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Scientific Literary: Issues and Perspectives

Why Should we Promote the Public Understanding of Science?

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Introduction

The public understanding of science is widely regarded as A Good Thing. Given that it is difficult to argue against the greater comprehension of almost anything by almost anybody, this is not particularly surprising. For the most part, however, such support as exists for the promotion of public understanding of science is largely tacit; certainly, it often escapes close examination. Yet such examination is the more necessary at a time when greater public awareness of matters scientific is being actively encouraged by Government agencies, leading representatives of the scientific community, and many others. What, exactly, do we mean by the public understanding of science; and why, exactly, should we be concerned to promote it?

This paper is offered as a contribution to the current debate on these and related questions. The first half of the paper rehearses a number of different arguments that are commonly deployed in favour of promoting the public understanding of science. On the basis of this review, the second half of the paper examines critically a number of assumptions that are embodied in some of these arguments. This examination paves the way for a discussion of the notion of scientific literacy, which provides at least some preliminary criteria according to which the nature and extent of public understanding of science may be assessed.

Before turning to these topics, we must say something about the phrase "public understanding ofscience" itself. In many ways, it is regrettable that this phrase has come to stand for a concern with wider perceptions of science in society. For one thing, public understanding of science may be taken to imply what is almost certainly false, namely that there exists in society a single and/or a stable outlook on matters scientific; and for another, it is at least triply ambiguous. As will become obvious in our review of arguments in favour of promoting public understanding of science, different authors mean different things by the terms public, understanding, and science. For this reason, at least, it may be helpful at the outset to say what *we* intend by these terms.

By *public* may be meant anyone and everyone from legislators and civil servants, at one end of the spectrum, to private individuals at the other. For present purposes, we shall take the public to be the people as a whole other than those acting in their professional capacity as expert representatives of the scientific community. (An alternative term for the public thus defined is "lay people"). *Understanding* is an even trickier notion than public. In popular parlance, on the one hand, it is commonly used to mean anything and everything from knowledge to sympathy; and in dictionaries, on the other hand, it is generally defined as: to grasp mentally; to perceive the nature or significance of; or to know how to deal with. In each case, conventional usage is rather too extensive for present purposes. Later on, we shall offer a somewhat more restricted interpretation of the notion of understanding with reference to the concept of scientific literacy.

Finally, there is the term *science* itself. While the root meaning of science is knowledge, this is clearly too broad a definition to be of much use. For our purposes, scientific knowledge is knowledge that is produced by and in some sense bears the seal of approval of the scientific community. (The scientific community, in turn, is simply that group of people who are recognized as the professional knowledge-producers in our culture.) This sociological definition has the great advantage that it presupposes nothing about the nature or the significance of science,. other than that it is an authoritative or officially recognized form of knowledge. We are concerned here with scientific knowledge of all kinds, embracing not only what are generally termed the natural sciences but also the scientific aspects of medicine and technology.

Nine Arguments for Promoting the Public Understanding of Science

The literature on our subject is extensive and diverse. Calls for the promotion of the public understanding of science have come from many and varied quarters and have been motivated by many and varied concerns. We shall rehearse briefly no fewer than nine different arguments, distinguished according to the nature of the benefits which they see as stemming from greater public understanding of science. The alleged benefits are to: science itself; national prosperity; national power and influence; individuals; democratic government; society as a whole; intellectual life; aesthetic appreciation; and morality. This classification has its weaknesses: it represents a complex picture somewhat simplistically; it may be taken as exhaustive, when almost certainly it is not; and it may conceal the overlap which can and does exist between different arguments. Despite these weaknesses, the classification is offered both as a convenient guide to a complex literature and as a basis for discussion.

1. Benefits to Science

It is quite common for advocates of greater public understanding of science to suggest that such understanding benefits science itself. Quite apart from the need to attract new recruits into the scientific community, it is often argued that public support for science depends upon at least a minimal level of public awareness of the processes and products of scientific research. The prolific science writer Isaac Asimov, for example, has claimed that "Without an informed public, scientists will not only be no longer supported financially, they will be actively persecuted". The difference between understanding and non-understanding, Asimov suggests, is "the difference between respect and admiration on the one side, and hate and fear on the other".[1]

Whether or not they share Asimov's somewhat dramatic view of the matter, many practising scientists are inclined to respond to perceived threats to the well-being of their disciplines by trying to promote greater public understanding of them. In the early 1970s, Paul Couderc saw the roots of public opposition to science in "widespread lack of knowledge on the part of the general populace of the concepts of science, its objectives, its capabilities, its promise", and he went on to advocate knowledge itself as an "antidote for anti-science".[2] Similarly, in the early 1980s American biologists responded to the growth of religiously-motivated opposition to evolution by entering the public arena to expound their views on origins.[3] Here, once again, the assumption appears to have been that public understanding would bring public consent to the findings of science.

There is another way in which science itself may benefit from the promotion of greater public understanding. Given the kind of hyperbole that from time to time attaches to particular scientific and technological developments it would not be surprising if sections of the public were to acquire unrealistic and unrealizable expectations of science. Wherever this occurs, it is arguable that there is a risk of loss of confidence, cynicism, and eventual withdrawal of support. (Could it be, perhaps, that there is something of this in contemporary public disenchantment with civil nuclear technologies?) In a recent work, the sociologist of science Harry Collins has defended his own discipline's concern to analyse science as a form of human, and therefore fallible, expertise in precisely this way. Professional scientists, he notes, are the experts to whom we must turn when we want to know about the natural world. However, they can offer only "the best advice that there is to be had". To ask for more than this, Collins suggests, is to risk "widespread disillusion with science with all its devastating consequences".[4]

2. Benefits to National Economies

It is not difficult to see a connection between public understanding of science and the economic wealth of nations. Let us suppose that national wealth is determined in part by success in competition for the sale of goods and services in international markets, and that success in such markets is based in part upon the possession of vigorous research and development programmes for the generation of new goods and services. Vigorous research and development programmes depend in part upon a steady supply of scientifically and technically trained personnel; and it seems clear that only nations whose peoples possess a generally high level of scientific and technical understanding will be able to sustain this supply, and hence maintain their ground in the international competition for economic wealth.

This argument was given due prominence in a report of the Royal Society on *The Public Understanding of Science* in *1985:*

> Improvements in existing technologies demand some degree of scientific and/or technical understanding from all concerned—the designer, the operative, the manager and the decision-maker. The new technologies, such as those involved in electronics, synthetic materials, telecommunications or biotechnology, have developed from the underlying science. Their successful exploitation requires those responsible for the nation's industries, as well as a supportive government, to be aware of science and technology, to recognize their potential value and to accept the opportunities they can generate.'

This is certainly not the only kind of economic argument in favour of promoting public understanding of science. For example, it can be argued that a certain familiarity with science and technology is necessary in order to sustain consumer demand for science- and technology-based products. In recent years, however, it appears that the argument based on national competitiveness has had particularly wide currency, at least in the English-speaking world.

3. Benefits to National Power and Influence

Over and above any purely economic benefits, greater public understanding of science has been claimed to bring wider political benefits in its wake. For example, such benefits were widely touted in the debates on scientific education which took place in the United States in the post-Sputnik years. Phillipe Le Corbeiller, Professor of Applied Physics and General Education at Harvard, suggested that the problem facing the United States was "to bring the American public to know what science is". For one thing, the country needed many more scientists and engineers, not only to sustain its expanding civil and military industries, but also to help spread American influence to the rest of the world. "Our adversary", he wrote, "has taken full advantage of the progress of science, not only on the interior front but also in his external propaganda, where he presents himself to the world as the champion ofscience, the bourgeois countries as sunk in obscurantism."[6] Le Corbeiller's message was clear: scientific education for young people and adults alike was a national necessity if the United States was to maintain its position of intellectual and ideological leadership in the world. Of course, similar reasoning has been employed outside the sphere of "Cold War" politics; but the sharpness of that particular conflict has generated perhaps the clearest examples of this particular argument in the literature.

4. Benefits to Individuals

It has often been suggested that improved understanding of science and technology is useful to anyone living in a scientifically and technologically sophisticated society. The claim here is that more knowledgeable citizens are able to negotiate their way more effectively through the social world: that they are better-equipped to take decisions about diet, health-care, and personal safety; and that they are better-placed to make a wide range of consumer choices in the face of conflicting (and often spuriously "scientific") promotional claims on behalf of products. The Royal Society Report outlined part of this particular argument as follows:

> Ignorance of elementary science cuts off the individual from understanding many of the tools and services used every day. Same basic understanding of how they function should make the world a more interesting and less threatening place. It is obviously not necessary, and hardly possible, for an individual to understand the functioning of everything from a bus to a ball point pen or a television set, But those who have never been stimulated to enquire about how things work and who lack the basic knowledge to pursue such an enquiry are surely at a disadvantage in the modern world.

Another crucial area of benefits to individual citizens relates to employment. Clearly, individuals who lack basic information about and understanding of science and technology may be either cut off from job opportunities altogether or prevented from taking full advantage of technical developments in their place of work. Here, of course, the interests of individuals and those of national economies may overlap to a significant degree.

5. Benefits to Democratic Government

Much of the literature on the public understanding of science is concerned with the politics of decision-making about science. The issues at stake here are easily summarized (but perhaps not so easily resolved, as the article by Robert Fullinwider in this volume makes clear). In democratic societies, citizens possess the right to influence decisions that are taken on a wide variety of matters in which they have an interest. Fairly obviously, modern science is far more than a purely private pursuit: for one thing, a great deal of scientific research is funded from the public purse; and for another, the results of this research exert a profound influence over many aspects of public and private life. Clearly, therefore, citizens have legitimate interests in science, and there is a case to be made that they possess the right to influence the science policy-making process.

The bridge from these preliminary points to our theme is now easily made. If science is to be controlled by the people, then the people had better know something about science. It is worth observing that two distinct benefits are at stake here. Greater public understanding of science may be thought to promote more democratic decision-making (by encouraging people to exercise their democratic rights), which may be regarded as good in and of itself; but in addition, it may be thought to promote more effective decision-making (by encouraging people to exercise their democratic rights wisely). The former benefit has been widely discussed in the literature on public participaton in science,' and the latter appears to be embodied in the Royal Society Report's contention that "wider understanding of the scientific aspects of a given issue will not automatically lead to a consensus about the best answer, but it will at least lead to more informed, and therefore better, decision-making".

6. Benefits to Society as a Whole

The last section was concerned with public understanding of science as an aid to democratic decision-making. Also operating at the level of relationships within society, but this time not concerned with specifically political processes, is the argument that the general health of a nation in which science is practised depends upon the effective integration of science into wider culture. Understandably, perhaps, this is an argument that has found favour with some social anthropologists. Writing at the end of the 1950s, for example, the American anthropologist Margaret Mead noted with concern the growing alienation of lay people from the worlds of science and technology. She suggested that a "schismogenic process" was under way in western civilization, and that this could and should be stopped by the discovery of 'new educational and communication devices" capable of bridging the gulf between "the specialized practitioners of a scientific or humane discipline and those who are laymen in each particular field"."

This last quotation makes it clear that the problem of divisions within culture is not confined to science alone. All sorts of activities may cut themselves off from the common weal by becoming specialized and highly technical. However, science is the paradigm of specialization and technicality, and it presents us with the problem of fragmentation in a particularly acute form. As long ago as 1961 the historian of science A. Hunter Dupree warned that the isolation of science from the rest of American culture was producing a scientific "cargo cult". Many of the media-generated symbols of science in the public mind, he asserted, were "no more functional parts of the scientific enterprise than are the bamboo antennas of the Melanesians". Failing to understand science properly, the public responded with a mixture of fear and adulation; and it was thus the "positive duty" of the Universities to set about destroying the "cultic" images upon which such unproductive responses were based.[9]

The problem of the gulf between science and the wider culture has been addressed in an interesting way by the science policy analyst Maurice Goldsmith. In several publications, Goldsmith has developed the notion of the "science critic" by analogy with the more familiar ideas of literary or music critics.[10] His suggestion is that each person should become his or her own science critic; but it is some measure of the scale of the problem that the whole notion seems lightly odd. Science broadcaster, yes; science journalist, certainly; science popularizer, of course; but science critic? The very notion seems slightly odd, conjuring up vague images of indignant protests against the laws of nature. Yet it is precisely the sense of detachment underlying this reaction that Mead, Dupree and many others have seen as such a powerful argument in favour of the promotion of the public understanding of science.

7. Intellectual Benefits

No review of this kind would be complete without reference to the place of science in our intellectual culture, where by intellectual culture we mean the attributes of an educated and cultivated mind. This notion of culture as cultivated intellect may be traced from the writings of Victorian educationalist and man of letters Matthew Arnold in the middle of the nineteenth century to those of the physicist and novelist C. P. Snow in the middle of the twentieth century. For Arnold, culture was the sum of the very best human intellectual achievements, with the emphasis firmly upon the classics and humanities. The Darwinian biologist Thomas Huxley challenged Arnold's emphasis championing the place of science in intellectual culture, and boldly asserting that,

> "the man who should know the history of a bit of chalk which every carpenter carries about in his breeches pocket, though ignorant of other history, is likely, if he will think his knowledge out to its ultimate results, to have a true and therefore a better conception of this wonderful universe and of man's relation to it than the most learned student who is deep-read in the records of humanity and ignorant of those of nature"."

Repeatedly from Huxley's time to our own, the argument has been put that science is an intellectually enabling and ennobling enterprise. For Snow, the scientific edifice of the physical world was "in its intellectual depth, complexity and articulation the most wonderful collective work of the mind of man".[12] Snow's advocacy of a common culture, in which (for example) molecular biology would be a requisite, was part of a long-standing attempt to broaden the notion of what it is to be an educated person. If the need for such broadening is accepted, then the promotion of public understanding of science becomes part and parcel of the promotion of intellectual culture itself.

8. Aesthetic Benefits

Closely linked to the intellectual argument outlined above is an aesthetic argument that would make science as central to a truly cultivated mind as literature, music, and the performing arts. This argument suggests that science is the distinctively creative activity of the modern mind. To one American scientist and writer, for example, science is this century's cathedral building;[13] while to another it is this century's art—"the most interesting, difficult, pitiless, exhilarating and beautiful pursuit we have yet found".[14] To many scientific humanists, in particular, it has seemed that the Romantics had it quite the wrong way round; so far from degrading the mind with its arid, soulless conceptions, science has been portrayed as continually expanding what the historian ofscience Bentley Glass called "the area of beauty and meaning" which it reveals."

The American advocate of science Warren Weaver has eloquently captured both the intellectual and the aesthetic arguments in favour of the promotion of the public understanding of science:

> The capacity of science progressively to reveal the order and beauty of the universe, from the most evanescent elementary particle up through the atom, the molecule, the cell, man, our earth with all its teeming life, the solar system, the metagalaxy, and the vastness of the universe itself, all this constitutes the real reason, the incontrovertible reason, why science is important, and why its interpretation to all men is a task of such difficulty, urgency, significance and dignity".[16]

Here, therefore, are arguments to the effect that we should promote public understanding of science for the same sorts of reasons that we preserve rare books, conserve beautiful buildings, and promote the arts. Without knowledge of science, it is suggested, life would be that much less worth living.

9. Moral Benefits

Finally, there are ethical arguments for promoting the public understanding of science. According to a number of authors, of whom perhaps the scientist and broadcaster Jacob Bronowski is best-known in the recent past, the internal norms or values of science are so far above those of everyday life that their transfer into wider culture would signal a major advance in human civilization. If science could convince us, for example, that many social evils stem from ignorance or neglect of the scientific spirit itself, then according to the biologist Paul Weiss it would have given us, "another noble gift: a basis for responsible and judicious self-direction as a design for living"."

The mathematical biologist Anatol Rapoport has suggested that the following ethical principles are inherent in scientific practice:

> the conviction that there exists objective truth; that there exist rules of evidence for discovering it; that, on the basis of this objective truth, unanimity is both possible and desirable; and that unanimity must be achieved by independent arrivals at convictions, that is, by examination of evidence, not through coercion, personal argument, or appeal to authority.

Rapoport argues that this list represents a substantial part of a superior ethical system which might, with considerable benefit, be much more widely adopted in human affairs.[18]

Minimally, at least, this ethical argument depends upon science providing especially powerful illustrations of moral precepts whose ultimate justification lies elsewhere. However, it is possible to go further by claiming that science can establish as well as exemplify moral precepts. This was the position adopted by the nineteenth-century English philosopher Herbert Spencer, who looked to scientific laws as the basis not only for the understanding of nature but also for the organization and regulation of society. Spencer's evolutionary ethics was but one (albeit particularly influential) version of a more general philosophy, traceable at least as far back as the Enlightenment, which holds that scientific understanding makes people not merely wiser but better.

In recent years, ethical arguments for the promotion of the public understanding of science have become rather unfashionable. Partly, at least, this may be because they have attracted a great deal of critical attention from moral and social philosophers; but partly, also, it is because the scientific humanism upon which they commonly rest has gradually withered in the face of growing public concern about what have come to be seen as the totally unwelcome social implications of much scientific research. To take only the most dramatic example, our generation has become accustomed to the idea that a substantial fraction of scientific research and development is devoted to sustaining the international arms race; and in this situation, Bronowski's sweeping claim that "every machine has been a liberator"[19] has come to seem not so much complacent as utterly fantastic.

Scientific Understanding and Scientific Literacy

We have now rehearsed nine distinct kinds of argument in favour of promoting the public understanding of science. We do not intend to assess and criticize each of them in turn. Inevitably, individuals will differ in their attitudes to each. Practising scientists may perhaps find themselves drawn to some version of the scientific argument; other academics may perhaps incline towards the intellectual and the aesthetic arguments; cabinet ministers and civil servants may perhaps find one or more of the economic and the political arguments to their taste; and so on. We happen to be working in the field of continuing education, and in general we find ourselves drawn to arguments based on the enhancement of the lives of individuals (nos. 4, 7 and 8) and the welfare of society as a whole (nos. 2, 5 and 6). We are less attracted to the arguments based on benefits to national power and influence (no. **3**) or to morality (no. **9**), since such benefits appear to us either illusory or undesirable (or both). We say more about the argument based on benefits to science below.

Having rehearsed so many different arguments, we have felt obliged to summarize our own view of them in this way. This, however, is not our main object. To repeat what was said at the outset, most people who have taken the trouble to comment on the question at all appear to be agreed that the promotion of the public understanding of science is "A Good Thing"; but what the nine arguments reveal is the fact that beneath this superficial consensus there lie profound differences of orientation, of outlook, and of aim, That these differences are not more obvious is due chiefly to the deceptive simplicity of the notion of public understanding of science. Take, for example, the first of the arguments outlined above. The scientific argument rests upon the key assumption that greater public understanding of science brings greater public approval of science in its wake; but what is meant by understanding and approval here? By understanding, do we mean a grasp of the aims of science, the norms of science, the processes of science, the products of science, or a combination of some or all of these? And by regard, do we mean approval of the practice of science, the principles of science, the expert judgments of science, the research priorities of science, or again a combination of some or all of these? Without being clearer here, it is difficult to see what we are being invited to accept.

Even granted that these ambiguities can be cleared up, the scientific argument raises a second and larger problem, namely that in order to have any general force it appears to rest either upon the unacceptable notion of understanding as the manipulation of consent or upon the unexamined notion of science as inherently approvable, or both. If, on the one hand, to understand something is automatically to approve of it, then of course the argument holds; but who would wish to defend such a view of understanding? If, on the other hand, to understand something is not automatically to approve of it, then the argument holds only if it can be shown that science is inherently approvable; but while this last proposition may appear superficially attractive, a moment's thought is enough to show that it is implausible. For surely even the most sanguine view of science and even the most generous view of society must allow that there may be cases where as least some rational and informed observers will find cause to disapprove of one or another aspect of science; and if this is conceded, then it becomes clear that the relationship between understanding and approval is not necessary but rather contingent upon the nature of the particular understandings and the particular contexts in which they occur.

This point is treated in the chapter in this volume devoted to a discussion of our pilot survey, but for the moment it may be illustrated by reference to an earlier example. It is perfectly possible that a firmer grasp of population genetics and palaeontology amongst American fundamentalists would help to reduce levels of organized opposition to the teaching of evolution in American public schools and colleges; but it is also perfectly possible that it would not. Here, everything depends upon exactly what fundamentalists are really objecting to, and why. To judge from the nature of their interventions in the creation/evolution debate, some of the representatives of science appear to believe that more population genetics and paleontology are the answer, whereas others take the view that in the end the problem will only be overcome by resolving issues that are fundamentally moral and political.[20]

We have explored the implications of the scientific argument in this way simply in order to emphasise the importance of being clear about what we mean by the public understanding of science. In developing our own thoughts on this subject, we have found it helpful to make use of the concept of *scientific* **literacy.** This concept encapsulates what in our view should be a major, or even the main goal of efforts to enhance public understanding of science; and at the same time, it serves to convey the fundamental nature of the issues. What, then, do we mean by scientific literacy?

According to the Oxford English Dictionary, to be literate is to be "acquainted with letters; educated, learned". One who is literate is "a liberally educated or learned person". Thus, literacy has to do not merely with the ability to read and write but with a certain measure of learning which may reasonably be expected to flow from the application of these basic skills; and if we take a liberal education as being in the most general sense an education for citizenship, then literacy takes on even wider connotations of active and effective participation in society.

For some years, the wider connotations of the concept of literacy have been taken up in debates about political education. Thus, the Working Party of the Hansard Society's Programme for Political Education published their report under the title "Political Education and Political Literacy". They defined political literacy as "the knowledge, skills and attitudes that are necessary to make a man or woman both politically literate and able to apply this literacy". They went on to identify a complex, situation-dependent combination of knowledge (e.g., of the political system), skills (e.g., gaming and simulation studies), and attitudes (e.g., values such as "rules for civilised procedures, freedom, toleration, fairness, respect for truth and reasoning") which are to be found in the politically literate person. Such a person, they wrote,

> will then know what the main political disputes are about; what beliefs the main contestants have of them; how they are likely to affect him, and he will have a predisposition to try to do something about it in a manner at once effective and respectful of the sincerity of others. Put another way. . . teaching should help to develop empathy about other political viewpoints and to give people a knowledge of the actual political conflicts of the day; some language or system of concepts with which to express themselves critically about these problems, and neither to expect too much or too little from their own action".[21]

How far can this usage be applied in the fields of science and technology? The political scientists' emphasis on a suitable combination of knowledge, skills and attitudes seems, on the face of it, quite appropriate. Presumably, scientifically literate people have some basic knowledge of science and technology, particularly in the context of their own lives; also, they have the skills that are necessary to interpret new developments in science and technology, particularly as they impinge on their own lives or the lives of others around them; and finally, they possess the attitudes that permit them to respond actively and effectively to these developments where appropriate. (Some of the political assumptions underlying these ideals are discussed at greater length in the paper by Michael Shortland in this volume.)

In the realm of citizenship Kenneth Prewett has taken a similar approach and used the term "savvy" in discussing scientific literacy. Savvy people are those with skills and insights that make for success in what would otherwise be perplexing and intimidating situations. They are not bewildered by the arrival of new scientific languages or the introduction of new techniques and technological appliances. Being generally familiar with the scientific–technological underpinnings of society, scientifically literate people are "in-the-know" and can make the system work to their own advantage." To this extent, scientific literacy may be regarded as a basic survival skill in a scientifically and technologically sophisticated society.

This approach to the notion of scientific literacy incorporates much of the spirit of the Hansard Society Working Party's concept of political literacy. In common with their approach, it rejects any narrowly technical knowledge of particular branches of science and technology, however thorough, as of itself sufficient to constitute scientific literacy. Seen as the fostering of this sort of scientific literacy, attempts to promote the public understanding of science become attempts to enhance people's abilities to live with and benefit from, while at the same time they avoid being mystified or oppressed by, the scientific and technical expertise that are such fundamental aspects of our society.

Thus far, our discussion has focused on one major area of competence — what Benjamin Shen has termed civic science literacy.[23] The hope we have identified is that scientifically literate people may be both more active and more effective citizens; but by the same token, of course, it may also be hoped that such people will find that the quality of their personal and working lives has been enriched. Here, however, it is less easy to generalize. Fairly obviously, individuals differ in the extent to which they gain intellectual and aesthetic satisfaction from great art or great literature; and presumably the same is also true of great science. The task here, we suggest, should be to ensure that science is at least as publicly available and accessible as are other major products of human creativity.

As in personal life, so also in working life there must be large differences in the extent to which individuals find themselves in need of an acquaintance with either the processes or the products of science. This having been said, however, it appears that the number of tasks in modern industrial societies which require familiarity with one or another aspect of science and technology increases more-or-less continually. Throughout the 1980s, for example, Britain has experienced both chronically high levels of unemployment and debilitating shortages of certain sorts of scientifically and technically skilled labour. Here is a case where greater levels of public scientific literacy would seem to have been in almost everybody's interests.

There is a danger in trying to identify the component terms within the concept of scientific literacy in too rigid and formal a way. Much of the existing literature on the subject[24] identifies some or all of the following characteristics of scientific literacy:

1. An appreciation of the nature, aims and limitations of science; a grasp of "the scientific approach" — rational argument, the ability to generalize, systematize and extrapolate; the roles of theory and observation.

2. An appreciation of the nature, aims and limitations of technology, and of how these differ from those of science.

3. A knowledge of the way in which science and technology actually work, including the funding of research, the conventions of scientific practice, and the relationships between research and development.

4. An appreciation of the inter-relationships between science, technology, and society, including the role of scientists and technicians as experts in society and the structure of relevant decision-making processes.

5. A general grounding in the language and some of the key constructs of science.

6. A basic grasp of how to interpret numerical data, especially relating to probability and statistics.

7. The ability to assimilate and use technical information and the products of technology; "user-competence" in relation to technologically-advanced products.

8. Some idea of where or from whom to seek information and advice about matters relating to science and technology.

One has only to glance at a list like this to realize how unsatisfactory it is. While our eight items certainly cover many topics relevant to scientific literacy, they are abstract and ideal qualities that appear extremely remote from the needs and interests of ordinary people. Together, they amount to a formidable combination of qualities rarely encountered anywhere, even within the expert domains of science and science studies. Whatever we may have in mind when we think about the promotion of scientific literacy, presumably it is not the prospect of creating a society composed entirely of professional scientists-cum-science policy analysts!

What has gone wrong in the attempt to define the component parts of scientific literacy in the abstract is that we have come up with many relevant attributes but somehow missed the heart of the matter, which is the way in which ordinary people relate to the world of science. To be scientifically literate is not to be expert in anything in particular, but rather to be able to deal effectively with matters scientific as they arise in the course of life; it is to be able to cope with science in a way that is both respectful of scientists' legitimate expertise and wary of their many fallibilities and weaknesses; it is to be able to recognize science for what it is, and thus to make discerning judgments about its personal and social relevance.

Conclusion

In this paper we have reviewed some of the commoner arguments that have been used by those who support the promotion of the public understanding of science. Within these arguments, we have detected the presence of a number of rather different ideas about and interests in the public understanding of science. In many ways, the promotion of the public understanding of science is rather like the protection of the environment: both are eminently worthy causes which easily recommend themselves to many and varied supporters; but while it is difficult to imagine how anybody would wish explicitly to oppose them, it is almost equally difficult to achieve a consensus amongst their supporters about what, exactly, they entail and why, precisely, they are deserving of so much support.

We have attempted to provide a preliminary account of the nature of the public understanding of science in terms of the concept of scientific literacy. Undoubtedly, this concept is itself problematic; but we believe that it offers a promising way of bringing into sharper focus the question of the relationship between science and the rest of society. At the same time, the concept of scientific literacy lends itself to the clearer articulation of the essentially political argument for promoting the public understanding of science which is concerned with decision-making about science-related issues in a democratic society. As several of the other articles in this volume make plain, the politics of the public understanding of science is far from straightforward. We hope that by making more explicit some of the assumptions that are embedded in the literature on this subject we have at least contributed towards the clearer articulation of the problem.

Notes

1. Isaac Asimov, *Nature,* 1984.
2. Paul Couderc, "An Antidote for Anti-Science", *Impact of Science on Society,* XXI, 1971, pp. 173–9.
3. For an account, see Dorothy Nelkin, *The Creation Controversy,* New York and London, Norton, 1982.
4. Harry Collins, *Changing Order,* London, Sage, 1985.
5. The Royal Society, *The Public Understanding of Science,* London, The Royal Society, 1985.
6. Phillippe Le Corbeiller, 'Education in Science. Prerequisite for National Survival", *Daedalus,* 88 (1959), pp. 170–4.
7. See, for example, G. Boyle, D. Elliott and R. Roy (eds). *The Politics of Technology,* London. Longman and The Open University Press, 1977, Section 3.
8. Margaret Mead, "Closing the Gap Between Scientists and the Others", *Daedalus* 88, 1959, pp. 138–46.
9. A. Hunter Dupree, "Public Education for Science and Technology", *Science* 134, 1961, pp. 716–18.
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