we are infallible at it." Thus, although an anthropomorphic view of termites is undoubtedly bad science, a termitomorphic view of some of man's activities may be illuminating.

There are many other refreshing comparisons between human and animal behaviour in these essays. For instance, a great deal is known about olfactory sensing among animals and insects; but smells play no part in recognition or signalling between human beings. Because of this deficiency (writes Dr Thomas) "we feel somehow inferior and left out of things." Perhaps this sense has atrophied among humans; but the specific smells are still there, for a tracker dog can follow the trail of a man across the tracks of dozens of other persons. A promising line of research here (writes Dr Thomas) for an Institute of Human Fragrance; for if smells are so specific that dogs can distinguish them, have they any link with the equally specific immunological characters in man?

Readers of *Nature*, accustomed to the severe austerity of prose in which a scientific communication has to be made if it is to be credible, may well ask what relevance these whimsical essays have for them. I think they have considerable relevance, and this is why I think so. In the 1970s pure scientific research is on the defensive. Not only is there the first anti-science movement for over a century; there is also, and more ominous, an air of scepticism about the value of pure science on the part of the Establishment. Research Councils are considering the cost-benefit values of their support for some lines of work. Government-sponsored science has now to be regarded as a sort of trade-relationship between 'customers' (who often do not know how to ask the right questions) and 'contractors' (who are paid to answer the questions even if they are not the right ones). In these circumstances it is essential that the public should understand the value to civilisation of encouraging sheer exuberant curiosity about nature. They will not understand this unless they understand what the scientific attitude to nature is like. The end results of scientific research are well popularised in books, films, and TV programmes; but the public know very little about the conception of scientific ideas, the leap of imagination necessary to ask the seminal questions to which research provides the answers. The future patronage of science by the public may therefore depend on a fresh kind of popularisation. If I had to recommend to a non-scientist a book which gives a vivid impression of how scientific ideas are born, this is the book I would recommend.

Eric Ashby

Problems and progress in theoretical physics

Quantum Gravity: An Oxford Symposium. Edited by C. J. Isham, R. Penrose and D. W. Sciama. Pp. 605. (Clarendon: Oxford; Oxford University: London, July 1975.) £10.50.

THE first quarter of this century witnessed two major revolutions in fundamental theoretical physics: quantum theory and relativity. As we enter the last quarter of the century, these two cornerstones of modern physical science are still irreconciled.

Quantum theory was originally developed as a theory of matter, whereas relativity is a description of the structure of space-time and its relationship to gravitation. The latter development of the quantum theory of fields, however, with its spectacular successes in describing electrodynamic phenomena, naturally prompted investigation to determine whether these successes could be repeated for the gravitational field. The only theory of gravity so far tried for quantisation in any seriousness is Einstein's general relativity (and minor modifications thereto), an enterprise which has encountered extraordinarily complicated technical problems, demanding great dedication and courage from would-be quantisers. These difficulties, together with some fundamental problems of principle, have resulted in a whole range of well-tried approaches, all of which have so far failed to yield a satisfactory quantum theory of gravity. Many practitioners, disillusioned with the slow progress of these "frontal assaults", have advocated nothing less than a rejection of the direct use of either general relativity or quantum theory, and propose instead intriguing new principles at a more elementary level of nature. In direct contrast, another popular "second-best" effort has been to try to first cope with the quantum theory of better understood fields which are located in the curved space-time of general relativity, that is, quantum matter in classical gravitational fields.

A whole range of such philosophies and techniques appear in this impressive book. The text, apart from an article by S. Deser, is based on a symposium given at the Rutherford Laboratory in February 1974. There are nine chapters, and although each is by a different author, the organisation and level of presentation are sufficiently consistent to make the book a very useful collection of topics.

The symposium itself was a memorable occasion, because it simultaneously provided a good deal of pessimistic prognosis about achieving a proper quantum gravity using the more traditional techniques, together with the first public announcement of an extraordinary new result about black holes by Stephen Hawking. There is no doubt that this development, which predicts that black holes create particles and "evaporate" away, has provided a great stimulus for research into quantum field theory in curved space.

Hawking's explanatory article is accompanied by one of the most concise and elegant accounts so far of the theory of twistors, presented in two chapters by Roger Penrose and his former student, George Sparling. Penrose's twistor formalism provides by far the most developed and promising possibility of a completely new approach to the structure of space-time and matter.

The more traditional techniques are dealt with by M. J. Duff, with a clear account of covariant quantisation, S. Deser discussing recent Feynman graph calculations and A. Salam, who outlines some results from his long programme of treating gravity from a particle physicist's viewpoint. The main conclusion to emerge from these discussions is the impasse of non-renormalisability; when matter is present, the divergences which always occur in quantum field theory cannot be isolated for the gravitational field in a systematic fashion.

The book also contains a well-written account of some aspects of quantum cosmology—the slightly bizarre technique of quantising the whole universe as a simple mechanical system—by M. A. H. MacCallum. The final chapter carries the unmistakable stamp of J. A. Wheeler in a wide-ranging assessment of the subject, complete with philosophical perspectives and intriguing illustrations. This chapter, entitled "Is Physics Legislated by Cosmogony", is jointly written by Wheeler and his student, C. M. Patton.

No book of this type could be complete without a good review of the whole subject. A useful and very readable account is given at the beginning by an acknowledged quantum gravity expositor and contributor, C. J. Isham.

For the first time the researcher has available in a single volume a broad range of material, edited by three experts, in this most challenging and difficult area of theoretical physics. It is to be recommended to all departments with an interest in cosmology and astrophysics, and more generally to anyone concerned about the really fundamental aspects of physics.

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