THE USES OF EXPERIMENT

STUDIES IN THE NATURAL SCIENCES

EDITED BY

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Van Helsing: 'He is experimenting, and doing
it well.'
Harker: 'But how is he experimenting? The
knowledge may help
us to defeat him!'

Bram Stoker, *Dracula* (1897)

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PREFACE

Experiment is a respected but neglected activity. It is a commonplace that experiment is one of the hallmarks of science. Since this bit of conventional wisdom happens to be true, it is all the more surprising that students of science have paid so little attention to how and why this particular activity has become so significant. Of course, the *results* of experiment – observations and data – are universally acknowledged to be important. These outcomes have received much attention from philosophers and the influence of experimental results is largely taken for granted by historians of science. Thus it is common to treat science as nothing more than sets of statements about how nature is. In such a picture, there is no place for the practical activity which gives these statements their power. So the *process* of experimentation is taken to be either unproblematic or uninteresting. This account of science licenses a neglect of the process by which meaning is made. The neglect of experiment is symptomatic of a prejudice against practical activity and in favour of speech acts. Epitomised by the linguistic turn in philosophy, this vision of western science seeks to preserve scientists' power over the world while distancing their reasonings from practical engagement with that world. That such a literary and cerebral activity might have such authority over our imagination and even our experience is not surprising, since many other aspects of our culture do so; we think it *is* surprising that it could also have power over nature.

Many students of the accomplishments of western science will find these claims contentious. Experiment generates results which do not appear to depend on any of the features peculiar to experimenters' practices. After all, one of the most striking attributes of natural science is that its statements have such general, if not universal significance and practical application in settings very distant from those in which

they were first constructed. We contend that the practicalities and particularities of experimental work are central to the understanding of the success and power of what scientists do. Far from denigrating intellect, we argue that its power is not really appreciated unless we recognise that it deals with the practicalities of a natural, material and social world and not only with disembodied, self-evident phenomena. Recognising experiment's significance even implies a new view of the uses of theory.

Experiment is more interesting and significant than the received stories about science imply. Study of experimental work shows that the ways in which scientists' endeavours give rise to their statements about nature help explain the content and influence of those statements. There are features of experiment which illuminate the means scientists use to transform specific events in the laboratory into general world-views. A key aspect of this process – also a perennial problem of philosophy – is the move from the particular to the general. According to one received view of science, the solution to this problem lies in similarities between the structure of nature and the processes of the mind. Such an account pauses only briefly to contemplate this version of the problem of generalisation. More considered and informative studies of experimental work show two results of importance. First, the production of universals implies a co-ordination of particular experiences. Experimental work sets out to achieve this. Similarities between such structures are not ready-made universals disclosed in experience – they are made by people. The second finding is that creation and construction are integral to what experiments show. The experimenter's task is therefore the persuasion of others. The experimenter is never alone with nature: there is always an audience, real or implied, which must be addressed and persuaded that what one experimenter makes is meaningful and important even in their very different circumstances. Experimental products must make sense for these others, and this sense is made successfully only if the original experimenter can enable the meaning of a trial to transcend the space in which that trial is performed. Experimental reasoning will try to get rid of any feature of a trial which ties it to particular settings.

Is science so different from the received view? If so, then it is extraordinary that much philosophical ink has been spilt on a view of science bearing little relation to actual practice. Here, we must acknowledge that scientists' own accounts often support the received view in two ways. First, their published accounts of their use of experiment show that experiment speaks directly to theoretically well-formulated prob-

lems. Second, they seek to show that decisions between alternative theories seem to rest wholly on the verdict of experiment. In scientists' accounts, experiment appears to invoke nature as an independent judge of the questions scientists put to her. This is because their public accounts focus on results and the arguments for them. Given that the purpose of science is to transcend the particular, there are good reasons why scientists may ignore the vicissitudes of construction and discovery. It does not follow that a similarly restricted view of science is appropriate for disciplines with other objectives and responsiblities, such as philosophy, history or sociology. Students of science need to examine actual practice, not merely reconstructed practice.

Like a growing number of historians and sociologists, and not a few scientists, contributors to this volume want to show why experiment is more interesting and more important than traditionally realised. This importance warrants careful attention rather than honorific neglect. We focus on different uses of experiment as a way of drawing attention to the range and diversity of experimental activities since the sixteenth century. A glimpse of this diversity may be gathered from the rare but welcome focus on experimental practice in the studies collected by Conant in *Harvard Case Histories in Experimental Science* (1948) and by Harré in *Great Scientific Experiments* (1981). Experiment has many uses apart from supporting or refuting knowledge claims: active observation, invention, the construction of models, imitation of natural phenomena, or the design of instruments to extend the senses. Not the least important use is the provision of evidence for rival philosophies of science, even if this support usually relies on a cursory account of experimental work. Our case studies include Galilean mechanics, Newtonian optics, early Victorian electromagnetism, experiments on insects, on clouds and thunderstorms, on quarks and on the accuracy of nuclear missiles. This sample hardly exhausts the fields in which experiment matters. Generalisations across such a range are likely to be provisional and we do not imply that there is some essential and unchanging activity called experiment. Yet there are some important lessons about the way this kind of human activity has developed and the uses it serves. These include human agency and skill, the role of persuasion and of rhetoric, and the significance of the site of experiment and of instrumentation both to learning and persuasion.

There is a surprising degree of unanimity both in the analytical resources which our authors use to study experiment and the image of experiment which they develop. Tools drawn from disciplines such as historical epistemology, constructivist sociology and literary criticism

are used here to imply an account which sees experiment as an active process of argument and persuasion: human agency in the production of agreement about the contents of nature becomes the principal locus of enquiry in the studies which follow. Yet those seeking a new revisionist orthodoxy in this collection of studies and reflections on the experimental life and its implications will not find it here. Within the limits imposed by their admirable restraint, contributors have developed rival arguments and the editors have been keen to encourage this debate. To aid this process we have grouped the chapters in five parts, each representing a theme central to understanding experiment: instrumentation, the deployment of experiment in written argument, the realisation and representation of phenomena, the constituencies which use and perform experiments and relationships between experimentation and testing for reliability. In our introduction, we offer a survey of the contents of this book and indicate some ways in which studies of experiment might develop in the future. The selected bibliography at the end of this volume was assembled by inviting contributors to nominate titles from chapter references which they considered to be of general importance. It contains few studies which predate 1960; even fewer from classical philosophy of science. No doubt a citation analyst is already at work, charting this feature of our referencing patterns. We are convinced that the scarcity of older work which seems helpful is a mark of welcome reorientations in science studies, not a consequence of the discipline's modish ignorance and neophilia.

This book arises out of a meeting at Bath in September 1985, one of the first conferences devoted to experimentation in the natural sciences. The organisers were surprised and overwhelmed by the response to initial soundings which showed that a large audience was concerned with the process of experiment. The book is not the proceedings of this conference (only 14 of the 39 papers given at the conference are published here). The collected papers have been substantially revised and, in some cases, such as the chapters by Geoffrey Cantor and Jim Bennett, we should signal that these are contributions explicitly commissioned by the editors as comments upon the other papers in their respective sections. Allan Franklin has revised a chapter from his recent book *The Neglect of Experiment* for inclusion here.

Such a project incurs many debts. This is an appropriate place to thank those other contributors and discussants who made the conference a success, and Joyce Brown and Eve Gonty, who ran the show. We also thank the British Society for the History of Science, British Society for the Philosophy of Science and the Science Studies Group

of the British Sociological Association, who co-sponsored the meeting, and the Royal Society and the International Union for the History and Philosophy of Science, who provided funds towards travel expenses of some of the overseas contributors. Frank James, at the Royal Institution Centre for the History of Science and Technology, has offered hospitality and encouragement on numerous occasions. We are also very grateful for help, whether deliberate or unwitting, from our friends and colleagues Harry Collins, Steve Shapin, Jan Golinski, Alan Simpson, Owen Hannaway, Mike Dennis, Rom Harré and Pat Burdett. The following have generously permitted us to use illustrations and other material: Cambridge University Library, the Masters, Fellows and Scholars of Churchill College in the University of Cambridge, the British Museum (Natural History), the British Library, the Institution of Electrical Engineers, the Public Record Office (Kew), the Science and Engineering Research Council, Edinburgh University Library, the Edinburgh Meteorological Office, the Royal Society, the Staatsbibliothek Preussischer Kulturbesitz at Berlin and the Museo di Storia della Scienza, Florence. We express our gratitude to Susan Sternberg and her colleagues at Cambridge University Press, as well as to an anonymous referee for very helpful comments and criticism. The editors thank all the contributors to this book for their unstinting patience, forbearance and goodwill. Trevor Pinch and Simon Schaffer take this opportunity to indicate their gratitude to David Gooding, who has carried the mass of administration, coordination, and sheer hard work upon his shoulders. As a result, of course, all the errors are his responsibility alone.

David Gooding
Trevor Pinch
Simon Schaffer

Bath–York–Cambridge October 1987

In the 1993 impression we have added to the select bibliography on p 467, a number of monographs and collections of studies of experiment in the natural sciences which have appeared since 1987.