# The Bias of Science

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I would be most pleased to receive comments, criticism or suggestions from any reader, and to further discuss the material here. I may be contacted C/- Society for Social Responsibility in Science (A.C.T.), P.O. Box 48, O'Connor, A.C.T. 2601, Australia.

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# Foreword

"Science is but one special and actually rather small part of knowledge, whose truths depend on the social beliefs of the time and the cultural atmosphere in which they are created."[1]

"No theory is moral and no theory is immoral. The question of morality does not apply, it just does not arise."[2]

"He [Wittgenstein] believed that the dominance of scientific thought since the Renaissance is a disaster. For it drives us to assimilate other modes of thought to science and, as a result, we misconstrue them and misunderstand them."[3]

"[The Committee] unanimously agreed that it could find no substantiated scientific evidence of a causal link between the use of 2,4,5-T and human birth defects . . . In the light of present knowledge there is no reason to place any restrictions on [it]."[4]

"The scientific assessment is clear that no one in Australia need worry[5] . . . The risks . . . from fallout . . . are insignificant in comparison with the normal hazards of everyday life.[6]"

"Under emergency conditions, even with the severest rationing, more than 50 per cent of current liquid fuel supplies will be required to maintain normal industrial activity."[7]

These quotations offer a small sampling of different attitudes concerning values in science.[8] Some of the quotations provide examples of value judgements made by scientists in the course of 'scientific' assessments of real world problems. They lead us to consider the following questions:

- What kinds of scientific thought and activity contain value judgements?
- How do values enter science?
- What social effects do they have?
- In particular, whose interests do they serve?

These questions are important because science has become an arbiter of resource, environmental and health issues, a reference frame for 'objective' information and decision-making, and even a basis for ethics and morality.[9] Scientists dominate expert committees which advise governments. Business and advertising, education and the press, all pay homage to science but also make use of science. Riding on the crest of the wave created in the Golden Age of Modern Physics of the 1920s and 30s, the 'scientific method' has come to dominate the social sciences and even the humanities. Much that is fresh, original, beautiful or socially relevant in human thought has been neglected or rejected because it is not measurable, because it is not 'scientific'.

Recently, however, there have been the beginnings of an awareness that science is not necessarily ethically neutral. Concern has been activated by the apparent increase in environmental, health, social and economic problems in the rich countries, despite an increase in gross national product; by a growing suspicion that science and technology tend to benefit certain groups in the population much more than others; and by the feeling that scientists, working together with powerful bureaucracies in both East and West, have been pushing society towards a more centralised, complex, high-energy, unstable state in which there could be massive unemployment and little participatory democracy.

As an expression of the new awareness, scientists have produced new journals of social relevance — for example, *Science for the people* (U.S.), *Radical science journal* (U.K.), *Undercurrents* (U.K.) and *New doctor* (Australia) — and sociologists have established a thriving critical study of the social impact of science. Philosophers have pointed out that areas such as energy policy, which in Australia are completely dominated by engineers, contain major ethical issues: for example, should the interests of future generations be neglected in comparison with those of the present generation?[10] A recent series of Australian examples of the bias of scientists has exhibited their conflicts of interest and their tendency to misdefine social and ethical questions as purely scientific ones.[11]

The appearance of *The bias of science* is therefore timely. It triggered an extremely stimulating discussion meeting of the Society for Social Responsibility in Science (A.C.T.). Not everyone agreed with Brian Martin's conclusions. In particular, several members feel that he has not established that bias is inherent in such areas of science as electronics, high energy physics or pure mathematics, in which systems can be well defined and can be settled by experimental tests of internal consistency. However, in many real world problems, complete information may be forever beyond our grasp and so it is certainly clear in these cases that value judgements must inevitably be made in choosing data and in giving weight to different observations.

Following these discussions, there has been strong agreement that this book raises important issues which are in great need of consideration by scientists and non-scientists alike.

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Society for Social Responsibility in Science (A.C.T.)

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# Introduction

According to the modern radical critique, science* is organised to serve production and profit and to enforce social control. This perspective may be obvious to some. But to others it is merely a meaningless or a false generalisation. For many scientists, the trouble with such a statement is that it doesn't have any connection with their day-to-day work. To most researchers, scientific work seems harmless if not positively beneficial to society.

This book seeks to begin to build a bridge across the gap between the working life of the scientist and the entry of values from the wider society into science and into the scientist's work. As such, it is not an attempt to 'prove' that science is organised for production and profit. There are two basic stages involved in this bridge building. The first is an illustration of how value assumptions enter into scientific arguments at a detailed level (parts I to III). The second stage is a description of some of the fundamental value assumptions underlying the scientific enterprise as a whole (parts IV and V).

The values I am particularly concerned with are political values, having to do with the distribution of political and economic power in society. The value assumptions underlying science which are analysed in parts IV to V are ones which make science selectively useful to powerful groups in society. Thus, an analysis of these values becomes a political analysis of science. Parts IV and V will certainly seem political in nature to some readers.

The trouble with a political analysis of science is that to many people involved in science at a practical level, science does not seem political. It is for this reason that I start with a detailed technical analysis of two scientific research papers, and only gradually expand to wider perspectives. The research papers (part I) and my analysis of them (part II) are presented to show the nature of bias in scientific research at a detailed level. Then in part III the perspective is widened. The point of view is that of attitudes and values of scientists and of the scientific community. From this perspective, bias is seen as a natural part of scientific research. The analysis in part III ranges from general assumptions made by scientists about what they are trying to prove, to the way in which values may be embedded in the context in which research work is done.

In part IV the perspective on science is broadened. The fundamental values underlying scientific research, and their relation to different groups in society, are considered. For example, I argue that scientific research is not equally useable — accessible, understandable and exploitable — to all groups in society, and that this selective usefulness of scientific research serves a political function. The chapters in parts II and III are mainly concerned with values expressed in individual research papers or held by individual scientists. The chapters in part IV are concerned with values which are built into current science in a fundamental way. These values are expressed in established research practices, in the organisation of the scientific community, and in the content of scientific knowledge.

Finally, part V is an overview of the politically based values in science from the perspective of what an alternative science might be like. The alternative science which I describe is one in which there is maximum participation by the public in decision-making about science and in the doing of scientific research. The perspective of 'self-managed science' is sufficiently different from current science to strongly highlight the values underlying current science.

There is an enormous difference between the levels of analysis in part II and part V. This may create problems, as several readers of the manuscript have warned. The early chapters are much more technical and rigorous; the later chapters treat broader questions, and therefore will be much more accessible to many people. The solution for some readers may be to get through the early technical chapters by skimming or jumping, thereby arriving more easily at the later, more accessible chapters. Since there are summary or conclusion sections at the ends of the early chapters, and because the technical content is greatly reduced by about chapter 7, this course of action seems reasonable. An alternative might be to read the chapters in reverse order! But I have left the chapters in their present arrangement because it is the more logical order, if not the most readable one for everyone. Note that sources for all quotes and works mentioned in the text are given in the reference notes at the end of each chapter.

*Definitions of 'science', 'value-laden', and a few other important terms are given at the end of the introduction.

The rest of this introduction is an expanded overview of the book.

The two scientific papers of which a case study is made are concerned with the effect of exhausts from supersonic transports, such as Concorde, on the upper atmosphere. These papers are reprinted in part I, along with a glossary of some of the technical terms in the papers, so that they can be read and inspected directly. It is true that scientific papers are a rather unrealistic and pale reflection of scientific practice. Nevertheless, there is a great difference between studying a scientific paper oneself and making judgements on the basis of it, and merely accepting the word of an 'authority' about what science is really like.

In part II my argument is that certain features of the scientific arguments in the two papers can be seen as being manifestations of 'pushing'. The authors do not seem to make a balanced selection of assumptions and evidence or a balanced presentation of results. Instead, they appear to select and orient their arguments towards a particular conclusion. I have chosen to elaborate on this aspect of the papers partly because it differs from the conventional stereotype of scientific practice.*

A further reason why I have chosen to select 'pushing' in the two papers for analysis is that I wish to reinterpret this pushing by looking at it from another view. In the first chapter in part III the arguments in the two scientific papers are reinterpreted as being due to assumptions, built into the construction of the scientific arguments, made by the scientists about what they were trying to do. The scientific arguments in the papers thus can be looked at from at least two perspectives: in terms of pushings of the argument, and in terms of presuppositions underlying the arguments.

The later chapters in part III amplify this double perspective. In chapter 6, I demonstrate how presuppositions underlying a scientific argument may be inferred. In chapter 7, I present evidence that pushing of a scientific argument is not unusual in terms of what is known about the personalities of scientists and about the way science develops. And in chapter 8 I argue that presuppositions like those underlying the two papers are common in scientific research.

In short, the object of parts I to III is to show *how* values can enter into scientific research at the immediate research level.

The argument in part IV is that there are a number of fundamental presuppositions underlying all scientific work. These presuppositions may be considered to be the answers to basic questions. Who does scientific research? What are the consequences of scientific research? What practices does scientific

*Some people may argue that if these authors make an unbalanced selection of evidence or unduly favour one explanation, then the authors are less than 'scientific'. I reject this viewpoint entirely. My view is that an understanding of science should be based on a study of the practice and products of its capable practitioners, among whom I believe the authors of the two papers included herein certainly belong. If capable scientists do not conform to some ideal conception of what is 'scientific', then this conception should be revised rather than deviations from it being treated as illegitimate.

research justify? The answers to these sorts of questions are called *pre*suppositions because they are solidly built into the current practice of science and into scientific knowledge. As assumptions they are most unrecognisable from the point of view of the day to day work of scientists. "The bias of science" refers not to the bias of scientists, which of course exists as well, but to these fundamental presuppositions underlying science.

An example may help. One feature of science is that only certain select people are scientists, and that the bulk of the populace are not. This feature has ramifications. The very idea of the scientific community is based on this feature. The practice of science has developed and is geared so that only highly trained and specialised people can do it. And scientific knowledge is organised so that only such people can understand it, generate it, and use it. The scientific community, the practice of science, and scientific knowledge are based, to a greater or lesser extent in each case, on an assumed answer to the question, "who does scientific research?"

It is useful, as a first approximation, to think of different presuppositions underlying science as being at different levels. At an individual or personal level, individual scientists can be and are dogmatic and biased; they make assumptions about the directions, uses and conclusions of their work. At the level of research organisations, the organisations for which scientists work have vested interests in certain types of research and in obtaining certain types of results. At the level of scientific disciplines, it is implicitly assumed that it is useful to single out particular aspects of the universe for study, and advantageous to study them in special ways. At the level of the material organisation of society, pressures for the selective development of science and for specific applications of scientific knowledge lead to the development of tools useful primarily to select groups. At an ideological level, scientific theories can provide justification for policies and practices, or provide the authoritative and exclusive plane for discussion. At the level of perception and cognition, some ideas are harder to express and promote than others. This is due to the particular concepts available in language and to the constraints implicit in perceiving on the basis of past experience and in the existing context.

The other important argument in part IV is that many features of the current structure and organisation of science make science selectively useful to powerful groups in society. This of course should not imply that there is a 'plot' or even concerted action by elites in society to manipulate science for their own ends. But it should be expected that powerful and privileged groups in society will adopt policies and promote practices concerning science which lead to scientific developments selectively useful to them, and for them to invoke reasonable sounding justifications for these policies and practices.

Throughout parts III and IV, wherever possible I use illustrations from the research area of the two scientific papers presented in part I and analysed in part II. One advantage of this research area is that it is not so dramatically value-laden or distorted by social and political influences as is some scientific research, as in the area of race and I.Q. or the biological effects of napalm. Therefore an analysis of how values enter into this scientific area is less easy to dismiss as being concerned with an exceptional case. On the other hand, the two scientific research papers are still far from typical, being concerned with a topic of some social significance, and in which the data allow a considerable range of scientific opinion. This again is an advantage: the subject matter of the papers is not totally boring, and the values associated with the research are relatively easy to discern. In various places I present arguments and evidence which indicate that my conclusions apply much more widely than to these two papers. In particular, the reference notes provide a survey of some relevant studies. However, my aim is not to document the input of values into scientific research in every case, but to present a perspective from which it is possible to understand how such a process takes place.

My claim is that the more basic presuppositions, such as the answer to the question of who does scientific research, are built into science in a fundamental way. In other words, one cannot do scientific research, or conceive of current scientific knowledge or institutions, without at the same time accepting many assumptions currently built into the structure and organisation of the scientific enterprise. It is commonly presumed that these assumptions are natural, inevitable, and that science could not go on without them. Therefore they are not to be questioned, or even mentioned. My view is that the presuppositions underlying science should be brought out into the open. My hope is that many of them will be challenged and replaced. Perhaps the result will be a science so different from the present one that it should be called by a different name. The subject of part V is one such alternative science, 'science' in a self-managed society.

Since my aim is to present a perspective for understanding science, I have not mentioned or treated the many alternative interpretations to mine. In my opinion, a large majority of them are merely convenient justifications for the current state of affairs. In most cases I disagree with the fundamental assumptions on which these interpretations (or justifications) are based. My aim is more to try to expose the assumptions and their implications than it is to answer every objection.

Even so, it is difficult to avoid responding to other views on occasions. For example, my treatment of the seamy side of the behaviour of scientists is a response to the prevalent view that in their work scientists are a cut above the average moral standard. The danger posed by other views, which I may not have overcome, is being trapped within the realm of discourse established by prevailing explanatory frameworks.

It is worth noting that my argument is very one-sided in being apparently pessimistic: I treat in detail the mechanisms by which science is conditioned to sustain the prevailing political and economic order, but do not treat the forces which create challenges to this state of affairs. There is some justification for this: the challenging forces from within the scientific community seem at the moment to be very weak. Science may be in a state of crisis, but this is due much more to cuts in funding than it is to a challenge by scientists to the institutions in society which condition their work. Even so, this lack of treatment of countervailing forces and potentialities is an important limitation and should be kept in mind.

Finally, I hope it is clear that this work is meant to be self-exemplifying. If I say scientists are biased, then I am biased too. I select my evidence and push my arguments. If there are presuppositions underlying science, there are presuppositions underlying my own endeavour. I hope that the bias in my arguments and the presuppositions underlying my analysis make this work selectively useful to the interests of the community at large as freely pursued by members of that community.

## Explanation of some terms

By 'science', I usually refer simultaneously to several conventionally recognised entities. The first of these is a set or body of beliefs about the world which are accepted by acknowledged experts or authorities in science. This I refer to as scientific knowledge. The second is a method of achieving these beliefs. This is not necessarily the so-called scientific method, the existence of which is in some dispute. More generally, it refers to the actual procedures and actions which scientists use to attain scientific knowledge. This aspect of science I refer to as the practice of science. The third component is a socially rooted institution, the interacting community of people who practise science. This I usually refer to as the scientific community. Scientists, then, are people whose collectively accepted beliefs about the world define scientific knowledge, who practise science, and who are members of the scientific community. There are other features of science as well, whether explicit or not, such as a philosophy and an ideology. When I refer to 'science' without qualification, this usually refers to any or all of these components, each to a greater or lesser extent depending on the context. Naturally these components interact; the distinctions are for convenience of discussion.

I refer only to 'modern' science, the science that has developed mainly in Western Europe since the 1600's. Also when I speak of science, usually I am thinking of physical, natural, or 'hard' science. This refers to physics, chemistry, and parts of geology and biology. Much of my analysis will apply to other disciplines, such as the social and behavioural sciences. Indeed, much of what I say should be obvious to social scientists, among whom there are a relatively large number who reflect on the assumptions underlying their work, and on the social implications of these assumptions. Perhaps all I am trying to do is to argue that certain features of science, which are well recognised by many people such as social scientists, also are characteristic of physical science.

By presuppositions (in part IV), I mean constitutive assumptions: if a given presupposition underlying science were altered, then most likely science would be changed considerably. In the philosophy of science, presuppositions are generally taken to be concerned with scientific knowledge. For example, the attainment of and content of scientific knowledge may be dependent on the assumption that nature can be described by mathematics, that perceived order in the past will persist into the future, and so forth. I use the term presupposition in a much broader sense, to refer to assumptions underlying the practice of science, the community of science, the social uses of scientific knowledge, and so forth. In many cases my phrase 'presuppositions underlying science' may be replaced by 'features of science'. By referring to presuppositions I imply that the features of science in question are fundamental to the current scientific enterprise. A science based on different presuppositions would be a qualitatively different science.

Two further points about the idea of presuppositions are worth making. First, the idea of presuppositions does not necessarily imply that changing science should be, or could be, approached and effected by changing the underlying assumptions. Presuppositions do not cause science, but rather are characteristics of it. Second, most presuppositions underlying science are implicit: few people are aware of them. But the defining feature of a presupposition is that science could not, or would not, exist or be carried out in a given manner without a certain assumption being made.

By 'biased' or 'value-laden' I mean conditioned by social and political forces, and dependent on judgements and human choices. These terms are not meant to imply that it is possible for science to be unbiased or value-free. Closely related to these terms is the idea of selective usefulness: usefulness for some purposes more than other purposes.

'The people', 'the public', and 'citizens' refer to all the people in society, as distinguished from scientists (who are a small professional group) or powerful elites. Only in part V, where I talk of science being done by all the people, does this terminology become inconvenient; this difficulty points up the need for a new name for science in a qualitatively different society.

In speaking of the political and economic structure of society, I speak either of 'powerful groups in society', or 'inequitable political and economic institutions'. These different phrases reflect different ways of looking at society structured in a way that leaves most people relatively powerless, and which is far from optimally serving the interests of all people. To speak of political and economic institutions is to emphasise the structures which condition all actions: changing individuals or policies without changing the structures does not change much at all. To speak of powerful groups in society is to emphasise the asymmetry of decision-making power, and remind one that political and economic institutions are composed of people.

## Reference notes

The 'modern radical critique', in which science is seen to be organised for profit and social control, is expounded in Rose and Rose (1976, 1976a), the British magazine *Science for people*, and the U.S. magazine *Science for the people*.

The breakdown of 'science' into different aspects is common practice in studies on science. My treatment is conventional, except the description of scientific knowledge as beliefs accepted by the scientific community, which is taken from Barnes (1974). However, the analysis in part IV would mostly be unaffected under a more conventional interpretation of scientific knowledge, such as the one that considers it to be an approximation to the 'truth'.

Benjamin (1951) usefully analyses the meaning of the presuppositions by scientists about the way nature is. He concludes that the significance of these presuppositions stems from the fact that if these beliefs were shown to be false, science would lose its justification. My own analysis of features of science can be called an analysis of presuppositions underlying science by a generalisation of Benjamin's perspective.

For analyses of inequitable political and economic institutions in Western capitalist democracies, see Domhoff (1970) and Miliband (1969).

# Part I: Two scientific research papers

Two scientific research papers are reprinted in this part, followed by a glossary covering the basic technical terms used in the papers. I had several reasons for getting the papers reprinted. One is to give you the chance to look at them and study them, and to draw your own conclusions about science on the basis of them. Another reason is that I analyse the papers from different points of view in parts II and III. It is only fair that if I evaluate and criticise the arguments in the papers, that the authors of the papers be allowed to speak for themselves as well. Also, looking at and drawing conclusions on the basis of the papers, and of the research area in which they fall, forms a good basis for analogy when I make an analysis of science as a whole in part IV.

You may feel that it is quite beyond your ability to understand the scientific arguments in these two papers. Many people develop a mental block against anything to do with science or mathematics. Such an aversion usually results from science and mathematics courses. Incidentally, scientists do not discourage the idea that some special innate ability is required for understanding science. There is little evidence for this idea, although it is certainly flattering to scientists. In any case, before you give up trying to understand the papers, let me make a few comments.

First, understanding scientific research is not so hard as it is made out to be. Although science students are not usually given research papers to read until they begin research themselves, most students are capable of understanding scientific research papers at a much earlier stage. H. T. Epstein has developed a highly successful learning/teaching method based on the reading and discussing of scientific research papers by people with little or no background in science. Typically this involves first year university students reading a series of research papers under the direction of a researcher in the field of the papers. The aim for the students is to gain an understanding of what scientists do when they do research. In addition a considerable amount of scientific knowledge is learned in the process. The students do not have to be science students, and the method has been used with non-university groups as well. The success of Epstein's method indicates that understanding scientific research papers is not beyond the ability of the average person.

Second, for parts II and III it is not necessary to understand the details of the scientific arguments in the two papers. Instead, I will be trying to highlight certain assumptions behind the arguments. To understand these assumptions does not require a great deal of expertise or an extensive background in the field.

Indeed, a great depth of understanding or expertise in the field may make it more difficult to follow some of my arguments. This is because often there is associated with detailed understanding and expertise an immersion in the assumptions underlying the research. In other words, making certain basic assumptions is often a necessary preliminary to getting down to understanding scientific arguments. In analysing some of these assumptions, in some cases it may be that the non-specialist or non-scientist is better able to observe and comprehend them than the specialist or scientist.

Finally, it may be useful to describe what scientists generally mean by 'reading' a scientific paper. When scientists say they have 'read' a scientific paper, this usually refers to what other people might call skimming or glancing over the material. Typically, the only parts of scientific papers actually read by scientists are the abstract, the introduction, and the conclusion, with glances at the length and technicality of the experimental or theoretical details of the argument, the results, and the references. Usually the only scientists who read a paper thoroughly are those who wish to relate it to their own research, or base their research on it — and even then these scientists may only do a careful reading and study of an isolated part of the paper. It is true that scientists can quickly grasp the essentials of a piece of research, by putting it in the context of their experience in the field. On the other hand, the purposes that a scientist has in reading a research paper are different from my purposes here in encouraging you to read (or 'read') these papers.

If you wish then to get the essential ideas of the papers while omitting as much technical detail as possible, I suggest the following: for Johnston's paper, page 517 up to the reactions, the paragraph including equation (1) in column 2 of page 518, Figure 2 on page 521, and the final paragraph of text on page 522; for Goldsmith et al.'s paper, page 545 up to the section "Shock wave", the section beginning on page 548 "Nitrogen oxide production by Concorde" up to the last paragraph on page 549, the second full paragraph after Table 4 on page 550 and the concluding section "Implications". In making these suggestions I beg the pardons of Johnston and of Goldsmith et al., who no doubt would claim that a full understanding of their work requires study of all of their papers, if not considerable further reading, study and background knowledge as well.

Another alternative is to start reading my analysis in Part II, and refer to the papers when you feel it is necessary.

After saying all this about how most people can understand scientific research given the right conditions, it would be unrealistic if I didn't concede that most people will find these papers very hard indeed. Several friends with good science training have commented on how discouraged they became trying to read the papers in full detail. There are difficulties. Johnston's paper is not well organised, probably because it was rushed into publication. Goldsmith et al.'s paper leaves out many of the technical details. This is usual practice, but it makes it hard for non-specialists to gain a confident understanding of the material. Johnston does include most of the technical detail, and in this respect I consider his paper to be an unusually valuable one for study purposes.

So understanding the two papers is not easy. A considerable amount of study and familiarity (that is, conscious and unconscious thinking) probably will be required before confidence in thinking about the material can be obtained. I only suggest that a useful degree of understanding is not inherently impossible.

## Reference notes

Epstein's method for learning science and learning about science is described in detail in a book (1970) and summarised in an article (1972).

Garvey and Griffith (1964), in describing the methods of scientific communication in psychology, refer to their finding that to a scientist 'reading' a paper most often means just skimming.