Book Review Section

Compiled by John Jenkin*

John A. Schuster and Richard R. Yeo (Eds.), *The Politics and Rhetoric of Scientific Method: Historical Studies — Australasian Studies in History and Philosophy of Science, Vol. 4.* Dordrecht: Reidel, 1986. 305 pp., $106 approx.

I have always wondered how ancient navigators could, in the name of their Sovereign, occupy territories dozens of times greater than their own simply by planting a flag and saying a prayer. This interesting book is about the ways tiny groups of scientists are able to plant a flag and claim ownership of vast domains they will never be able to fully colonize.

Is science universal? Of course it is, or such is, at least, what used to be its most essential trait. Beliefs, religions, customs, laws, even ethics are hopelessly local and peculiar, but the results of science escape these contingencies and are universally valid. Indeed, this is a tautological definition: there are valid scientific results only in so far as they are universal.

Then things began to deteriorate. Studies by historians, sociologists and even anthropologists tended to break down the universality of science and replace it by local, technical, crafted, idiosyncratic achievements. Writers as different as Duhem, Koyré, Kuhn, Collins and Shapin made many diffident about the universality of scientific principles. A new, much more fragmented picture of science started to emerge. Universality is a pleasant myth of science as it is taught, but it is not a property of science as it is made. Sciences are no more universal than the freeways or the railways. To be sure they extend in many directions, but not everywhere, and certainly not for free. Instead of being a continuous land, blotted here and there by a few pockets of disorder, the sciences are now often seen as an archipelago of tiny islands, disseminated over a vast sea.

This new picture, however, also has its shortcomings, and this is where the book under review enters the discussion and makes a valuable contribution. Although the sciences are practised in local, isolated and contingent settings, they do claim to be universal, and this claim is to be taken seriously. No-one has ever heard a scientist boast at once that his or her results are local, temporary, irreproducible, impossible to expand, and not tied to any other fact or theory. Even the social constructionists who insist on local studies of scientific practice pride themselves on the universal validity of their method; they do not suggest that is is a local, isolated achievement that leads nowhere. Even Feyerabend turns his own destructive method into another '-ism'; he favours anarchism. Thus there is something essential, if not in method, at least in claims to method. As the very name 'method' indicates, the sciences lay down a certain path, from the local to the global, that cannot be mon sense define their ties with the global. Even if we recognise the local character of the rails, we understand that they are laid down in a particular way that allows trains to speed along them; they are not laid down to interrupt, side-track or slow down the trains. Even if we recognise science as an archipelago, how is it that each of the islands has discoverers who wave their flag and say that the whole world is theirs?

Since, for an edited volume, this book has a remarkable unity of intent, it seems reasonable to comment on it as if there was but one author. The book is divided into two main parts. The introduction and the first two chapters are the most ambitious, and try to uproot what has been taken for granted as the scientific method of the great heroes — Newton, Galileo, Descartes. The second part is less ambitious but nicely documented: what is the use of 'method talk' in scientific controversies; when others fail, tell your colleague that they are not 'really' doing science.

Feyerabend's work on Galileo rendered a great disservice to the study of science by using polemically the bizzare notion of propaganda. Galileo was accused, 'not only' to discipline rigorously 'but also' to indulge in propaganda. This is a most damaging definition of rhetoric, since, inevitably, defenders of science point out that 'in addition' to a flourish of rhetoric, Galileo did demonstrate some of his laws. Then we are back where we started; that is, with a dichotomy between rhetoric and the rest, the real science. The author of the first chapter, Chalmers, rightly debunks Feyerabend's pretention. After all, if Galileo wished to *propagate* his results, to extend them, to generalise them, then propaganda is just one way among very many; the invention of mathematical physics is another, that allows one to go on from one result to another. Equations themselves trace a fascinating path from the local (the variables) to the global (the structure of the equation itself). Why call rhetoric the first, if no study of the second is made?

Unfortunately, Feyerabend's dualist position contaminates even Chalmers, who cannot find a common ground for all operations of propagation and is forced (p. 23) to reintroduce the dichotomy he wished to attack: 'as far as the creation of social space for the new science is concerned, it is certainly the case that there was *much more* involved *than* rational argument, given the variety of interests at stake'. Ah, this little 'more than': how many crimes have been committed in your name, whether on the side of the old Whiggish positivism or, as is now the case, on the side of social historians.

Methods play in science the same role as constitutions do in politics. Although sociologists can argue that no-one ever follows exactly their rules, nevertheless, the constitution plays much more than a cosmetic role. It organises assent and dissent, loyalties and procedures. The methods of Galileo or Descartes cannot be dismissed as window-dressing, because they are as important as Hobbes' social

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it is local, but it is our way; we love it or leave it and do our own thing'. This sort of talk does indeed occur, as nicely illustrated by the folk-sociology of as important as Descartes' reshuffling of who should be trusted.

The first one is taken seriously by Chalmers, but the second is treated as a mere literary resource — in the old sense of the expression — by Schuster. Schuster's chapter is an interesting case of self-contradiction. He does not hesitate to offer a universal definition of methodology, from the Greek to the present day — deleting the constant dispute between scholastic rhetoric, Renaissance Platonism and Cartesian rhetoric — in a book dedicated to the local achievements of scientists; and he criticises the whole literature on Descartes for its failure to see his rules of method as a literary trick, without realising that this is indeed the success of Descartes — to have provided the resources, the vocabulary, the tricks, the formats, for everyone else thereafter, including Cartesian scholars and Schuster himself in his formalised presentation. If this equipment had been seen as a literary trick, it would have lost strength immediately. Why? Because Descartes, like Boyle, invented the very distinction between literature (or rhetoric) and demonstrated (or experimental) science. The definition of rhetoric and literature used by Schuster to explain Descartes has been made unfit for this sort of usage by Descartes himself.

Bacon, Boyle and Descartes may never have lived up to their rules of method, but they invented a way of proceeding from the local to the global. Descartes, like Leibniz, was fascinated, as Schuster rightly points out, by the model offered by algebra and linear functions. Either you call literature all these resources (including algebra) — which I am happy to do, but then it is necessary to uplift literary theory quite a bit — or you find a word that specifies more clearly the innovative character of this new political constitution of faith and knowledge. No: Descartes' distribution of witnesses and trials, his system of checks and balances, his political philosophy, to use Shapin and Schaffer's expression, is not that of Aristotle, not that of Galileo, not that of Bacon, not that of Boyle.

What is the most important lesson to be drawn from the second part of this volume, where scientists are shown to use resource-talk in order to escape from difficult situations? Poor Weneger is beaten down by dear colleagues for his lack of method (Le Grand), Sasisekharan, an Indian biochemist with an alternative model of the double-helix, is dismissed for not doing real science (Stokes), and the proponents of cytoplasmic heredity are defeated by molecular biologists because their work does not follow the changing pattern of good science (Sapp).

These chapters offer an interesting addition to Kuhn, since Kuhn cannot explain why a paradigm should never appear as a Kuhnian paradigm. Why is hegemony, network building, the quest for universality so much part-and-parcel of science? Why can't a scientist say 'this is how we do things here — contract or the Declaration of Independence. Galileo's decision to believe mathematical physics instead of common sense in experimental matters is science collated by Sapp. But it is never officially articulated as an acceptable way of talking. Is this reworking an ideology or a legitimisation of what really happens, as some remarks of the authors too often suggest? Or is the notion of paradigm simply wrong? Of course, in many instances an appeal is made to method when everything else has failed; it is the last straw to break the camel's back. But this does not solve the problem. Although there is no unique definition of science, and although groups disagree on what is and is not good science, few can resist the temptation to talk of a universal method. If there is no common method, then something essential to science is threatened. If the local idiosyncrasies of paradigms are accepted as such, science ceases to exist.

The book as a whole takes this problem less seriously than one might expect from the Introduction. Generally, it is suggested that there is bad faith involved in the scientists' flag waving. It seems that they could or should do without method talk, if they were honest and not self-serving and self-righteous. But it might very well be the case that methods play the same role in science as standards do in industry. Each industry, each country, imposes its own standards in order to build its own markets. It cannot do without standardisation, for it is an essential part of that which makes an industrial product industrial rather than (say) craft. The fierce fights for computer compatibility offer a parallel with the ruthless debates among scientists to define what a good, respectable science should look like. Nevertheless, no-one would say that fights over communication standards among computer firms are mere legitimisation tactics or window-dressing. They define in part what a computer does; that is, how it can tie its fate to others. Method plays an essential role in the very definition of scientific fact: it provides an interface, where one science may connect with another.

In summary, this book is a valuable one, that starts to turn the tide away from the repetitious claim that science is a hopelessly idiosyncrastic and locally negotiated endeavour and back towards consideration of method. From now on, I am sure, it will be much more profitable to go back to the study of method claims, provided it is strongly tied to the study of theories and freed from the sort of dualism that still lingers in this book.

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C. A. Fleming, *Science, Settlers and Scholars: The Centennial History of the Royal Society of New Zealand.* Wellington: RSNZ Bulletin 25, 1987. 353 pp., 80 figs., NZ$55.

A recent review in *Nature* of the bicentenary history of the Linnean Society of London had this to say: 'Though clogged with too much loving detail, and

not very enthrallingly written, Gage's history was too substantial to be disregarded lightly'. Charles Fleming's centennial history of the Royal Society of New Zealand also fits that description, as do the histories of several other academies of science.

In his preface to Ronald Clark's biography of J.B.S. Haldane, Peter Medawar wrote: 'The lives of scientists, considered as Lives, almost always make dull reading . . . Academics can only seldom lead lives that are spacious or exciting in a worldly sense.' Academies likewise may have rather dull lives, making their histories a difficult genre unless enlivened by the promise of things to come as in Thomas Sprat's *History of the Royal Society*, or by a major theme as in Marie Boas Hall's *All Scientists Now*, or by the clash of strong personalities. None of these elements enlivens *Science, Settlers and Scholars*, which might more aptly be called a chronicle rather than a history. So conscientiously has Fleming been through the council minutes and other records of the Society that he becomes trapped by the details, with the result that his book lacks a sense of perspective.

Two other features compound the problem; the structure of the book and the long period over which it was written. There are four parts; the first is a narrative history, while the other three deal with the Society's domestic affairs (II), its national responsibilities (III) and its international responsibilities (IV), each of these parts revisiting subjects introduced in the opening narrative, several times for some of them. Too much repetition remains, despite the author's prefatory disavowal. Begun in 1967, the book has grown by accretion until times ranging from 1972 to 1987. The years since the centennial in 1967 are partly covered by an epilogue, but the accretionary character of the text can be illustrated by reference to pages 253 and 254: on the first we read 'At the time of writing (1980) . . .', while on the very next page we are told 'On 1 April 1987 the Government established . . .'. So much for the faults, not to mention the occasionally errant English and Latin.

The book's strength is its comprehensiveness. Charles Fleming was President of the Society from 1962 to 1966, playing a major role in reshaping it into its present form and in finding it a home of its own, and assimilated its past as thoroughly as he mastered the geological history of New Zealand.

The first hundred years divide naturally into three periods. From its establishment in 1867 until 1903, when its Act was amended, the New Zealand Institute, as it was initially called, was ruled by the increasingly autocratic James Hector as manager, editor, bureaucrat and patron. Fleming aptly calls this the Hector hegemony, reminiscent in some respects of Sir Joseph Banks' long presidency of the Royal Society of London. Then from 1903 until 1933, when it became the Royal Society of New Zealand under a new Act, there was a more democratic period, under a succession of presidents, and with representation of the various provincial and local institutes. Geologists still predominated, along with biologists, the first nine presidents coming from those disciplines. Twenty original fellows, including Ernest Rutherford, were elected in 1919, and more followed, but they had no corporate role in the affairs of the Institute. That changed to a small extent in 1933, along with the name of the Society, but R.S. Allan's plea for a Council of Fellows was not realised until 1965 when the constitution was amended yet again, with the various national societies being admitted as member bodies within the new federal structure.

The last chapter of Part II of the book portrays the 34 men who served as president up to the time of the centenary, but the account of activities is not built around them as it is in Cochrane's centennial history of the U.S. National Academy of Sciences. There were quite a few amateurs in the early years, but mostly professional scientists later. Some presidents were polymaths, others specialists. There were school teachers, headmasters, a botanising vicar who advocated missionary work in science, and even a bishop. They ranged from silver-tongued orators to one president with a reputation for silence. One, G.M. Thomson, was even elected to Parliament while President of the Institute.

In relation to national responsibilities, one continuing role of the Society has been to sustain research that leads to understanding, when several governments have wanted science 'with as practical an objective as possible'. Relations with the D.S.I.R., established in 1926, seem to have been generally constructive. There was initially some rivalry as to whether the Institute or the D.S.I.R. should be the adhering body for I.C.S.U. and the International Unions, but this amounted to no more than 'polite bickering', with none of the fireworks that bring histories alive. Fleming admits that the Society has had little impact on science education, unlike its Australian counterpart. On the other hand, in its early years it was the main, if not the only, body with an interest in the conservation of nature and natural resources, and it can claim quite a few successes over the years. The format of its meetings with Members of Parliament, in which the topics for discussion are chosen for their relevance to the legislative program, has succeeded in attracting up to six Ministers on occasion.

Funding for international activities has nearly always been tight, even when New Zealand's subscription to the International Research Council was only £2-0-4. Fleming makes clear the very great stimulus derived in earlier years by New Zealand scientists, especially the young, from the occasional visiting scientist, such as Rutherford on his periodic visits to his mother, or Skottsberg in 1938 inspiring Fleming himself. Even greater stimulus came from the holding of the seventh Pacific Science Congress in 1949. This was New Zealand's first inernational scientific congress, held partly in Auckland and partly in Christchurch, and, for the vulcanologists at least, the country's reputation as a conference host was made when Mt Ngauruhoe erupted with its first lava flow in historic times while the delegates transferred from one venue to the other.

This chronicle is rich in such glimpses, if not in broader themes. It ends with the thought that the Society's unique structure as a federation of scientific societies is New Zealand's special contribution to the organisation of national scientific endeavour. This is an experiment which other countries, including Australia, will no doubt watch with interest, and it is a pity that its architect has not given us a more probing assessment of it in this, his last book.

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J. Bonnemains, E. Forsyth & B. Smith (Eds.), *Baudin in Australian Waters: The Artwork of the French Voyage of Discovery to the Southern Lands, 1800–1804.* Melbourne: Oxford University Press, 1988, 347 pp., illus. $250.

Baudin in Australian Waters is a lavish book that would grace any library. It is part of the Australian Academy of Humanities' series of publications that reproduces major scientific artwork from European expeditions to Australia. This volume presents a rich collection of zoological and anthropological sketches and paintings that until now have been available only to scholars researching in Le Havre. Supporting these reproductions is a series of essays.

For many decades, Baudin's voyage to Australia has been a little known and often misrepresented expedition. Claims of the voyage's ulterior political motives have most often overshadowed appraisal of the impressive scientific results it achieved. With over 100,000 zoological specimens collected and over 10,000 new species identified, it could be said that Baudin's voyage is to zoology as Cook's is to botany. Moreover, in contrast to previous expeditions — and to many after — Baudin's voyage provided insightful anthropological details of Australia's indigenous populations. It becomes apparent from *Baudin in Australian Waters* that the artwork is much more refined than in many contemporary renditions. In all, this volume will help to instate the voyage of Baudin to the Southern Hemisphere among the crucial expeditions of discovery.

The captain, Nicolas Baudin, although not formally trained, had interest and experience in the acquisition of scientific collections. François Péron, who would chronicle the voyage, was the most important scientist. The artists whose work is represented in this volume were originally hired as gunners, although it seems clear that Baudin was aware of their artistic capacities. Charles Lesueur was largely responsible for the zoological artwork, and his realistic portrayal of specimens has rarely been equalled. Lesueur, whose delicate skills are manifest in this book, eventually migrated to America and gained recognition for his artistic rendition of fish. The second artist, Nicholas Petit, had trained under David in Paris, but his career was cut short when he died of a gangrenous injury some months after his return from southern waters. The majority of the anthropological artwork is by Petit.

The quality of the reproduction of artwork in this volume is excellent. Of a particularly high standard are Lesueur's vellum oils, where the translucency and delicacy of the originals are apparent. Even the very faint, rough pencil sketches are reproduced with impressive clarity.

The artwork is organised by subject matter: landscapes and inhabitants of New Holland and Van Diemen's Land, sponges, ctenophora, medusae, molluscs, arthropods, echinoderms, tunicates, fish, batrachians, reptiles, birds and mammals. In total, there are over three hundred reproductions from the archives of Le Havre's Muséum d'Histoire Naturelle. In addition, thirty-five plates present other aspects of the voyage, including maps, portraits and some of the final published engravings.

The portrayal of the Tasmanian aborigines is imbued with Eurocentric attitudes, not only to 'savage' societies but also to the norms of artistic representation. Though not as neoclassicist as many other contemporary portraits — absent are the Grecian urns and togas — there was clearly a problem in getting the figures into proportion. Many look decidedly unbalanced. Although one could excuse such 'faults' as due to the illustrations being done in haste — the more leisurely Sydney portrait series shows a more natural, 'human' people — there appears to be an inherent cultural bias in the representation. The lack of proportion in the body and the ever-present maniacal grin match Péron's description of the Tasmanians as 'all extremities thin and feeble . . . and the belly a little too large . . . their look always had something sinister and savage in it'.

Seven introductory essays, mostly brief, place the artwork within the frame of Baudin's expedition. An excellent overview of the voyage is provided by Frank Horner's essay. Some brief biographical expositions are given of Péron and the artists, as well as a history of the 'Lesueur collection' at Le Havre, which houses not only the illustrations but also many manuscripts and is the biggest repository of archives for the Baudin expedition.

Rhys Jones' essay, 'Images of Natural Man', is the most substantial, comprising almost half of the sixty-five pages of introductory essays. Jones, an anthropologist by training, presents what will certainly become the definitive identification and interpretation of the artefacts in use at the time of Baudin's expedition. He offers a clear and thorough description of the social systems and the methods of production of the artefacts depicted in the illustrations. From a theoretical point of view, more could have been made of links between the 'fieldwork' and the contemporary intellectual setting. For example, the depictions of the Aborigines could have been tied back to contemporary theories of physiognomy, or Péron's use of the dynamometer

to measure native strength could have been analysed in terms of the rise of an objective scientific methodology.

What I found most disappointing about *Baudin in Australian Waters* was the absence of an essay that did justice to the art in the way that Jones' essay pays tribute to the anthropological depictions. An essay that placed the method of representation of the landscapes, fauna and Aborigines into the context of the late eighteenth century French school would surely have been appropriate. The volume would also have been improved by a closer integration of the essays to the artwork. However, the volume is certainly worth owning for the illustrations alone.

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J.J. Basinski. I.M. Wood and J.B. Hacker (Eds.), *The Northern Challenge: A history of CSIRO crop research in northern Australia.* Brisbane: CSIRO Division of Tropical Crops & Pastures, 1985. 186 pp., illus., $8.00.

A.G. Eyles, D.G. Cameron and J.B. Hacker (Eds.), *Pasture Research in Northern Australia: Its history, achievements and future emphasis.* Brisbane: CSIRO Division of Tropical Crops & Pastures, 1985. 222 pp., illus., $8.00.

These two books were produced to mark the 25th anniversary of the establishment of the CSIRO Division of Tropical Crops and Pastures. By their nature, however, they trace histories which cover a period of much more than 25 years. In the case of the second book, that dealing with pastures, the starting point is 1867; for the first it is the early 1930s. Thus we are presented with relatively exhaustive reviews of two related and major areas of Australian research effort. Given the purposes of the books, this juxtaposition is, of course, not accidental.

To speak of success or failure of research programs is to tempt providence. Not only may a piece of research deemed to be a failure actually produce knowledge which may be the source of a future bonanza, but also one has to be careful about what is meant by failure. To the devotee of value-free science, the notion of judging research to be successful or not would presumably be repugnant. Hypotheses are either rejected or not rejected and, either way, knowledge is gained. This reviewer does not adopt such a value-free stance. 'Curiosity research' perhaps aside, research has objectives, be they implicit or explicit, and, in the case of the Division of Tropical Crops and Pastures, there can be no denying that those who made decisions to allocate resources to crop and pasture research in northern Australia had clear and materialistic objectives, related to the establishment of a viable cropping industry on the one hand and the facilitation of productivity growth in already established pastoral industries on the other. In the final analysis, the performance of the Division must be assessed in terms of those objectives.

In a sense, the book on crop research could be seen as something of a last hurrah for the ethos that, if money was thrown at science in sufficient quantities and for long enough, economically viable solutions to obstinate problems could be found. In the world of the 1980s, where so much reliance is being placed on institutional and structural change in order to pursue the objectives of society, these books provide an interesting post mortem on an exercise which appears to reflect a then widespread faith in the ability of science and technology to solve problems.

In the crop research book, the editors comment on the timeliness of their efforts, not just because of the anniversary marked by the books, but also because they were produced when many of those closely involved with the early days of CSIRO research in northern Australia, while close to retirement or retired, were still available for consultation. Further, CSIRO involvement in this area of research was, and is being, reduced and the production of a record such as that provided by these two books was felt to be desirable.

The book has eight chapters, one being devoted to each of the six research stations that have been involved in crop research — the Kimberley Research Station, the Katherine Research Station, the Coastal Plains Research Station, the Tobacco Research Institute, the Narayen Research Station, and the Cooper Laboratory — and a number of associated locations. The book closes with a chapter which attempts an overview and presents some lessons from the experience of crop research in the north. The Introduction contains an outline of the history of the Division and its antecedents, together with a useful review of operational problems organised under the general headings of administration and funding, staffing and living and working conditions.

Given the purposes of the book, this form of organisation works well. The reader is confronted with a series of chapters written in the sober and non-dramatic way that one would expect from scientist authors. Despite this, or perhaps because of it, the difficulties of working in such an environment, along with the associated tensions, are starkly and effectively presented. The attempt to produce a scientists' history was helped by the allocation of much of the biographical material and personal anecdote to notes at the end of each chapter. This stratagem works well, even though it contributes to the production of an end product with large chunks of rather dry reading.

The concluding chapter should be required reading for all research administrators aspiring to excellence in their calling. It is a concise statement of some lessons that the authors (Wood and Basinski)

feel can be learnt from the Division's experience in northern Australia crop research. This experience constituted a school of hard knocks, characterised by difficulties of location, environment, deficiencies in administration and planning, and a degree of political involvement which would be uncomfortable for most research teams. This last was not surprising, given the highly political atmosphere within which northern development, particularly that on the Ord River, was conducted over many of the years under consideration.

In summary, this book is a useful contribution to the history of Australian science. It is by no means entertaining reading, but it is valuable for the record it provides and for the lessons provided by that record; lessons which are well summarised and discussed in its concluding paragraphs.

Perhaps because of the relative success of much of the research it describes, the second book, dealing with pasture research, lacks the drama of the first. It is much more concerned with technical issues, less with questions of policy, administration and economics. This is very much a scientists' history. In fact, it could be represented as a location-specific scientific review rather than a history. Such a designation is not intended to denigrate the book. As the authors point out '... the early pasture workers in northern Australia were pioneering a science not only for the Australian tropics, but for the tropics of the world'. This alone would seem to justify the book, regardless of what it is called, history or review. One does, however, regret the lack of attention to the questions of policy and administration that concerned the authors of the first book.

The second book has three sections, one dealing with the pioneers and covering the period till 1952, the second the period from 1952 to 1984. The third section is an assessment of what has been achieved and what could be done in the future. A significant feature is the record of successful co-operation between State agencies, particularly the Queensland Department of Primary Industries and its predecessors, and the Division. Indeed, in places the book seems as much a record of the pasture research of the Queensland Department as of the Division. Evidence of such co-operation is much less apparent in the first book, which does, however, report dissonance, particularly between the Western Australian Department of Agriculture and the Division. This dissonance reflected differing objectives of the two organisations, which in turn were a reflection, at least in part, of the much higher degree of political intervention in the crop work. In the case of pastures, there was clearly a much greater coincidence of objectives and hence a more congenial environment for co-operation.

In summary, the two books should be of considerable interest to readers of this journal and to those interested in the history of the CSIRO, particularly with regard to its involvement in northern Australia. To the bulk of lay people they would make very dull reading, while those interested in the question of the extent to which the Division met its overall objective will be left feeling somewhat frustrated.

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Patrick O'Brian, *Joseph Banks: A Life.* London: Collins Harvill, 1987. 328 pp., illus., $39.95.

Sir Joseph Banks (1743–1820) continues to fascinate and confound. Here we have another semi-popular biography addressed to a general audience, based on wide reading (as any biography of Banks must be), but with little in the way of novel material or insight.

O'Brian opts for a broadly chronological account with some thematic cross-cutting between chapters. To the reader already acquainted with the major episodes in Banks' life, most of the content will be, perhaps distressingly, familiar. Indeed, the chapters on the voyages to Newfoundland and Labrador and on the *Endeavour* only supply connective tissue for long extracts taken from Banks' journals. Whilst allowing that there is sometimes value in letting the subject of a biography speak for himself, this practice is here carried too far. Having said this, the device of devoting the final chapter to a selection of revealing letters from various stages of Banks' life (with commentary) is a pleasing one, sparing us the traditional finale of demise and eulogy. That this device stands in the stead of a concluding overview is less satisfactory, since it deprives us of O'Brian's reflections on the major messages he wishes the reader to take away from the book. We are left to guess.

Throughout the book, the focus is upon Banks' 'character': upon building up an image of the man by examining his relationships with family, lovers, friends, enemies, servants, natives, collectors and librarians, and by revealing his attitudes towards institutions — king, country, the Royal Society, Parliament. Banks was wealthy, extremely well-connected and widely honoured, but he was never a snob nor ever lost the common touch. He had tremendous energy in a startling array of activities, and had a 'disinterested love of science', if a certain mysterious shyness about publication. He was a generous patron and benefactor, unstinting in his personal relationships, and sometimes a little too trusting of the fineness of others' motives. He was a man of order, who wanted reform of the Royal Society, but he was frustrated by the general political climate. He was benevolent, but grew impatient at being contradicted, especially in his later years. He was apolitical in having a distaste for parliamentary politics, and he did much to maintain scientific relations with 'enemy' savants during times of war. O'Brian engages in much strenuous characterisation of this kind.

Some of the characterisations, however, are dubious, and O'Brian is too dismissive of those who had a less glowing opinion of the benign Sir Joseph. A deeper understanding of conflicting agendas in the scientific and learned world is necessary to fully appreciate Banks' role in it. And, although Banks did studiously avoid the entanglements of parliamentary politics as much as possible, he was clearly a Court man (James Edward Smith once called him a 'Royal Toady') and a supporter of the Pitt administration through unorthodox, unofficial and, at the time, invisible channels.

But these complaints aside, the result of O'Brian's characterisation is the shell of a man defined reactively. Absent is any account of Banks' larger vision and purpose. To be fair, this is a fault which O'Brian shares with almost all other biographers of Banks. The great man was not given to programmatic statements. But his actions and activities, when viewed in some contextual depth, betray vision and purpose which are otherwise clouded by the colour and clutter of his life. This much has been shown by the writings of H.B. Carter and, particularly finely, by those of David Mackay (*In the Wake of Cook,* 1985) on the relationships of exploration, science and Empire in the late eighteenth century.

This is not a bad book. As a popular biography it compares favourably with that by Charles Lyte (*Sir Joseph Banks*, 1980), both in accuracy and readability. Even for the afficionado it contains the occasional gem, notably hints of Banks' role in the early days of the French revolution in conveying secret intelligence to Pitt. The book will certainly be of value to the interested layman concerned to learn more of the man on the five-dollar note before it becomes a coin. And yet it seems to me that any further popular biographies of Banks must await new historical insights. Then, perhaps, we may have a genuine 'life and times' of this enigmatic figure.

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D.D. Millar (Ed.), *The Messel Era: The Story of the School of Physics and its Science Foundation within the University of Sydney, Australia, 1952–1987.* Sydney: Pergamon, 1987. 157 pp., illus., $17.50.

Twenty six years ago, a book containing the lectures from the 1961 Science School for Physics held at the University of Sydney was thrust into my hands for review. I was a young postgraduate student, newly arrived in the eastern states from Adelaide. When I discussed what I might say with the people around me I was amazed at the vehemence of their opinions. I soon realised that the centre of the antagonism was the founder and guiding spirit of the Science Schools, Professor Harry Messel.

In my journeying through physics since then I have bumped into his name continually, but not in the literature of the fields in which I was engaged or at physics conferences or meetings of the Australian Institute of Physics. Nor is he a member of the Academy of Science. Yet he has been the most visable and influential person in Australian physics for more than a generation. The contradictions have intrigued me, on and off, for years.

The present volume goes some way to explaining them. It was prepared for, and sponsored by, the Science Foundation within the University of Sydney to mark Messel's retirement as Head of the School of Physics and Director of the Foundation. The bulk of the text has been prepared by J.B.T. McCaughan, a former student and now Senior Lecturer in Physics, and the volume concludes with a fine chapter by Emeritus Professor R. Hanbury Brown. Its title is accurate and pertinent. Messel's time at Sydney already claims the title 'era' and this is its 'story': not a history, but a view from the inside of a very remarkable episode in the history of science in Australia.

Born in the wilds of Canada, of immigrant parents, Harry Messel early learnt the value of self-reliance, physical fitness and hard work. As an undergraduate immediately after World War II, he completed two concurrent degrees in Engineering Physics and Mathematics, both with first-class honours and at the top of both class lists. He completed his Ph.D. in Dublin, under the supervision of Janossy and Schrödinger, famous refugees from the Nazi regime. Newly married, Messel followed his Dublin acquaintance, Herbert Green, to the mathematical physics group at the University of Adelaide.

Here he proposed the formation of an institute of advanced study, to foster research and to retain in Australia some of the capable young scientists who went abroad to do their postgraduate work. He was supported by some of the university staff and by the State Premier, Sir Thomas Playford. When the rug was pulled from under the scheme by the Vice-Chancellor, A.P. Rowe, Messel resigned the same day and headed back overseas via a chance interview in Sydney. It all seemed far too brash and unconventional: the Federal Government, for example, had decreed that scientific research was to be conducted by CSIRO and the new National University. The State universities were primarily teaching institutions, although they were not debarred from research.

The story of Messel's appointment in Sydney is already legendary. He asked for 14 new permanent physics appointments, funding for a major research programme and permission to redirect the teaching and research of the department. Sydney physics had been leaderless for some years. Much to Messel's surprise Sydney accepted him and all his demands. The Vice-Chancellor believed that 'while the tribulations of the administration will probably be added to by this dynamic personality, the Department of Physics will gain increasing inter-

national reputation'. Unfortunately, a volume such as this does not reveal even a little of the later tribulations that the administration and other sections of the University of Sydney experienced.

It does record in some detail, however, the subsequent and very considerable achievements of Messel, the School of Physics and its Science Foundation. Harry Messel was the first, and still one of only very few entrepreneurs in Australian science to tap the private, corporate and government sectors to anything like their full funding potential. During his 35 years in Sydney he raised $34M (now worth $100M or more) for the work of his School.

It started with the formation of the Foundation. Initially focussed upon a possible nuclear power industry in Australia, but based squarely upon fundamental research and the need for highly trained graduates, it had little trouble changing and broadening its view when the money flowed in. New staff of high quality were recruited, often from overseas, and, again in a manner unprecedented in Australia, theoretical physics received its strong and rightful emphasis.

In his flirtation with nuclear power, and with the School's success in cosmic-ray and theoretical nuclear-physics research, Messel quickly alienated the nuclear physicists in Melbourne and Canberra. Whatever the reasons for the frosty disdain between Sydney and the rest of the country — and this book provides few insights into such questions — the result was a tragedy for Australian science. It has always needed the united effort of all its leaders.

As the School and Foundation expanded, Messel won a bitter battle to allow multi-professor schools and departments in the University of Sydney. Later, the School of Physics incorporated the Packer Theoretical Department (led by Butler), Wills Thermonuclear Department (Watson–Munro), Chatterton Astronomy Department (Brown), Falkiner Nuclear Department (McCusker), an Astrophysics Department (Mills) and the Basser Computing Department, a pioneer in Australian computing.

McCaughan suggests that the School reached its zenith around 1970, with Hanbury Brown's interferometer, Mills' cross, the Supper plasma physics research machines, the Cecil and Ida Green KDF9 computer, and outstanding work in theoretical and cosmic-ray physics. The 1970s and 1980s, however, have not been without achievement and controversy, and new initiatives were taken in the areas of environmental and applied physics.

In the realm of teaching — of the general public, secondary students and tertiary undergraduates — Messel, the School and the Foundation have also accomplished much. The Science Schools, first for teachers and from 1962 for secondary students, have stressed the need for education and especially for excellence. They provided the first lengthy science programmes on Australian television and they brought to Australia an extraordinary array of talent: George Gamow, Thomas Gold, Hermann Bondi, Carl Sagan, Margaret Burbidge, Wernher von Braun, several astronauts, Glenn Seaborg. Richard Dalitz, Wolfgang Panofsky, James Watson, George Porter and Paul Ehrlich, among many others.

Through Messel's contacts with the Duke of Edinburgh, President Lyndon Johnson, Japanese prime ministers, captains and kings, the Science School has become international, with participating students from New Zealand, the U.K., the U.S.A., Japan, Singapore, Malaysia, Thailand and the Philippines. Altogether, more than three thousand students have participated directly, at a total cost to the Foundation of $1.7M.

In the early 1960s the School produced a number of texts for physics students and secondary-school science classes. Messel's recent work on some 100 tidal systems and their crocodile populations in the various rivers of northern Australia has been recorded in 20 monumental volumes, published by Pergamon Press. The number of research publications in physics (or the average number per year) is not stated, but by any standard the output of the School of Physics during the Messel era has been very substantial indeed.

Love him or hate him, Harry Messel cannot be ignored in the history of Australian science. In due time a scholarly and probing study will be required of the man, his influence, his achievements and those of his School. For the present this volume provides the bones of the story, a good starting point for future scholars, and a good deal else besides. For graduates and associates of the University of Sydney it will be especially interesting. It is a pity that it lacks an index.

Here, the last words can be left appropriately to Hanbury Brown: 'Let us hope that one day someone will write that book . . . a proper biography . . . In the meantime, I hope that I have written enough to show you that Harry Messel is a complex, talented man . . . It has been a rare privilege to have known him.'

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Alwyne Wheeler, *Catalogue of the Natural History Drawings Commissioned by Joseph Banks on the Endeavour Voyage 1768–1771 held in the British Museum (Natural History) — Part 3: Zoology.* London: Bulletin of the British Museum (Natural History) — Historical Series Volume 13, 1986. 171 pp., illus., £27.00.

The *Endeavour* expedition was the first great voyage of discovery on which professional naturalists and artists were included in the ship's company. Sir Joseph Banks and his colleagues returned with an enormous wealth of specimens of plants and animals, drawings and descriptions in manuscript. As is well known, only a relatively small number of the species of animals represented by specimens or

drawings were formally described and published. Most of these specimens were given by Banks to scientific friends or correspondents, or were otherwise dispersed, so that few of them have survived or can now be recognised as *Endeavour* material. Under the terms of his will Banks left his drawings, manuscripts, books and specimens to his curator-librarian Robert Brown for life, to be transferred to the British Museum on his death or earlier if Brown and the Trustees reached agreement. In 1827 Brown and the Trustees so agreed, and when the new British Museum (Natural History) was built at South Kensington in the early 1880s the Banksian natural history collections and related drawings and manuscripts were transferred to that institution, where they have remained.

In recent decades there has been a great revival of interest among scholars in the Cook expeditions, and in the last four years detailed catalogues of all the surviving drawings from the *Endeavour* voyage have been published. These include drawings of places visited, peoples encountered and artifacts collected, and charts, coastal views and other drawings of navigational interest. Catalogues of the natural history drawings have been published in three volumes in the Historical Series of the *Bulletin of the British Museum (Natural History).* Volume 11 (1984) covers the botanical drawings from Australia, and volume 12 (1987) deals with the botanical drawings from all other places visited.

All of the zoological drawings, numbering 299 in total, are catalogued in the single volume under review, published in 1986. The drawings are the work of three artists, Alexander Buchan, Herman Diedrich Spöring and Sydney Parkinson, none of whom survived the voyage. Buchan was employed as a landscape artist but produced some drawings of invertebrates and fishes from Madeira and Brazil. He became ill at Tierra del Fuego and died at Tahiti. Spöring's role was that of amanuensis to Banks and Daniel Solander, but he was an accomplished artist and did some drawings of fishes and crabs. He contracted malaria and dysentery at Batavia and died soon after the ship left Java. Parkinson was among the best natural history artists of his time. He produced a very large number of botanical drawings and the great majority of the zoological drawings. He also died after the ship left Java. The drawings are accompanied by a number of contemporary manuscripts, the most important of which are Jonas Dryander's *Catalogue of the drawings of animals in the library of Sir Joseph Banks,* and Solander's zoological manuscripts, containing his descriptions of animals obtained on the voyage and from other sources.

In the Introduction the author discusses in detail the drawings, the artists and the manuscripts. It concludes with a review of the drawings and manuscripts as a zoological resource. Apart from the value of the drawings as a pictorial record of a most important early voyage of scientific discovery, the drawings and manuscripts also provide a superb resource for the better interpretation of the inadequate taxonomy of the seventeenth and early eighteenth centuries. Drawings that were the sole basis of published descriptions, or those representing specimens that have since disappeared, have the status of types for taxonomic purposes.

The catalogue, the greater part of the work, is set out in a standard format. The drawings are serially numbered and the animals are listed under their modern scientific names, as far as identification is possible, and the family names. A description of the drawing in abbreviated form is then given, with the artist's name, annotations on the drawing and size, references to Solander's manuscript, if any, and Dryander's catalogue. A final section includes a discussion on identification, references to citations of the drawing or manuscript relating to the drawing, and the possible continued existence of specimens.

It is of interest that only a small number of the drawings represent Australian animals. There are two drawings of kangaroos, one of another marsupial, a kangaroo skull, a cockatoo, two drawings of a marine turtle, ten of fishes, three of crabs, and an unidentified jellyfish. The work is illustrated with black-and-white photographs of a page from Dryander's catalogue, seventeen drawings of animals representing a number of classes, and examples of the work of all three artists.

Alwyne Wheeler's well-prepared and comprehensive catalogue is an important addition to the literature of the great age of maritime discovery. It will be of great value to animal taxonomists and historians, particularly those with a special interest in the discovery and development of knowledge of the fauna of Australia and the Pacific.

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C.R. Twidale, M.J. Tyler and M. Davies (Eds.), *Ideas and Endeavours: The Natural Sciences in South Australia.* Adelaide: Royal Society of South Australia, 1986. 277 pp., illus., $28.

The aim of this excellent collection of essays, as the title indicates, is to evoke the ethos and achievements of the natural sciences in South Australia over the past 150 years. It is the fifth in the Society's series of Occasional Publications, and represents the Society's contribution to the sesquicentennial celebrations of South Australia in 1986.

The spectrum of contributions is wide, which makes the presentation of a critical review most difficult. Because of the variation in the breadth and depth of the work described, the contributions are themselves uneven, both in depth and length, and, as pointed out in the Introduction, in the periods of time they cover.

There are nine chapters, which I have chosen to outline separately.

1. **Understanding Landscape** by C.R. Twidale
   Early exploration of South Australia is described, and many features of the landscape — such as the stony desert and the Simpson desert — are illustrated. The origins of particular features of the landscape are discussed, with some emphasis being given to the effects of wind and water erosion.
2. **Geology** by D.W.P. Corbett, B.J. Cooper and P. Mooney
   This chapter charts the development of geological studies in South Australia, and encompasses the early explorations by personnel from the Department of Mines and the University of Adelaide in mapping and in mineral exploration. This work resulted in the detailed elucidation of the structure and stratigraphy of the countryside. Particularly notable is the vast amount of work carried out by a very small group of scientists, some of whom are legendary in Australian geology.
3. **Soil Science** by C.G. Stephens and N.K. Northcote
   The rapid development of soil science, especially after 1926, is here reviewed. The contributions of the Waite Agricultural Research Institute of the University of Adelaide, the CSIRO Division of Soils, and the South Australian Department of Agriculture are discussed, although the authors state that it was necessary to be selective in the emphasis given to particular areas of work. Nevertheless, the coverage of topics is wide, dealing with the history of soil science, the construction of soil maps, soil classification, soil chemistry, physics and mechanics, and soil biology.
4. **Agricultural Climatology** by A. Marshall
   This review is concerned essentially with research at the Waite Agricultural Research Institute. Attention is given to the outstanding contribution of a number of workers in the field, notably to such topics as the relation of soils to vegetation and climate, the conditions of soil moisture governing the hatching of insect pests, and the development of indices of agricultural potential. In relation to this last topic, the chapter contains a revealing and interesting account of the development of the 'Length of Growing Period Map', its progressive modification, and the recognition of its limitations.
5. **Botany** by Enid L. Robertson
   This extensive chapter deals with the development of botany from the time of coastal surveys and inland exploration, through the foundation of the University of Adelaide and the establishment of its Botany Department and the establishment of the Adelaide Botanic Gardens, the Museum of South Australia and the State Herbarium, to the foundation of Flinders University and its School of Biological Sciences. A detailed description is given of the work of some eminent botanists in such areas as ecology, taxonomy, genetics, mycology, phycology, plant physiology and plant biophysics.
6. **Plant Pathology** by H.R. Wallace
   The difficulties encountered by early settlers in South Australia, in the absence of knowledge of the factors governing disease in crop plants, are explored in this chapter, and the role of science in overcoming many initial preconceived concepts of causes is well presented. The role of the Waite Agricultural Research Institute and CSIRO is attested, and the contributions of particular individuals described. The historical account of the 'Take-All' disease is particularly illuminating, set against a background of early prejudice as to its cause and the results of later scientific investigation.
7. **Zoology** by S.J. Edmonds
   Like the chapter on Botany, this chapter is comprehensive. It begins by noting the observations of naturalists on the Baudin and Flinders expeditions, which preceded the foundation of the colony in 1836, and follows the findings of early exploration. Later, in the period from 1860 to 1880, studies in zoology were actively pursued through the South Australian Institute and the University of Adelaide. On this foundation, rapid growth in studies of the fauna took place in many fields: ornithology, entomology, parasitology, anatomy, ecology and physiology. In these investigations there are contributions by the University of Adelaide, the South Australian Museum, the CSIRO Division of Animal Nutrition and Soils, the Waite Institute and Flinders University. The chapter conveys the many achievements of zoological studies and the excitement which accompanied them.
8. **Medical Sciences** by R.V. Southcott
   As the author states at the outset, this chapter has a more restricted canvas, being largely confined to an historical survey, until 1924, of non-clinical aspects of the medical sciences in South Australia. This year marks the foundation of the *Australian Journal of Experimental Biology and Medical Sciences.* While the author does not conform strictly to these constraints, a most interesting description is given of the medical problems of early explorers and settlers, with epidemics of measles, smallpox and tuberculosis, and the use of extracts of native plants in the treatment of bowel and respiratory disorders. As in the development of other disciplines, the establishment of the University of Adelaide signalled the formation of a distinguished medical/scientific community. Work on other areas of disease — such as hydatid disease — in both black and white communities, and their interaction with each other, is also surveyed.
9. **Anthropology** by Norman B. Tindale
   This contribution complements the preceding chapter on medical sciences, especially in relation to the impact of the initial cultural contact of foreign explorers on the aboriginal population, and the import of European diseases on it. The discussion is especially apposite in relation to current discussions on the relation of white and black communities in Australia, and

recognises that present problems were defined in South Australia in the last century.

Of the chapters listed, the first two constitute an excellent background for the succeeding five presentations. In the same way, the chapters on Botany and Zoology relate well to the final chapters on Medical Sciences and Anthropology. This volume documents, and is testimony to, the very substantial contributions to the natural sciences in Australia which have originated in South Australia. It is especially welcome, since, like the greater history of Australia itself, the history of South Australian science is often overshadowed by, or neglected in favour of, that of the eastern states.

In outlining the contents of this book, it was stated above that many distinguished scientists participated in the fields surveyed. While all of these cannot be listed, they include W. Howchin, C.T. Madigan and D. Mawson (earth and related sciences), T.G.B. Osborn, J.G. Wood and R.N. Robertson (plant sciences), H.G. Andrewartha, T.H. Johnston, H.R. Marston and W.P. Rogers (animal sciences), and J.B. Cleland, F. Wood Jones and E.C. Stirling in the fields of medicine and anthropology. In addition to describing the work of these and many other scientists of stature, however, the work is also peppered with relevant anecdotal comments.

The book is excellently produced, soft covered and clearly printed, with many photographs and engravings — some in colour. Many of the photographs are of significant historical interest. The photographs of early expeditions by camel, car and air emphasise the difficulty of these enterprises. The book is also valuable in that the disciplines described are traced through the establishment and growth of institutions: the Museum, herbaria, universities and government departments. The only reservation the writer has about this excellent work is the absence of a subject index to the more than 1100 references listed at the end of the volume and cited in the text.

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John Forge (Ed.), *Measurement, Realism and Objectivity: Essays on Measurement in the Social and Physical Sciences.* Dordrecht: Reidel, 1987. 346 pp., $130 approx.

The collection of essays under review is the fifth volume in the series Australasian Studies in History and Philosophy of Science. Whilst each of the essays is related to one or more of the three themes, measurement, realism and objectivity, the issues discussed are diverse so that the volume is not a coherent whole. Nevertheless, the essays taken individually make useful contributions to their respective fields.

The opening essay, by James R. Flynn, deals with the ontological status of intelligence and, in particular, the status of the Spearman-Jensen theory of intelligence. The author defends the theory from some misguided criticism but offers other criticisms of his own. He appraises the theory from the point of view of Lakatos's methodology, and finds it wanting in this respect and suggests that it must either be seriously modified or replaced. I found this to be an interesting illustration of the fact, pointed out by a number of critics of Lakatos, that the methodology of scientific research programmes has no normative force. However badly a programme has fared, one can stick with it in the hope that things will improve. Lakatos's methodology is impotent for one of the purposes he hoped it would serve, namely, 'stemming intellectual pollution'.

A second essay with a psychological theme is Robert McLaughlin's attempt to put Freud's theory of psychoanalysis on a realist footing. To do this he makes a distinction between Freud's psychology, which he refers to as 'epistemically dubious', and his realist metapsychology, which McLaughlin construes as the assumption that psychoanalysis can be underpinned by neurology. This latter assumption is referred to as Freud's 'insight'. Whilst I can accept that the physicalist assumption might well serve to define a research programme, presumably what is needed to justify classifying it as an insight, rather than as a prejudice (say), is the success of the programme in practice. However, McLaughlin's disparaging remarks about the epistemic status of Freud's psychology suggest that that success was not forthcoming, at least in Freud's own work. McLaughlin's treatment is certainly interesting as an attempt to interpret Freud's theory in a physicalist way, but it does little to justify the superiority of that interpretation over other possible ones for those not already committed to physicalism.

Two of the essays are concerned with philosophical issues in modern physics. Henry Krips employs his version of Bell's Theorem to persuasively argue that, if we accept Quantum Mechanics and reject non-locality, then we are forced to accept an indeterministic dimension to measurement in Quantum Mechanics. As Krips portrays that indeterminism, measured values are undetermined, not because of some indeterminacy introduced by the measuring process, but because the values measured are themselves indeterministic. Thus measurement in Quantun Mechanics is not a failure. It faithfully reflects an indeterminacy inherent in the reality measured. Krips invokes Popper's discussion of indeterminism in classical physics here to soften the blow for those who, unlike the reviewer, are averse to indeterminism.

John Norton's essay clarifies some aspects of Einstein's general theory of relativity, and deals with technically difficult material in an admirably clear and accessible fashion. He considers some texts in Einstein's papers which can be, and frequently are, interpreted as supporting a positivist or operationalist stance and re-interprets them in the light of a detailed study of the evolution of

Einstein's formulation of his theory. The relevant texts stress verification as coincidences between measuring devices and the system measured and see the general theory of relativity as 'taking away from space and time the last remnant of physical objectivity'. These are interpreted by Norton as Einstein's response to the so-called 'hole-argument'. Einstein's initial formulation of the class of transformations to be included in the demand for general variance had the consequence that the field inside an arbitrarily small hole would be undetermined by the boundary conditions around it. This problem is removed once the class of transformations is adequately characterised as those that actively transform the gravitational field rather than merely relabel its co-ordinates. Re-interpreted in this context, Einstein's remarks offer no support to the positivist or operationalist. For those, like myself, who are unsympathetic to those doctrines, it is re-assuring to find that someone of Einstein's stature is not to be counted amongst one's opponents.

David Oldroyd contributes a detailed and fascinating account of a controversy involving the dating of some sedimentary rocks which had a bearing on the controversial theory of 'punctuated equilibrium' in evolutionary biology. The dispute over the dating of the rocks raged for over a decade. However, with the refinement and multiplication of methods, the dispute was eventually settled to the satisfaction of most, though not all, when several methods of measurement based on quite different principles yielded similar results. Oldroyd stresses the social character of the disputes involved and presents his work as supporting images of science currently fashionable amongst sociologists of science. Bearing in mind the extent to which some of the sociologists, such as H.M. Collins, seriously challenge the objectivity of experiment and measurement in science, I found Oldroyd a little unclear about the extent of his agreement with them.

Two essays involve a critical look at the unsatisfactory and frequently misleading way in which scientific measurement is employed in a broader social context. S.O. Funtowicz and J.R. Ravetz suggest that the problem be countered by insisting that the expression of quantitative information, especially that to be used in the social sphere in areas such as risk analysis, be qualified in various ways. Some of these qualifications involve the already familiar notions of estimates of experimental and systematic error. Their novel suggestion is that the quantitative estimates be accompanied by their 'pedigree', which would involve a summary of an evaluative history of how the quantity was produced. These considerations remain in the epistemological sphere. Ian Lowe broadens the scope of the discussion to investigate how values and political considerations enter into the use of scientific measurement in social contexts. He offers striking and convincing, if not surprising, examples of how values and politics enter into debates concerning alleged measures of such things as the hazards of low-level ionising radiation, the operating safety of nuclear reactors and the viability of 'alternative' energy sources. I certainly have no problems accepting the general tenor of Lowe's case here, and found his examples interesting and illuminating. However, he goes further to suggest that his case leads inexorably to a questioning of the whole idea of science as an objective exercise. This latter claim is difficult to evaluate since it is not clarified nor argued for, other than by citing a few references, one of which, somewhat disconcertingly, is my own book.

The book under review concludes with four interrelated essays on the issue of what it is that is measured by the measuring process in science. Chris Swoyer offers a realist account, arguing that what is measured corresponds to properties of the system measured. John Forge, by contrast, develops a version of the view once held by Brian Ellis, that the quantities measured in science are best understood in terms of classes of linear ordering relationships. The existence of a quantity is nothing other than the existence of the measured order. I have reservations about the terms of this kind of debate, which seems to assume that a metaphysical account of the nature of quantities can be abstracted from considerations of the procedures involved in such things as length measurement and the use of balances. Setting aside this reservation and accepting the terms of the debate, I did not find Forge's case sufficient to sway me from my realist predilections. This was also the view expressed by David Armstrong and Brian Ellis in their commentaries on Swoyer and Forge, the former giving a beautifully clear and concise summary of the issues at stake and the latter raising some justified objections to Swoyer's somewhat undiscriminating deployment of invariance considerations.

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