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Notes on the Value of Science

It is generally believed that science is a good thing. (I use the term "science", in this paper, to include not only the natural sciences, but also the social sciences and the humanities.) Many people—and, in particular, most scientists—seem to take it for granted that scientific knowledge is valuable for its own sake. In addition, scientific research has very important social effects, and while some of these are generally held to be bad or neutral, I think the predominant view is that the total impact of science on society is positive rather than negative. After all, we do spend a lot of money on science, and scientists have a lot of prestige in our society. This might be explained by the assumption that most people think that science is valuable. (This ought to be the correct explanation, at least in a democracy.) But is the belief true? Is science, on the whole, good or bad? This is the problem I want to discuss in the present paper.[1]

Most people would agree that so far science has had some positive as well as some negative effects. For example, it has given us electricity, which may be used to make our lives more comfortable, but it has also given us terrible weapons, which may one day put an end to our very existence. Einstein once described the situation as follows:

> Penetrating research and keen scientific work have often had tragic implications for mankind, producing, on the one hand, inventions which liberated man from exhausting physical labor, making his life easier and richer; but on the other hand, introducing a grave restlessness into his life, making him a slave to his technological environment, and—most catastrophic of all—creating the means for his own mass destruction.[2]

Most people would accept this statement. However, there may be some disagreement over other alleged effects of science. For example, some people may claim that only certain natural sciences, like physics and chemistry, can have negative effects, and that other sciences (including, in particular, the humanities) have only good effects, in addition to being valuable for

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[1] This paper partly derives from a talk given in January 1990 to a seminar on "Humanistic Aspects of Scientific and Technological Progress" at the Institute of Philosophy of the USSR Academy of Sciences in Moscow. I am grateful to the participants for many helpful comments. I also wish to thank Hans Mathlein, Torbjörn Tännsjö, and Jan Österberg of Stockholm University for comments on the first written version.

[2] Albert Einstein, "A message to intellectuals" (1948), p. 148, in *Ideas and Opinions*, New York: Crown Publishers, 1954, pp.147-51.

their own sake. Rousseau, on the other hand, makes no such distinctions when he claims, in his famous first *Discourse* of 1750, that "our minds have been corrupted in proportion as the arts and sciences have improved".[3] He says that the sciences "generate idleness" and contribute to "the destruction and defamation of all that men hold sacred".[4] Rousseau's ideal is Sparta, which is "as famous for the happy ignorance of its inhabitants, as for the wisdom of its laws", and which is also "eternal proof of the vanity of science".[5] This view is very far from being generally accepted.

So, in order to make an overall evaluation of science, it seems that one would have to do two things. First, one would have to decide what the positive and negative aspects of science are. Second, one would have to weigh these positive and negative aspects against one another and decide whether or not the positive aspects outweigh the negative ones.

Different people may come to different conclusions here. Even if a majority believes that the positive aspects prevail, there are also some dissidents. For example, in a note from 1947, Wittgenstein writes:

> It isn't absurd […] to believe that the age of science and technology is the beginning of the end for humanity; that the idea of great progress is a delusion, along with the idea that the truth will ultimately be known; that there is nothing good or desirable about scientific knowledge and that mankind, in seeking it, is falling into a trap. It is by no means obvious that this is not how things are.[6]

A similar, but even stronger thesis has been advanced by Michael Dummett. He says that

> it seems to me indisputable, with hindsight, that we should be, on balance, far better off than we are if, in 1900 or in 1920, all scientific research had come to a permanent stop. With the experience of what happened, we have little reason to doubt that the net practical result of future research will be increasingly disastrous.[7]

It seems to me that the pessimism expressed by Wittgenstein, Dummett, and others ought to be taken seriously. It is not obviously correct, but it is not obviously wrong either.

1. Science and knowledge.

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[3] Jean Jacques Rousseau, "A Discourse on the Moral Effects of the Arts and Sciences", in *The Social Contract and Discourses*, translated with introduction by G.D.H. Cole, Everymans's Library, London: Dent, 1968, p. 123.
[4] See ibid., pp. 131-2, 135-6.
[5] Ibid., p. 126.
[6] Ludwig Wittgenstein, *Culture and Value*, Oxford: Blackwell, 1980, p. 56.
[7] Michael Dummett, "Ought research to be unrestricted?", *Grazer Philosophische Studien*, vol. 12/13 (1981) p. 292.

The main argument for engaging in scientific activities is that this is a way—and perhaps the only way, or the best way—of gaining *knowledge*. And knowledge, in turn, is supposed to be valuable, either intrinsically or extrinsically (instrumentally) or both.

However, contrary to popular opinion it might be argued that scientific work does not really give us much knowledge. I am taking it for granted, then, that knowledge (in a strict sense) has to be true and justified. This is in accordance with the standard account of knowledge.[8] If I know that *p*, then *p* is true and I am justified in believing that *p* is true. Now, it seems clear that science produces theories. So, if science produces knowledge, the theories in question have to be both true and justified. But several influential positions in modern philosophy of science seem to imply that science cannot or may not produce theories which are both true and justified. Let us consider some of these positions.

(1) Popper. According to Karl Popper there is no criterion of truth.[9] Even observational statements may be mistaken—mainly because "all observation involves interpretation in the light of our theoretical knowledge"[10]—and there can be no inductively valid inference from observational statements to theories. A given scientific theory may happen to be true, but we never have any good reason to believe that it is true. We are never justified in believing that a theory is true. Our so-called "knowledge" merely consists of conjectures: "even if we hit upon a true theory, we shall as a rule be merely guessing, and it may well be impossible for us to know that it *is* true".[11]

Popper sometimes seems to imply that we have some knowledge, as e.g. when he says that "by far the most important source of our knowledge—apart from inborn knowledge—is tradition".[12] But in such cases he seems to be using the term "knowledge" in a loose or weak sense. What is referred to as "knowledge" in this sense may very well be false and unjustified. For all we know, it might still have some value, but it is certainly not knowledge in the strict, standard sense. Knowledge in the strict sense is impossible according to Popper.

(2) Kuhn. According to Thomas Kuhn, a theory cannot even be true. Kuhn seems to hold that the term "true" has only intra-theoretic applications, and that there is no sense in which one theory may be a better approximation to the truth than another.[13] Hence, on Kuhn's view, we cannot know that a theory as a whole is true or approximately true. It may still be possible to know some things, but it seems that Kuhn is rather pessimistic about the epistemological potential of science.

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[8] See e.g. the article "Knowledge and belief" in P. Edwards (ed.) *The Encyclopedia of Philosophy*, New York and London: Macmillan and The Free Press, 1967, vol. 4, pp. 345-52, esp. p. 345.

[9] See e.g. Karl R. Popper, *Conjectures and Refutations*, New York and London: Basic Books, 1962, p. 28.

[10] Ibid. p. 23.

[11] Ibid., p. 225.

[12] Ibid., p. 27.

[13] See e.g. Thomas S. Kuhn, "Reflections on my critics", in Imre Lakatos and Alan Musgrave (eds.) *Criticism and the Growth of Knowledge*, Cambridge: Cambridge University Press, 1970, pp. 321-78, esp. pp. 264-6.

Of course, this does not mean that Kuhn is pessimistic about the value of science. He believes that some theories are better than others—according to criteria which are internal to science—and that, in general, later theories are better than earlier ones.[14] His position is also compatible with the view that the scientific enterprise is useful and/or valuable for its own sake. It is just that any value it may have must be independent of our coming to know the truth.

(3) Quine. One of W.V. Quine's most well-known theses is that theories are underdetermined by all possible observations.[15] But if theories are underdetermined in Quine's sense, it seems that we can have no real evidence for them. Whatever observation would be counted for or against a given theory counts equally for or against some completely different theory. There is always more than one "best explanation" of any given set of data. Hence, we can never know that a given theory is true. Our evidence can never single out our own theory from a set of rival theories.

Quine is still willing to say, of any theory that he himself accepts, that it is true. There is nothing objectionable about this, for by saying that a theory is "true", Quine just expresses his acceptance of it; in his own words, "to call a sentence true is just to reaffirm it".[16] Maybe he would even be willing to say, of theories that he accepts, that he *knows* that they are true. By saying this he would merely express his acceptance of the theories in question and perhaps also his belief that this acceptance is "justified" in some sense.[17] However, the theories in question may still be false. And, more to the point, underdetermination still seems to rule out the possiblity of justification in the sense of a good reason for believing that the theories are true. If Quine is right, there seems to be no room for knowledge in the strict sense. There may be perfect coherence within one's total theory of the world, but underdetermination seems to guarantee that there would be equally perfect coherence within some completely different total theory.

(4) Instrumentalism. Another threat to scientific knowledge is instrumentalism. According to instrumentalism, scientific theories are neither true nor false; instead, they are tools which may be used to predict future occurrences. Tools may or may not be useful, but they do not tell us anything about the nature of reality. Tools do not tell us anything at all. We may be able to use a given theory for predicting what will happen under certain conditions, but the theory does not tell us why this will happen. Hence, if instrumentalism is right, the common belief that science gives us knowledge about the world is to a large extent mistaken.

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[14] See e.g. ibid., p. 264.

[15] For a recent formulation of the underdetermination thesis, see W.V. Quine, *Pursuit of Truth*, Cambridge, Mass. and London: Harvard University Press, 1990, pp. 95-102. For a discussion of the thesis and further references, see Lars Bergström, "Quine on underdetermination", in R. Barrett and R. Gibson (eds.) *Perspectives on Quine*, Cambridge, Mass. and Oxford: Blackwell, 1990, pp. 38-52.

[16] W.V. Quine, "On empirically equivalent systems of the world", *Erkenntnis*, 9 (1975), pp. 313-28, esp. p. 327.

[17] See W.V. Quine, *Quiddities*, Cambridge, Mass.: Harvard University Press, 1987, pp. 108-10. Quine also points out that the concept of knowledge "does not meet scientific and philosophical standards of coherence and precision", ibid., p. 109.

A similar conclusion can be arrived at from the assumption that the acceptance of a theory consists in the belief that the theory is empirically adequate. This may be combined with the view that theories are true or false. The point is that the acceptance of a theory does not involve the belief that what the theory says about theoretical (non-empirical) states and events is true. An account of this kind has been developed by Bas van Fraassen.[18] In so far as scientific theories are only meant to be accepted in this way, science gives us no knowledge about the unobservable features of the world. Of course, it may still give us knowledge concerning the observable world. But I think most people believe that science tells us more than that.

(5) The pessimistic induction. If you reject instrumentalism and adopt a realist conception of scientific theories, you are faced with another argument against the possibility of scientific knowledge. For the history of science seems to suggest that every theory which is accepted by the scientific community at some time will be rejected sooner or later. One possible explanation of this is that there are so many ways in which a theory may be wrong and only one way in which it can be right. This point is stressed by Rousseau in the following passage:

> What a number of wrong paths present themselves in the investigation of the sciences! Through how many errors, more perilous than truth itself is useful, must we pass to arrive at it? The disadvantages we lie under are evident; for falsehood is capable of an infinite variety of combinations; but the truth has only one manner of being.[19]

If we learn about the nature of reality by trial and error—as Popper suggests[20]—and if the nature of reality is very complicated, it is only to be expected that our theories are mostly wrong. It has even been held that no theory will be accepted for more than two hundred years.[21] A similar judgment has been expressed by a leading sociologist of science as follows:

> After all, the majority of all the theories which scientists have ever put forward have been rejected as false or misconceived, and the majority of the findings which they have reported have been forgotten. Scientific knowledge has an extremely short lifetime. The knowledge routinely accepted and used in any scientific field is on the whole extraordinarily recent: scarcely any fields make use of materials more than a few decades old, and such older material as is used is very rarely accepted just as it stands. Yet because we place such trust in it now, many people have difficulty in seeing that our present knowledge is likely to be treated in three or four generations much as we ourselves treat the knowledge of three or four generations ago.[22]

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[18] See e.g. Bas C. van Fraassen, *The Scientific Image*, Oxford: Clarendon Press, 1980, p. 12.
[19] Rousseau, "Discourse", pp. 130-1.
[20] See e.g. Popper, *Conjectures and Refutations*, pp. vii and 312-3.
[21] See W.H. Newton-Smith, *The Rationality of Science*, Boston, London and Henley: Routledge, 1981, p. 14.
[22] Barry Barnes, *About Science*, Oxford and New York: Blackwell, 1985, p. 66.

In other words, all scientific theories may well be false. If this is so, it seems that science produces delusions rather than knowledge.

(6) Interpretations. Instrumentalism is perhaps a plausible account of theories in the natural sciences. It is less plausible in the humanities and the social sciences. Theories within these latter areas cannot so easily be regarded as tools for prediction. There is not much prediction within these sciences—and even less successful prediction. However, theories in the humanities and the social sciences are often regarded as "interpretations",[23] and such interpretations are sometimes held to be neither true nor false.[24] If this is right, interpretations do not express or contain knowledge.

The upshot of all these considerations, then, is that science may produce much less knowledge than is ordinarily assumed. From the point of view of those who believe that science is valuable because it produces knowledge, this is bad news.

2. Knowledge and ignorance.

However, for the sake of argument, let us now accept the more normal view that science has given us a lot of knowledge. In any case, most of us would agree that science has provided us with much low-level empirical knowledge and technical know-how which is amazingly reliable. Nevertheless, it is paradoxical that, in a sense, science has also increased our ignorance in many ways.

The point may be put this way. As science progresses, more things are known, but at the same time each person knows less of what there is to know. Scientific progress has led to an extreme specialization and fragmentation of the scientific enterprise.[25] Even so, the literature within any given special field is unsurveyable. I think it is fair to say that for almost every important scientific problem it is completely impossible to find out what has been written about it. Even before the Second World War the situation was desperate. J.D. Bernal reports that there were 33.000 different scientific periodicals in 1934.[26] Maybe there are ten times as many today? Or more? The rate of growth is truly terrible! For example, Bernal also tells us that the number of entries in the *Biological Abstracts* had grown from 14.506 in 1927 to 21.531 in 1934. That is approximately a 50% increase in only seven years. In general, it has been estimated in the early 1960s that for at least two or three centuries, "the crude size of science in manpower or in

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[23] See e.g. Charles Taylor, "Interpretation and the sciences of man", *The Review of Metaphysics*, vol. 25 (1971), pp. 3-51.

[24] See e.g. Joseph Margolis, *Art and Philosophy*, Atlantic Highlands, N.J.: Humanities Press, 1980, Ch. 6, and Lars Bergström, "Explanation and interpretation of action", *International Studies in the Philosophy of Science*, vol. 4 (1990) pp. 3-15, esp. pp. 13-4.

[25] For example, it has recently been reported that "A catalogue of fields of study at German universities at present lists more than 4000 fields", see Martin Carrier and Jürgen Mittelstrass, "The unity of science", *International Studies in the Philosophy of Science*, vol 4 (1990) pp. 17-31, esp. p. 17.

[26] J.D. Bernal, *The Social Function of Science*, London: Routledge, 1939, p. 117.

publications tend to double within a period of 10 to 15 years".[27] The result is frightening. Already in 1939, Bernal claims that

> it has become impossible for the average scientific worker, who does not wish to devote the major part of his time to reading, to keep up with the progress in his own field.[28]

This was over 50 years ago. Today the situation is certainly much worse. Of course, much of what is written is not worth reading, but this is a poor consolation, for in order to know what is worth reading, one has to read everything. This may not be strictly true, but it is at least sufficiently true to present us with a genuine problem. Quine puts the point as follows:

> The mass of professional journals is so indigestible and so little worth digesting that the good papers, though more numerous than ever, are increasingly in danger of being overlooked.[29]

Quine is referring primarily to philosophical journals, but I am inclined to believe that the same is true in most or all fields. For some years I have had the habit of asking professors from various disciplines, whom I happen to meet, whether they would agree that something like 75% of the research done in their own field is bad or uninteresting. So far everyone has agreed to this. It is also confirmed by Bernal, who claims that scientific publications are "of very unequal value; a large proportion of it, possibly as much as three-quarters, does not deserve to be published at all".[30] So, a large percentage of the scientific work which is published is bad or boring or both, and possibly the percentage of bad work is larger the more that is published.[31]

A related point is this. Partly because of the increased specialization, and partly because of scientific progress, scientific theories have become increasingly difficult to understand. Most people may be able to grasp the principles behind the steam engine, for example, but only a small minority understand the functioning of a laser or a computer. Quantum theory is certainly more difficult than Newtonian mechanics. Hence, it may be safely assumed that people in general have never before been as ignorant of the science of their time as they are today. And this is not only true of people in general, but also of the scientists themselves. Something like this is suggested by Kuhn in the following passage:

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[27] Derek J. de Solla Price, *Little Science, Big Science … and Beyond*, New York: Columbia University Press, 1986, p. 5. However, as Barry Barnes points out, "the rate of scientific growth has fallen off very markedly since the early 1960s", Barnes, *About Science*, p. 5.

[28] Bernal, *The Social Function of Science*, p. 117.

[29] W.V. Quine, *Theories and Things*, Cambridge, Mass.: Belknap Press, 1981, p. 197.

[30] Bernal, *The Social Function of Science*, p. 118.

[31] The last point is also supported by Quine. He says that new journals "were needed by authors or articles too poor to be accepted by existing journals", *Theories and Things*, p. 196.

> Is it not possible, or perhaps even likely, that contemporary scientists know less of what there is to know about their world than the scientists of the eighteenth century knew of theirs? Scientific theories, it must be remembered, attach to nature only here and there. Are the interstices between those points of attachment perhaps now larger and more numerous than ever before.[32]

In addition, there is also the mechanism that the more one knows about something, the more sceptical one becomes of various theories and ideas in the field in question, and the more one becomes aware that one really knows very little.

Hence, my general conclusion is that because of the scientific progress, there is more ignorance than before. And, presumably, if knowledge is good, ignorance is bad. So this is an unfortunate effect of science.

3. The intrinsic value of scientific knowledge.

If knowledge is good, then either it is good in itself, or it is good as a means to something else. Its value is either intrinsic or extrinsic—or both. I shall discuss the extrinsic value of knowledge in sections 4 and 5. In this section, I shall consider the question of whether knowledge is good for its own sake.

I guess most scientists would answer this question in the affirmative. The claim that knowledge is valuable for its own sake is perhaps especially popular among people who work in areas where economically or socially useful applications are rare or nonexistent. But it also seems to be accepted within more "useful" disciplines.

So, the claim is widely accepted. But is it true? It is hard to say with certainty, but it seems to me that we have no reason to believe that it is true and some reason to believe that it is false.

In order to support the claim that knowledge is intrinsically good, we might refer to the fact that people do desire knowledge for its own sake.[33] This is the argument that is usually given, in so far as any argument is given. But it is not a good argument. In the first place, it is doubtful whether anyone really desires *knowledge* for its own sake. Rather, what people desire is the state of affairs that they *themselves* know the answer to some *particular* question or questions. And what a scientist typically desires for its own sake (if anything) is probably something even more

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[32] Thomas S. Kuhn, "Logic of Discovery or Psychology of Research?", in Lakatos and Musgrave (eds.) *Criticism and the Growth of Knowledge*, pp. 1-23; the quotation is from pp. 20-1.

[33] Such an argument reminds one of Mill's "proof" of the Principle of Utility in Chapter 4 of his *Utilitarianism*, see J.B. Schneewind (ed.), *Mill's Ethical Writings*, New York and London: Collier, 1965, pp. 308-15. An argument of this kind is also suggested by Richard Brandt. He writes: "There is *prima facie* support in our attitudes for the intrinsic worth of knowledge; we do seem to want at least some knowledge on its own account", see R.B. Brandt, *Ethical Theory*, Englewood Cliffs, N.J.: Prentice-Hall, 1959, p. 335. For counter-arguments and further references, see Lars Bergström, "On the value of scientific knowledge", *Grazer Philosophische Studien*, vol. 30 (1987) pp. 53-63.

specific, viz. that he himself be the *discoverer* of the answer to some question. We do not desire the state of affairs that someone at some time knows the answer, or that mankind dicovers it.

Secondly, once we realize that people desire very different and very specific knowledge-states, we can also appreciate the fact that most people are completely indifferent to most knowledge-states. In general, people do not even desire that they themselves know the answers to scientific questions. Barry Barnes puts the point this way:

> Most people see science, quite rightly, as an activity beyond their understanding. And very many have in any case not the slightest interest in understanding it: many of the most popular newspapers and magazines devote more space to astrology and horoscopes than they do to natural science and its results.[34]

Similarly, most people cannot care less about the latest scientific news about the use of adverbs in Shakespeare's plays or the causes of inflation in Yugoslavia in 1970-75. In fact, I want to suggest that *everyone* is completely indifferent to most knowledge-states, and that most knowledge-states are *not* desired for their own sake.

However, it might be claimed that there are exceptions to this general rule. For example, it has been suggested by Richard Brandt that there are certain pieces of knowledge that we desire for everybody. Brandt writes:

> Yet it does seem that there are certain kinds of knowledge we do wish everyone to have—not isolated bits, as if there were value in memorizing paragraphs from Keynes on economic theory, without understanding what they mean, but systems of knowledge: the understanding of the physical and social world, of man's nature, of science and the evidence for scientific theory, and so on. These we wish all to have. That we do so is doubtless part of the basis for advocating a "liberal" education and requiring acquaintance with certain fields of knowledge. Nor is the reason for this simply that we wish everybody to have some common areas about which he can *converse* with other people.[35]

Well, maybe this is something we do wish. However, I very much doubt that it is something we want for its own sake. I think that those of us who want it would agree, on reflection, that we want it as a means to some more hedonistic value, such as well-being. We believe that people need some kind of world-view, and that they are bound to be frustrated if their beliefs about the observable features of their surroundings are radically mistaken. But it is not essential that their beliefs are true. For example, Newton's mechanics would do fine for physics, even if it is not

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[34] Barnes, *About Science*, p. 20.
[35] Brandt, *Ethical Theory*, pp. 337-8.

strictly true. In fact, it might not matter much if our high-level theoretical beliefs were completely false, as long as our low-level empirical beliefs are approximately true. Moreover, different systems of belief may be quite acceptable in different cultures. Knowledge in a strict sense is not necessary.

Thirdly, even if some knowledge-states really are desired for their own sake, it does not follow that these states are intrinsically good. (Neither, of course, does it follow that *all* knowledge-states are intrinsically good.) It does not follow logically, for according to Hume's Law evaluative conclusions do not follow logically from factual premisses. But it does not follow inductively either, for the intrinsic value of knowledge does not constitute the best explanation of the intrinsic desire for knowledge. Rather, one can assume that the desire is best explained in either of the following two ways: (1) the intrinsic desire for knowledge may have survival value,[36] or (2) knowledge may often be desired as a means to something else, and there is a psychological mechanism to the effect that what is often desired as a means will easily come to be desired also for its own sake.[37]

Moreover, we cannot argue that knowledge is intrinsically good in virtue of some axiological principle to the effect that what is desired for its own sake is good in itself. For there seem to be many counterexamples to such a principle: some people may desire money, or fame, or power, and so on for its own sake, but we would not like to conclude from this that money, fame, and power are intrinsically good.

At this point, someone might say that even if knowledge as such is not intrinsically good, the *pursuit* of knowledge is. In other words, if we make the usual distinction between science as a *process* and science as a *product*, we can see that it is the former, rather than the latter, that has intrinsic value. Notice, that this version of the doctrine avoids the objection that the product of science is often ignorance or error rather than knowledge. Perhaps it is also more in accordance with Aristotle's conception of the intellectual virtues as the most important constitutents of *eudaimonia* (happiness or human flourishing), which in turn is the supreme good.[38] As before, the claim that scientific activities are intrinsically valuable cannot be supported by reference to our desires, but it is perhaps more plausible in itself than the corresponding claim for knowledge.

However, it seems to me that there are at least three considerations which tend to make one sceptical of both versions of the doctrine. In the first place, it seems somewhat *ethnocentric* to believe that scientific knowledge and/or the pursuit of such knowledge is intrinsically good. There are many cultures in which science is not regarded as important. Indeed, the majority of mankind is probably not at all interested in science. It may be that every culture needs some form of "intellectual" enterprise. (This may even be true by definition.) But one may think of

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[36] Notice, though, that desiring knowledge for its own sake may not have survival value under all circumstances. (For example, curiosity killed the cat.) More importantly, even if curiosity has had survival value in human history so far, it may not have survival value in the future, since technological conditions have changed quite a lot.

[37] See e.g. Charles L. Stevenson, *Ethics and Language*, New Haven: Yale University Press, 1944, pp. 193-8.

[38] See Aristotle, *Nichomachean Ethics*, VI.

various alternatives to science here, such as religion, music, story-telling, magic, gardening, poetry, painting, chess, astrology, Hermann Hesse's *Glasperlenspiel*, and so on. It is hard to see why science should be *intrinsically* better than any of these. On the other hand, if *all* these activities are intrinsically good to the same degree, then there is nothing special about science: its value, as compared to that of its alternatives, has to be judged exclusively by its external results.

Secondly, those who claim that knowledge or the pursuit of knowledge is intrinsically good are usually themselves scientists or intellectuals. It is obvious that they have a vested interest in this doctrine. They have something to gain from propagating it. Scientists are privileged in our society. Therefore, they need to justify their life-style, both to themselves and to those who pay for it. Moreover, scientists are usually the sort of people who are culturally influential. This is quite sufficient as an explanation of why the doctrine is so widely accepted. This explanation also seems to undermine the plausibility of the doctrine.

Thirdly, it is possible to construct plausible counterexamples to the idea that knowledge or the pursuit of knowledge is good in itself. For example, suppose that Ivan has a fatal disease that will kill him within a few weeks. He is in bed, and the only thing he can do is to watch television. There are two alternatives: on one channel there is a series of rather good movies, on the other channel there are good educational programmes. The movies will give him a lot of pleasure, the educational programmes will give him somewhat less pleasure but much more knowledge. Ivan prefers to watch the movies. However, if knowledge or the pursuit of knowledge were intrinsically good, he ought to watch the educational programmes, since this would produce more intrinsic value. Moreover, and for the same reason, if he does not watch the educational programmes of his own free will, his wife ought to persuade him to do so (other things being equal). But this seems quite absurd. It is certainly all right for Ivan to watch the movies, and to enjoy his last weeks as much as possible. Therefore, neither knowledge as such, nor the pursuit of knowledge, is intrinsically good.

4. The effects of science.

If my argument so far is correct, we may now disregard the idea that science or knowledge is valuable for its own sake. If it has any value at all, this must be purely extrinsic. The value of science must depend exclusively upon the value of its effects or consequences. Moreover, I shall assume that the only effects that are relevant here are those which somehow affect the welfare or happiness of sentient beings. In the present context, this assumption seems quite reasonable.

Science has many different effects which are relevant to the welfare of sentient beings. Notice that some relevant effects have already been touched upon in sections 1 and 2, for states of knowledge and ignorance may in turn affect people's welfare. The intended effects of science are described by J.D. Bernal as follows:

> Science as an occupation may be considered to have three aims which are not mutually exclusive: the entertainment of the scientist and the satisfaction of his native curiosity, the discovery and integrated understanding of the external world, and the application of such understanding to the problems of human welfare.[39]

This sounds reassuring, but it must be remembered that science also has effects which are not intended. Some of these may not even be predictable. And the value of science depends upon all its effects, whether they are intended (or predictable) or not.

This might be disputed. It is often suggested by scientists that they themselves are only responsible for the scientific quality of the theories that they produce, and, in particular, that they are not responsible for the effects of each practical application of those theories. Scientists take pride in good effects of applications of their theories, but they are much less willing to accept responsibility for bad effects which are unintended or unpredictable. Similarly, it might be held that the value of science is independent of unintended or unpredictable effects.

I myself do not accept the view that scientists are responsible only for the intended effects of what they do. But even if we were to accept this view, it seems clear that we may still insist that *the value of science* depends upon unintended and unpredictable effects as well. To some extent, this is also agreed to and even stressed by people who argue that science is valuable. It is often pointed out that the future applications of basic scientific research is always to a large extent unpredictable, but that in many cases such research turns out to be extremely useful. This is regarded as an argument for the positive value of basic research—particularly in cases where practical applications cannot be imagined. Similarly, I would say, negative effects of science and its applications are relevant to the overall value of science, even if they are unpredictable.

In any case, it would be completely arbitrary to claim that the instrumental value of science depends upon the good consequences of scientific activity (such as improved health and more efficient communications, and so on) but not upon bad consequences (such as nuclear and chemical war, pollution, bad TV programmes, and so on).

The effects of science are of course very varied. In order to approach an answer to the question of whether they are, on balance, good or bad, I suggest that we consider them under the following five headings (where we start with the first of the aims mentioned by Bernal): entertainment, power, health, security, and education.

(1) Entertainment. Scientific research can be quite entertaining. Scientists typically enjoy solving problems, and they can also derive satisfaction from studying the work of other scientists. In fact, Bernal considers the idea that the ultimate justification of science is that it is "quite an amusing pastime", and he goes on to say that this attitude, "though rarely admitted, is actually extremely widespread among scientists, particularly those in the safer and more

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[39] Bernal, *The Social Function of Science*, p. 94.

comfortable positions".[40] There is probably some truth in this. Moreover, some parts of science are also entertaining to non-scientists and non-specialist. (In many cases, this presupposes popularization.)

On the other hand, I think nearly everyone would agree that a lot of science is extremely boring, and that a lot of it is in fact completely unintelligible to the non-specialist. Scientific work can also be rather tiresome and unrewarding. I would suggest that, on the whole, modern science has comparatively little value as entertainment. As far as I can see, it is quite possible that alternative activities like alchemy, literature, religion, music, gardening, and the game of trivial pursuit might be equally or more entertaining.

It must not be forgotten, of course, that science also has more indirect effects which have to do with entertainment. The application of science has given us technological inventions like radio, television, aeroplanes, personal computers, motor cars, tape recorders, gramophone records, and so on, which can be used for our entertainment. The impact of science in this respect is indeed overwhelming. And we certainly do enjoy all these technological gadgets. However, in the last analysis it may very well be doubted whether they have made us happier than we would have been without them. Maybe they have just changed our social habits, and provided us with alternative means of enjoyment. It is not at all clear that the institution of science can be justified on the ground that it provides entertainment.

(2) Power. By increasing our knowledge of the world, we automatically increase our power over it. This is a classical idea, which goes back primarily to Francis Bacon. But there are different kinds of power. In fact, what Bacon seems to have had in mind here is just what Bernal refers to as the application of scientific understanding to the problems of human welfare. Bacon writes as follows:

> It will not be amiss to distinguish the three kinds and as it were grades of ambition in mankind. The first is of those who desire to extend their own power in their native country; which kind is vulgar and degenerate. The second is of those who labour to extend the power of their country and its dominion among men. This certainly has more dignity, though not less covetousness. But if a man endeavour to establish and extend the power and dominion of the human race itself over the universe, his ambition (if ambition it can be called) is without doubt both a more wholesome thing and a more noble than the other two. Now the empire of men over things depends wholly on the arts and sciences. For we cannot command nature except by obeying her.[41]

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[40] Ibid., p. 97.

[41] Francis Bacon, *Novum Organon*, 129. Quoted from Benjamin Farrington, *Francis Bacon. Philosopher of Industrial Science*, London: Macmillan, 1973, p. 7.

Unfortunately, the first two kinds of ambition are all too common, and I think Bacon would have had to agree that science can be used to satisfy those as well. But this is not what science is for, according to him. In another place he writes:

> For what is at stake is not merely a mental satisfaction but the very reality of man's wellbeing, and all his power of action. Man is the helper and interpreter of Nature. He can only act and understand in so far as by working upon her he has come to perceive her order. Beyond this he has neither knowledge nor power. For there is no strength that can break the causal chain: Nature cannot be conquered but by obeying her. Accordingly these twin goals, human science and human power, come in the end to one. To be ignorant of causes is to be frustrated in action.[42]

This view of science more or less originates with Bacon. Before him, the pursuit of truth was not in general regarded as a means to the improvement of the conditions of life for mankind.[43] After him, of course, similar ideas were central to the Enlightenment.

No one would deny that science has in many ways increased our power in Bacon's sense. However, three further points should be noticed here. In the first place, there seem to be many scientific disciplines which have *not* been of much use to mankind in the way Bacon aimed at. Examples of such disciplines might be theology, astronomy, philology, political science, fundamental particle physics, archaeology, musicology, futurology, topology, philosophy, zoology, and the history of art and literature.[44]

Secondly, the power over nature that science has given us is used very selectively. It has often been pointed out that knowledge is more commonly used for the benefit of the few than for the benefit of all,[45] and Bernal goes even further when he says that "science is being used mainly for the enrichment of the few and the destruction of the many".[46] I will say more about this below.

Thirdly, it seems that there is something about scientific progress itself which may, at least in some important cases, *reduce* our power over nature. For scientific progress seems to lead to

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[42] Francis Bacon, *The Great Instauration*, Part 6. Quoted from Farrington, *Francis Bacon*, p. 91.

[43] See e.g. Farrington, *Francis Bacon*, p. 5.

[44] This list of examples might be disputed. I shall not try to argue for it here. Let me just give the following quotation, which concerns one of the least obvious and most expensive items on the list: "The *cause célèbre* at present is the study of the fundamental particles of matter in high energy nuclear physics. This is of great interest academically—physicists are agreed on that. On the other hand, it is also a very expensive field of research, because enormous accelerators are required to bring particles to high enough energies. There are no signs of any useful applications emerging from knowledge of these fundamental particles. It is important to be quite clear that this really means exactly what it says: no use can even be envisaged", F. R. Jevons, *The Teaching of Science. Education, Science, and Society*, London, 1969, p. 75. For a similar, but more recent judgment, see Barnes, *About Science*, p. 27.

[45] Compare e.g. Harold D. Lasswell, "Must science serve political power?", *The American Psychologist*, vol. 25 (1970), pp. 117-123, esp. p. 117.

[46] Bernal, *The Social Function of Science*, p. 97.

larger and more complex systems of economy and technology, and it is far from clear that science can tell us how best to achieve our ends within such systems. The experts very often disagree when it comes to matters which are relevant to important decisions concerning economic policy and large-scale technology.[47] It seems reasonable to assume that the greater the socio-political impact of a given decision, the higher is the probability that the experts will disagree and that their views will be influenced by political considerations and by their personal and economic relations to various organizations in society. The debates concerning nuclear power, the greenhouse effect, and the transition from socialism to market economy in former socialist countries illustrate this.

So, the situation is not as simple as Bacon might have thought. As regards our power to improve our conditions of life it seems that science has been only partly beneficial. In particular, let us briefly consider two main dimensions or indicators of human well-being, viz. health and security.

(3) Health. For some people today, the health situation is of course very much better than it was for most people before the age of science. The progress of medical science has had the effect that many diseases have completely disappeared in certain areas, and that many of the remaining ones can be treated with excellent results. The infant mortality rate has decreased, and the average length of life has increased. In particular, this is true in the rich countries.

On the other hand, the situation is obviously much worse in the poor countries, where there is also a severe lack of medicin and effective health organizations. Thus, for example, around 40.000 children die every day in the world, and at least half of them could have been saved by quite simple means (polio vaccine, etc). Moreover, if some diseases have disappeared, others have replaced them, and some are even caused by the very technological progress which is in turn based on science. There is a shortage of food and clean water in many areas, and the environment is polluted almost everywhere. This affects people's health in a negative way. And while it is true that the average length of life has been increased in many countries, it is also true, even in the rich countries, that the quality of life is often rather bad for old people and for sick people who are kept alive by artificial means.

If we think about the state of health of sentient beings, we should also note the fact that a great many animals are are made to suffer as a result of our technological progress. Whole species are extinguished or at least severely threatened and reduced by changes in the environment brought about by us, and every year hundreds of millions of animals are killed, often in very painful ways, in scientific research.[48]

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[47] See e.g. Dorothy Nelkin (ed.), *Controversy. Politics of Technical Decisions*, Beverly Hills and London: Sage Publications, 1979.

[48] See e.g. Richard D. Ryder, "Speciesism in the laboratory", in Peter Singer (ed.), *In Defence of Animals*, Oxford: Blackwell, 1985. Ryder says: "It has been estimated that between 100 million and 200 million animals die in laboratories around the world each year" (ibid., p. 79). Another commentator says that "the total number of laboratory animals now used throughout the world anually is 200 to 250 million. The United States accounts for about 100 million of these animals as follows: 50 million mice, 20 million rats, and about 30 million other animals,

In short, it is not at all obvious that the average level of health of sentient beings has been improved as a result of the scientific development. It seems quite possible to me that it is rather the other way round. Moreover, there is really no indication that the situation can be improved by further scientific and technological progress. We already have the knowledge and the technological means to help the sick and the starving, but we do not use them. Perhaps it is, and will remain, politically impossible to do so.

(4) Security. It is possible that we feel more secure when we know more about the causes of events and about human nature, and when we do not believe that we are at the mercy of gods and evil spirits. Again, we are more secure when we can protect ourselves against wild animals, illness, and natural disasters like floods and thunderstorms. Science can be useful here. Thereby it contributes to a higher level of security, which in turn increases our welfare.

Science can also help us to defend ourselves against other people. As science has developed, the police have been provided with more efficient techniques, involving e.g. weapons, information storage systems, and a developed technology of surveillance. Similarly with the armed forces used for national defense.

On the other hand, obviously, the production and distribution of arms and other military technology also reduces security in many cases, and it has led to a lot of suffering and death. It seems that the number of wars in the world per year has been more or less constant during the rise of science, but that the average number of people killed in wars increases drastically with time. For example, 0.8 million people were killed in 92 wars in the years 1820-1859 , 4.6 million were killed in 106 wars in the period 1860-1899 , and 42.5 million were killed in 117 wars in the period 1900-1949. If the trends are extrapolated, it turns out that virtually 100 per cent of the world population will be killed in wars before the year 3000.[49] Of course, science has played an important role here. Without science, it would simply not be possible to kill so many people. And a very large proportion of scientific research has indeed been directed towards the development of weapons systems. For example, in the United States most of the economic resources used for research and development in recent decades has been used for military purposes.[50]

Besides, the application of scientific theories has created new environmental problems. For example, there are dangerous emissions from the chemical industry, there is radioactive waste

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including 200,000 cats and 450,000 dogs"; see Bernard E. Rollin, *Animal Rights and Human Morality*, Buffalo, N.Y.: Prometheus Books, 1981, p. 91.

[49] See Robin Clarke, *The Science of War and Peace*, London: Jonathan Cape, 1971, pp. 10-12.

[50] "Between 1950 and 1985, 65-70% of federal research and development funds were channeled through the Department of Defense, only 1-3% through the NSF [National Science Foundation]. (If one includes the Department of Energy, whose major focus is nuclear weapons, and the National Aeronautics and Space Administration, which is under heavy contract to the military, the military-related totals go even higher.)" Carl Mitchum, "The Spectrum of Ethical Issues Associated with the Military Support of Science and Technology", in *Ethical Issues Associated with Scientific and Technological Research for the Military* , edited by Carl Mitcham and Philip Siekevitz, The New York Academy of Science, New York 1989, pp. 1-9, p. 4.

from nuclear power plants, and so on. This tends to make our existence less rather than more secure.

(5) Education. Scientific research and higher education go together. Each presupposes the other. The scientific community will die out if it does not reproduce itself and makes itself respected in the rest of society, and higher education will become scholastic and boring if it is not intimately related to research. Moreover, it might be held that a high level of education is essential to the welfare of a population. Education will make people better equipped to solve problems, to communicate with others, and to learn from the experiences of earlier generations. It may be suggested that science has increased our freedom. It has provided new opportunities for action, and it has made it easier for people in general to choose the alternatives that they really want.

In this way, science may indeed have had beneficial effects. Moreover, this particular function of science is not restricted to natural science. Many of the human and social sciences may be even more useful in this particular respect. For example, to people in general, disciplines like economics and philosophy are probably more useful than physics and geology.

On the other hand, higher education may also generate new inequalities and preserve old ones. Scientists and educated people are privileged in our society. (Indeed, it seems quite likely that science as we know it would cease to exist if scientists were not privileged.) Besides, even if people's freedom has been increased in some respects, because of the development of science, it also seems to have been reduced in certain other ways. Harold Lasswell puts the point as follows:

> If the earlier promise was that knowledge would make men free, the contemporary reality seems to be that more men are manipulated without their consent for more purposes by more techniques by fewer men than at any time in history.[51]

In other words, even if a high level of education is desirable in many ways, there are certain aspects of it which are not desirable.

5. The overall extrinsic value of science.

What I have discussed above are the effects of *past* science. Past science may be defined as the totality of all scientific activities which have taken place in the world so far. (I have not yet been concerned with *future* science and its effects; this will be the subject of section 6 below.) Let us now consider the question of whether the overall *extrinsic value* of past science is positive or negative.

This question may be interpreted in different ways. For example, it may be taken as (1) the question of whether the total consequences of past science are on the whole good or bad or

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[51] Lasswell, "Must science serve political power?", p. 119.

indifferent. Or it may be (2) the question of whether these total consequences are better or worse than the consequences of some alternative to past science. Finally, it may be (3) the question of whether the total consequences of past science are better or worse than the consequences of that particular alternative to past science that would in fact have taken place if none, or very few, of the activities within past science had occurred. Of these three interpretations, (3) seems to be the most interesting one. It seems that our attitude towards science should depend upon our answer to this question. Moreover, I shall stick to the suggestion above that value is determined by the relative welfare of sentient beings.

However, if we reflect upon this formulation of the problem, we can see that it is far beyond our power to answer it in an intersubjectively reliable way. Even if we had access to a normatively acceptable, quantitative, and operational definition of "welfare", the combined resources of all scientific disciplines would not be sufficient to provide a reliable answer. The question of whether the psychological well-being of human beings, or of sentient beings in general, is favourably affected by past science seems to be a factual question. But science cannot solve it. It involves interpersonal (and "inter-organism") utility comparisons, large-scale conterfactual conditionals, and completely unsurveyable initial conditions which science cannot handle.

Sixty years ago, John Dewey expressed a similar scepticism concerning the future impact of science on society as follows:

> Externally, science through its applications is manufacturing the conditions of our institutions at such a speed that we are too bewildered to know what sort of civilization is in process of making. Because of this confusion, we cannot even draw up a ledger account of social gains and losses due to the operation of science. But at least we know that the earlier optimism which thought that the advance of natural science was to dispel superstition, ignorance, and oppression, by placing reason on the throne, was unjustified. Some superstitions have given way, but the mechanical devices due to science have made it possible to spread new kinds of error and delusion among a larger multitude. The fact is that it is foolish to try to draw up a debit and credit account for science.[52]

What Dewey says here is, I think, correct in many ways. However, his conclusion should be resisted. We should at least try to "draw up a debit and credit account" for science. We must realize that this cannot be done in a scientifically reliable way, but this is no excuse for ignoring the question. Science is too important an element of our culture to be taken for granted without criticism. Our attitude towards science must be based upon personal judgment, and this judgement can at best be made in awareness of arguments and considerations of the kind exemplified in section 4 above, concerning the effects of science.

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[52] John Dewey, *Philosophy and Civilization*, Gloucester, Mass.: Peter Smith 1968, p. 319.

My own judgment, for what it is worth, is that past science is probably *not* extrinsically good. We would have been better off without it.[53] In general, when its effects are beneficial, they are beneficial only to small minorities which are already quite well off. For example, the products of military science are useful mainly to arms dealers and superpowers. Other technology based on natural science is useful to industrialists and share-holders, and it also yields economic profit to other citizens in the highly developed countries. Social science may be useful to political elites by helping them to control the masses and to legitimize the policies preferred by the elites. (Of course, much social science is critical of political elites, but this makes it even more useful as a harmless token of tolerance and freedom in the society.) The humanities, finally, are usually regarded as fairly useless, at least if we disregard the personal satisfaction which they may give to some of the very few people who are actually working within these disciplines.

The thesis that past science is not extrinsically good is also reinforced by the following considerations. Science has produced technology, which has to some extent improved our material conditions of life (such as health, security, and so on). However, psychological well-being is not a simple function of such material conditions. It is more dependent upon the extent to which expectations are satisfied. And technological progress does not guarantee the satisfaction of expectations. Indeed, it may have the opposite effect. Nicholas Rescher puts the point as follows:

> There is what might be called the Fundamental Paradox of Progress: progress produces dissatisfaction because it inflates expectations faster than it can actually meet them. And this is virtually inevitable because the faster the expectations *are* met, the faster they escalate.[54]

Moreover, it seems clear that the extrinsic value of science should be taken to depend upon psychological well-being rather than upon material conditions of life. From a normative point of view, the latter are relevant only if they affect the former. Health, wealth, security, and power are not intrinsically valuable. They are only valuable as means to pleasure and happiness.

It is often pointed out that scientific and technological research is needed in order to neutralize or remove undesirable effects of scientific and technological research. More sophisticated weapons are needed to counteract the sophisticated weapons already in existence. New energy systems must be deviced in order to prevent or reduce pollution of the environment. And so on. Similarly, it might be held, higher education is required in order to avoid alienation and apathy among ordinary people in scientifically and technologically advanced societies. This

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[53] Quite possibly, many people in the rich countries today would find life intolerable if they were moved, miraculously, back to the 17th or 18th century. But this does not show that humanity is happier now than it used to be. Nor does it show that humanity is happier now than it would have been without science.

[54] Nicholas Rescher, "Technological Progress and Human Happiness", p. 19, in *Unpopular Essays on Technological Progreess*, Pittsburgh: University of Pittsburgh Press, 1980, pp. 3-22.

means that a high level of education in a population is perhaps best thought of as an antidote against the bad effects of science. In short, it might turn out that the main use of science nowadays is to protect us from the bad effects of science.

This point has some relation to the much discussed question of the rationality of science. Some philosophers think that the development of science is governed by a series of rational choices on the part of the scientific community.[55] But even if each individual choice is rational, the enterprise as a whole may be irrational or non-optimal. Individual choices may be rational relative to the internal aims of science, but if past science has left us worse off it seems irrational from the point of view of humanity.

6. Prospects for the future.

If I am right, science has not been a good thing so far. What about the future? The first point to be noted here is that future science is to a large extent unpredictable.[56] And if the content of future science is unpredictable, so are its effects. It is easy to suppose that the future will be like the past. But such an induction is extremely risky. Most of us may take it for granted that science will continue to grow as before, but there is really no justification for such a belief. There may be a saturation limit to the growth of science.[57] In fact, we may be close to such a limit right now. And if there is stagnation, there may also be decline. This possibility is recognized by Bernal:

> The continued existence of this institution of science is in general far too easily taken for granted; because science in its association with industry has in the past made such enormous progress, it is assumed that this progress will automatically continue. Intrinsically, however, there is no more justification for continued progress in science than for continued progress in industry. … We have seen, in the course of history, institutions grow up, stagnate, and die away. How do we know that the same will not happen to science?[58]

In any case, even if past science has been extrinsically bad, this may not be true of future science. However, it is hard not to be pessimistic. Michael Dummett makes the following prediction:

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[55] See e.g. Newton-Smith, *The Rationality of Science*. For the view that rationality is not very common and not very desirable in science, see e.g. Lars Bergström, "Some remarks concerning rationality in science", in Risto Hilpinen (ed.), *Rationality in Science*, Dordrecht, Boston, and London: Reidel, 1980, pp. 1-11.

[56] This point is stressed e.g. by Karl Popper in the "Preface" to *The Poverty of Historicism*, London: Routledge, 1961.

[57] "In its typical pattern, growth starts exponentially and maintains this pace to a point almost halfway between floor and ceiling, where it has an inflection. After this, the pace of growth declines so that the curve continues toward the ceiling in a manner symmetrical with the way in which it climbed from the floor to the midpoint", de Solla Price, *Little Science, Big Science*, p. 18.

[58] Bernal, *The Social Function of Science*, p. 11.

> For it seems to me evident that, were the option a live one, there exist overwhelming grounds for bringing *all* scientific research to a halt. Of no reseach is it possible to foresee what applications will be made. Even so intelligent a man as Rutherford is reported to have thanked God that his research was practically useless; but we have no excuse for making a similar mistake. All that we can say with confidence is that, of the scientific research carried out within any given future period, much of it will have applications, some of them quite unexpected, and that, of these applications, most of those that yield unqualified benefits for mankind will either be unexploited or, at best, used to enhance the lives only of people in the wealthy nations, while some will, for certain, be used to create as yet unimagined dangers and horrors.[59]

I think Dummett is wrong when he says that this prediction can be made "with confidence" and that we know this "for certain", but the content of his prediction may very well be right. It seems to me that if well-informed people disagree on the validity of Dummett's prediction—as they can be expected to do—their different views are caused mainly by different personality traits. Some people are optimists and some are pessimists, and this is all there is to the disagreement.

Dummett is probably right that we *cannot* bring all scientific research to a halt—except, of course, by starting the last world war. However, we might be able to discourage and reduce certain kinds of research by re-allocating the available economic resources to other disciplines or to non-scientific projects. As a rule of thumb, we might even assume that the more "useful" (in a conventional sense) a given field of research is considered to be, the more dangerous it is, and the less money should be invested in it. In particular, it may be a good thing to invest less money in disciplines which tend to generate technological applications. Some of the money spent in this way could instead be absorbed by the humanities, which are fairly harmless.

It is sometimes said that curiosity is part of being human, and hence that if we stop doing science, we stop being human. But this is mainly rethoric. In conclusion, three points may be noted. First, we can be curious even if we are not scientists, and even if there is nothing like modern science around. Second, even if we continue to do science, we can concentrate upon the more harmless disciplines. Third, many people are *not* curious in the sense of being interested in science, but we should not conclude from this that they are not human.

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[59] Dummett, "Ought research to be unrestricted?", p. 291.