matter of social convention, rather than analysis of data'" (Culotta, 1994; Holden, 1994b).

One session of the General Meeting of the National Association of Scholars in November 1994 was devoted to the question of antagonism against science. The New York Academy of Sciences held a conference in June 1995 devoted entirely to that. A discussion of that meeting in *Chemical & Engineering News* (Baum, 1995) concluded that "The deconstructionists and radical feminists and their collaborators on college campuses will fade away because their message is, at heart, ridiculous". Much more will be heard about "ridiculous" following the physicist Alan Sokal's "Experiment with cultural studies" (Sokal, 1996a): Sokal published in *Social Text* a deliberate spoof of post-modernist discourse (Sokal, 1996b) that the editors were unable to distinguish from the sort of article they publish; even though "about a half-dozen editors at the journal dealt with Professor Sokal's unsolicited manuscript" (Scott, 1996). Sokal "structured the article around the silliest quotes about mathematics and physics from the most prominent academics, and ... invented an argument praising them and linking them together .... All this was very easy to carry off because my argument wasn't obliged to respect any standards of evidence or logic" (Sokal, cited in Scott, 1996). To demonstrate the validity of the symmetry principle, a practitioner of STS must now show that it is possible to have published a like spoof in the scientific literature. But the collapse of the Soviet Union did not convince academic Marxists of the error of their thinking, it only convinced the rest of the world; so too Sokal's experiment will convince everyone except the editors of *Social Text* that the post-modernists and strong-programmers do not know what they are talking about.

The scientific backlash will not soon fade away. An editorial in *Chemical & Engineering News*, "The Antiscience Cancer", acknowledges that scientists "should clean our own house and speak out when scientists overplay their findings or promise more than they can deliver.... However, if the mainstream scientific organizations, like ACS, the American Association for the Advancement of Science, the National Academy of Sciences, the Council on Chemical Research, and the International Union of Pure & Applied Chemistry just sit back and watch, the future of science, at least in the U.S., is bleak". "Presumably, tenure decisions and promotions at

universities are based on scholarship, and academic scientists must take an interest in the academic decisions in other departments on campus. This is not a question of academic freedom, but rather one of competency. We should expose political correctness and fundamentalism that lead to misinformation about science" (Bard, 1996). That scarcely veiled threat to contest the academic position of those who attack science is worth noting most particularly because it comes not from some intemperate radical but from Allen Bard, editor of the leading ACS journal, one-time president of the ACS, who is known throughout the international community of chemists and scientists – as well as to this author personally – as a singularly judicious, level-headed person who has excelled in managerial matters calling for diplomacy as well as in technical tasks.

Scientists have come close to desperation as the ratio of research funds to researcher has steadily declined, and they are likely to vent their anxiety on any such obvious targets as those documented by Gross & Levitt (Gross & Levitt, 1994) and flushed into the open by Sokal. That the backlash did not come earlier may well have been due in part to the ignorance of most of the scientific community about the diatribes cited in *Higher Superstition.* Then too, scientists habitually defer to fellow specialists in other scientific fields and were therefore wont to defer also to philosophers, historians, sociologists and others, presuming that they knew what they were doing in their specialized areas, even if that included venturing insights into scientific activity. But such deference wilts in the face of statements about science that scientists know to be absurdly wrong as well as insulting. I find it striking that John Ziman, who has long been so deliberately respectful toward social science, allowed himself in print the sign of impatience cited at the outset of this essay. Gerald Holton, again hardly an enemy of STS, has warned of the consequences when anti-science is incorporated into political movements (Holton, 1993).

Organizational self-preservation of STS requires that it make its peace with science *on terms congenial to science and its publics.* STS must demonstrate that it has redeeming social value. I think, too, that the *intellectual* self-preservation of STS requires the same: it has been said often enough by now that strong-programme skepticism or relativism or sophism is oxymoronic as well as entirely self-indulgent. On its own terms it allows no reason why the strong programmer should be listened to by anyone.

NOTES

[1] Papers by Thomas F. Gieryn & Elizabeth Hunt and by P. G. Abir-Am at the 1987 meeting of the Society for Social Studies of Science, abstracted in Science & Technology Studies, 5 (1987) 74–76.

[2] In seminars at VPI&SU. In discussion, Shapin was unwilling even to restrict his assertion to the historical figures of several centuries ago whom he had actually studied. Pickering was also unwilling to concede that Nature constrains our science: "I hate that word 'constraints'", he responded to my direct question.

[3] More than 150 programs and more than 2300 courses in "Science, Technology & Society" were listed in (Heitowit, 1977). Nearly 200 colleges and universities reported some teaching on ethical implications of science and technology (Heitowit & Epstein, 1976).

[4] Ron Westrum rightly pointed out to me in this connection that failure to cite important work may signify that the work has become so generally well known that citation is considered unnecessary. And it is true that some of Westrum's intriguing studies build on the theme of resistance to discovery (Westrum, 1982 and references therein). Yet Barber's paper makes some every specific suggestions as to possible reasons for resistance and circumstances in which it is likely to be found, and there seem not to have been attempts to explicitly test them.

[5] Modified from Henry H. Bauer, "What should science studies be? Some questions, some answers, some provocations", Seminar at the Center for the Study of Science in Society, VPI&SU, 1 September 1994.

[6] Or someone who has become an "honorary" technical person through having been President of MIT.

[7] Circulation figures are from Ulrich's International Periodicals Directory, 1994–1995, 33rd ed., New Providence (NJ): R. R. Bowker.

[8] For example, Chemical & Engineering News, 13 June 1994, 4; 17 April 1995, 5; 6 March 1995, 4–5; 8 May 1995, 4 & 63; 5 June 1995, 4–5.

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