well-known objections to the instrumentalist position. Further, he offers no convincing reasons for supposing that his own account of scientific progress and rationality in terms of problem-solving differs from the accounts in terms of confirmation and explanatory power that he rejects. Instead of an argument we are offered a list of alleged differences between "facts" and "problems" (pp. 16 and 17); for example, "There are many facts about the world which do not pose problems because they are unknown" and "many known facts do not necessarily constitute empirical problems." These observations are, alas, perfectly consistent with the claim the author is out to refute. For unknown facts seem to correspond to unrecognized empirical problems, and recognized empirical problems that do not challenge a theory seem to correspond to known facts that are not relevant to the theory. The author's subsequent treatment of the various types of problems that a theory may face reinforces the suspicion that we have here merely a new jargon, not a new philosophical position.

This would be a minor criticism had the author succeeded in his primary aim, that of defining scientific rationality in a way that resolves the problems raised by the accounts of such philosophers as Carnap, Popper, and Lakatos. In the course of his discussion Laudan does indeed make some telling points—for example, he has many interesting things to say about the factors that affect the weight attached by scientists to different kinds of unsolved problems, and he presents a good argument for the interesting claim that the scientist who would make a rational choice among current theories on grounds of "promise" must be prepared to consider at least the recent history of his subject. But the definition of scientific rationality that finally emerges is vacuous. For the notion of a scientific problem is extended to cover almost anything anyone could conceivably consider relevant to the assessment of a theory; the "research traditions" between which scientists are supposed to make their rational choices are so vaguely defined as to cover almost any imaginable conglomeration of theories; and there are no definite restrictions placed on the relative weights to be assigned to different kinds of problem-solving in the estimation of problem-solving effectiveness. In consequence, anything goes: the criterion of rationality is apparently compatible with a vast range of strategies for choosing theories, including the very models of rationality the author rejects. No wonder the author is so confident that his model of rationality will do justice to the history of science. It is hard to imagine any historical development in science, however bizarre, that would not be shown to be rationally motivated and thus "explained" if we adopt this all too generous formula. And the scientist, faced with Laudan's account of rationality, may well complain, as Leibniz did of Descartes's analytic method, that it amounts to little more than "Take what you need; do what you should; and you will get what you want."

The instrumentalist approach to the history and philosophy of science, the approach that in the hands of Ernst Mach, Pierre Duhem, and the American pragmatists once yielded remarkable insights, is, I think, still a promising approach today. But to establish the credentials of instrumentalism painstaking historical case studies and careful philosophical arguments are needed. Laudan has offered us only gradiose promissory notes.

NICHOLAS JARDINE
Department of History and Philosophy of Science, University of Cambridge, Cambridge CB2 3RH, England

Rotating Neutron Stars

Pulsars. F. G. SMITH. Cambridge University Press, New York, 1977. xii, 240 pp., illus. $19.50. Cambridge Monographs on Physics.

Pulsars. RICHARD N. MANCHESTER and JOSEPH H. TAYLOR. Freeman, San Francisco, 1977. xiv, 282 pp., illus. $19.95. A Series of Books in Astronomy and Astrophysics.

In 1934 Walter Baade and Fritz Zwicky suggested that supernova explosions would produce compact stars with extraordinary properties—stars as dense as the atomic nucleus. The concept of "neutron stars" was received with great skepticism by most astrophysicists. At most it was usually thought that though such a state of matter was theoretically possible it was highly unlikely to exist in nature. The sudden and dramatic vindication of Baade and Zwicky's ideas, which were promoted most vigorously by Zwicky, occurred almost exactly ten years ago with the discovery of pulsars. The appearance of pulsars on the astronomical scene is an example of a breakthrough caused by new observational techniques. In this case the breakthrough resulted from the combination of a newly accessible waveband—radio frequencies—and the development of receivers with short time constants and their use in a repetitive observing mode. There was a sudden flood of complex observational detail followed by attempts at decoding the observations with physical theory. The rapid identification of the objects as rotating neutron stars is a well-known story, but the subsequent development of the complex interaction of observational details and theoretical models is not so well known. The time is ripe, the publishers of these two books tell us, for the appearance of a book pulling all this material together into easily digestible form.

The two books are quite similar in scope. They cover almost exactly the same material and in more or less the same depth. No topic covered in one is omitted in the other. Observational material is organized in both along obvious lines (integrated pulse profiles, individual pulses, timing, dispersion and scattering in the interstellar medium, distances, galactic distribution, the Crab Nebula and its pulsar, x-ray pulsars, and binary systems). Discussions of theoretical matters are divided between the characteristics of neutron stars and theories of the pulse emission mechanism (about which surprisingly little is known with any degree of certainty). The major difference in approach is that Smith has chosen to integrate the theory with the observational results more than have Manchester and Taylor, who survey the observations first and devote the last two chapters to theoretical material. Of course in both books there is much cross-referencing, and both are successful at synthesizing observational detail with interpretation. If forced to choose between the two, I would lean toward Manchester and Taylor because of their more complete subsidiary material: pulsar table (that has more data per object than Smith's and coverage of 149 objects compared to Smith's 105), reference list, and indexes (plus a list of symbols). A good index is of immense value when a volume is used for reference rather than bedtime reading. Manchester and Taylor also have more complete discussions of the more recently discovered binary pulsar and of the evolution of binary systems with mass transfer.

Both books have succumbed to the regrettable convention of omitting the titles of papers referred to. It is frustrating to dig out an obscure reference, vaguely cited in an important discussion, only to find out from the title alone that it is irrelevant to one's particular interests.

Both books are well written and have succeeded in providing a unified summary of varied and complex material, with little of the flavor of a batch of synopses of journal articles slapped together into a book. It is evident that all three authors are basically radio astronomers; the discussion of optical and x-ray observations would no doubt have been different in emphasis had they been written by specialists from these fields. The few mistakes in these discussions are unimportant to the main concepts.

The books will be used by advanced astronomy students and by astronomers and physicists whose specializations are in other areas. The "small band of pulsar specialists" (a phrase from Smith's preface) already know this material, although the books may serve them as useful compilations. Nonphysicists will have trouble because much knowledge of physics is assumed (of electrodynamics and the physics of nuclear matter, for example). But those who want to read most of what is known about pulsars should read one or both of these volumes.

JEFFREY D. SCARGLE
Theoretical and Planetary Studies Branch, Space Science Division, NASA-Ames Research Center, Moffett Field, California 94035

Outbreeding Mechanism

Incompatibility in Angiosperms. D. DE NETTANCOURT. Springer-Verlag, New York, 1977. xiv, 232 pp., illus. $24.70. Monographs on Theoretical and Applied Genetics, 3.

Self-incompatibility in flowering plants is the inability of a fertile hermaphroditic plant to produce zygotes after self-pollination. Self-incompatibility is genetically controlled by one or more loci, with from two to hundreds of different alleles, depending on the particular system. Fundamentally, it is a cellular recognition phenomenon in which self is rejected and nonself accepted.

Self-incompatibility is common in angiosperms and is a major mechanism for enforcing outbreeding in plant populations. It is therefore instrumental in determining the genetic structure of populations and is of considerable evolutionary significance. It is also of importance in agriculture, particularly in dictating the pollination requirements of certain fruit and seed crops.

Incompatibility in Angiosperms is the first book in English devoted to the subject. De Nettancourt has collected and summarized a large amount of widely scattered literature. The result is comprehensive and up to date, although many aspects of the subject are treated very briefly and the book is written in a rather telegraphic style.

More than ten different systems of genetic control of self-incompatibility are now known. A polygenic system with at least three or four loci has recently been discovered in *Ranunculus* and sugar beets. In this system the loci are complementary; that is, the three or four loci together specify one unique pollen incompatibility phenotype. Such complex systems are difficult to elucidate genetically and may be more common than is now apparent.

The biochemistry of the incompatibility reaction remains largely unknown. The book summarizes the limited data available and the abundance of wild and wonderful hypotheses. The sporophytic incompatibility system of the Cruciferae is the best understood. The evidence suggests that the diploid sporophyte synthesizes recognition proteins in the tapetum of the anther and in the stigmatic papillae. The tapetal proteins are transferred to the exine of the pollen grain and the stigmatic proteins are transferred to the pellicle that covers the surface of the stigma. At pollination the exine bound proteins diffuse out and interact with those of the pellicle. If the proteins are identical, a rejection response occurs in the papillae and pollen tubes do not penetrate the stigma.

The natural evolutionary breakdown of self-incompatibility systems is treated briefly. More coverage is given to the experimental modification of incompatibility, particularly as a tool for the plant breeder. Included are such sexual exotica as electrically aided pollination and mutilation of the stigma with a wire brush.

One-fifth of the book is devoted to interspecific incompatibility, the failure of pollen from alien species to germinate on a stigma—that is, the rejection of nonself pollen. This is a subject about which virtually nothing is known. The author concludes that the self-incompatibility gene is involved in the control of interspecific barriers to fertilization. The evidence is the phenomenon of unilateral incompatibility. Interspecific crosses between a derived self-compatible species and a closely related self-incompatible species often succeed when the self-compatible species is the pistillate parent, but the reciprocal cross usually fails. In this special case the self-incompatibility system may function as one barrier to hybridization, but it seems unlikely that it is the mechanism by which plants as unlike as apples and oranges recognize each other.

The major strength of the book is that it covers almost everything. The major weakness is that the author is usually noncommital and tends to present every conflicting hypothesis and bit of data at face value. One example: in a study of self-incompatibility in *Capsella* in the 1930's, Riley correctly concluded that the incompatibility behavior of the Cruciferae could not be explained by any known system. He proposed a system with two alleles at each of two loci to explain his data. After the elucidation of the one-locus, multiallelic, sporophytically controlled system in the Compositae and Cruciferae in the 1950's, Bateman showed that it could account for Riley's data and that it was extremely unlikely that *Capsella* differed from all other Cruciferae. Nevertheless, de Nettancourt seems to accept Riley's model, as well as a similar, earlier, model by Correns.

In some cases where the author does take a stand, his position seems to be dictated by historical precedent. He accepts the traditional dogma that one-locus gametophytic self-incompatibility is a primitive feature in the angiosperms, despite the fact that the system is found only in relatively specialized families and that self-incompatibility itself has never been conclusively demonstrated in any supposedly primitive angiosperm. He hedges later in the book, however, and admits that the recent discovery of polygenic systems may necessitate a revision of the traditional view.

There are a few mistakes in the book. For example, the segregations given for tristyly in figure 3 on p. 29 are incorrect.

All in all, the author has compiled a concise yet comprehensive summary of the subject, but he leaves it to the reader to recognize which conclusions are compatible and which are incompatible with the facts.

FRED R. GANDERS
Department of Botany, University of British Columbia, Vancouver V6T 1W5, Canada

Intelligent Invertebrates

The Biology of Cephalopods. Proceedings of a symposium, London, April 1975. MARION NIXON and J. B. MESSENGER, Eds. Published for the Zoological Society of London by Academic Press, New York, 1977. xviii, 616 pp., illus. $41. Symposia of the Zoological Society of London, No. 38.

This volume is the published version of a meeting held to honor J. Z. Young on his "retirement" from University College, London. Young in fact continues his research at the Wellcome Institute for the History of Medicine, hence the quotation marks. Most American