ence between Galileo's science and the conservative and stale natural philosophy of the Jesuits whose works he pored over in his early 20's. The evidence adduced by Wallace seems to be overwhelming in one sense: if this was Galileo's heritage he was born a pauper! Galileo's greatness is enhanced when we realize how far he had to travel to reach the avenue that was to lead to modern science. Galileo could not but hope to prove his system to the satisfaction of the Aristotelians, but he drew his inspiration from other sources. Niccolo Gherardino, who had known Galileo personally and was one of his first biographers, writes: "He exalted Plato to the skies for his truly golden eloquence, and for his method of writing and composing dialogues, but above everyone else he praised Pythagoras for his way of philosophizing, but in genius he said that Archimedes had surpassed them all, and he called him his master." The omission of Aristotle's name from this role of honors is not insignificant.

It is inevitable that a book of the scope and ambition of this one will be controversial and give rise to objections of the kind put forward here. What ought not be controversial, however, is that Wallace has given us an outstandingly lucid and intelligent account of matters of great interest. This book is the first comprehensive and unified treatment of the influence that the Jesuits exerted on one of the greatest minds of all times, and the nature and extent of that influence are now open for debate.

WILLIAM R. SHEA
Department of Philosophy,
McGill University,
Montreal, Quebec H3A 2T7

Atom-Atom Collisions

Theory of Slow Atomic Collisions. E. E. NIKITIN and S. YA. UMANSKII. Springer-Verlag, New York, 1984. xii, 432 pp., illus. $49. Springer Series in Chemical Physics, 30. Translated from the Russian edition (Moscow, 1979).

The theory of slow atomic collisions plays a fundamental role in the microscopic understanding of a variety of processes in chemical physics and chemical kinetics. The term "slow" means that the velocity of the atoms is substantially smaller than the velocity of the electrons in the atoms, and generally applies to atom-atom collision energies less than 10 electron volts in the center-of-mass frame. Considerable progress has been made on the development of this theory, and the time is ripe for a comprehensive presentation such as is provided by Nikitin and Umanskii. Both authors have been at the forefront of research in this subject and have made seminal contributions to the current form of the theory.

The main focus of the book is on the quasi-classical version of the theory. Most of the formal development has occurred with this version, perhaps because the fully quantum mechanical version is more "well defined" and hence is somewhat more of a computational problem. This is not to say that all aspects of a fully quantum mechanical description are well understood, but the quasi-classical approach allows for more "art" in its execution. Furthermore, it is generally simpler to apply (once the correct formulation is constructed for a given problem), and it often provides a clearer physical picture of the collision process. A theoretical analysis of slow, quasi-classical atomic collisions can be viewed in three stages: calculation of the adiabatic electronic terms and couplings between relevant states; calculation of the probability amplitudes of nonadiabatic transitions between these states, induced by the relative motion of the atoms; and calculation of differential and total cross sections using these probability amplitudes. Though previous books have dealt with selected aspects of the three stages, the present book provides the most balanced and up-to-date treatment of all three aspects.

Since the treatment of electronically nonadiabatic transitions in atomic collisions must include two or more electronic states (and, indeed, most atomic collisions of current research interest are nonadiabatic—the elastic approximation is generally restricted to the collision of two closed-shell atoms, both in ^1S states colliding at low energy, or to nonzero spin states when the electronic orbital angular momenta are zero), the collision theorist has been forced to consider electronic degrees of freedom explicitly. This means that the well-rounded collision theorist must be a good "spectroscopist" in terms of understanding various electronic and nuclear angular momentum coupling schemes. The authors, who are established experts in this regard, have devoted considerable space in the book to this subject. The novice collision theorist is no longer forced to look in many different places in order to gain a unified picture.

The authors have not sacrificed discussions of the cornerstones of basic collision theory, such as elastic scattering and two-state semiclassical models. With respect to the latter, they have tackled the fundamental problems of multiple transition points and the breakdown of the standard JWKB (Jordan-Wentzel-Kramers-Brillouin) approximation, such as occur in nonadiabatic transitions near a turning point.

The book is written in a very readable style. I would be happy to teach a course on modern collision theory based on it. The concepts presented are restricted to atom-atom collisions, and for an up-to-date understanding of atom-molecule collisions, particularly rearrangement processes, one must turn to journals and review articles. The restriction to atom-atom collisions is part of the reason for the success of the book: All three stages of slow, quasi-classical atomic collisions are covered thoroughly, with considerable attention given to many "nasty" details that are usually omitted. The book can be viewed as the first volume of the current theory of atom-molecule collisions.

THOMAS F. GEORGE
Department of Chemistry,
University of Rochester,
Rochester, New York 14627

Avian Ecology

Shorebirds. Behavior of Marine Animals, vols. 5 and 6. JOANNA BURGER and BORI L. OLLA, Eds. Plenum, New York, 1984. Vol. 5, Breeding Behavior and Populations. xvi, 437 pp., illus. $59.50. Vol. 6, Migration and Foraging Behavior. xiv, 329 pp., illus. $49.50.

The papers in these two volumes document the increased interest in shorebird biology that has developed over the last decade or so. The 15 contributions cover shorebird classification, population dynamics, breeding systems, migratory behavior, foraging and spacing patterns, and conservation and related topics. Most provide useful, interesting, and often provocative blends of literature review and current research that lead to new insight into ecological and evolutionary questions or at the least point out limitations in current knowledge. I was surprised in the review sections at how much of the information on shorebird biology derives either from what might be called anecdotal sources (incidental observations and short-term or topical investigations) or from a relatively few intensive investigations. The latter, in particular, have been concerned with only a handful of species, most of which have been studied by only one investigator at one site over a period of at most a

few years. It is evident that more thorough, intensive, and long-term studies are needed to confirm and extend the generalities presented in these and other recent papers on shorebirds.

A recurring topic in these volumes is what regulates shorebird numbers, particularly the relative importance of events occurring in the breeding areas versus those in migration or in winter. In a comprehensive and insightful review of shorebird population dynamics, Evans and Pienkowski conclude that regulation per se may in fact not occur, shorebird populations being held in check largely by climatic events operating in the breeding and especially in the wintering areas. Puttick in her consideration of winter feeding behavior assumes that winter food is limiting for shorebirds, but she wisely concludes with a plea for experimental tests of this assumption. Goss-Custard demonstrates that, even though wintering shorebirds spend considerable time foraging and have a potential impact on the abundance of their winter food, their mortality in winter may be relatively low. I think any conclusions regarding limiting factors are premature, especially considering that there is not even one shorebird population for which natality, mortality, and other demographic features have been critically assessed. Yet this remains a crucial question that must be addressed before appropriate management or conservation strategies, such as those discussed in these volumes by Senner and Howe, can be established. Evaluations of the importance of migratory stopover and winter areas in the population dynamics of shorebirds are particularly needed, because these estuaries and coastlines are being imminently threatened by development.

Another major topic covered in these two volumes is shorebird social systems. Shorebirds, which include such groups as the sandpipers, plovers, snipe, phalaropes, and other relatively long-legged "waders," exhibit an impressive array of ecological and behavioral traits making them excellent subjects for examination and testing of many aspects of behavioral, ecological, and evolutionary theory. Particularly noteworthy contributions on this topic are Oring and Lank's consideration of the relationship between dispersal and social structure and its evolutionary implications and Walter's thought-provoking review of hypotheses concerning limitations on clutch size and the evolution of parental behavior. Lenington concludes from a theoretical approach that polyandry may best be explained as the outcome of a historical process, but she provides little new insight into the evolutionary or ecological factors promoting such processes. Miller presents the most comprehensive review to date of shorebird ethology, pointing out the lack of good comparative data, especially on the functions of communication signals. Finally, using an optimization approach, Myers lucidly discusses the spacing patterns exhibited by wintering shorebirds and points to the need for consideration of why individuals within species vary in their spacing patterns at different times and places.

Other papers in these two volumes review shorebirds as marine animals (Burger), abiotic factors affecting migrant shorebirds (Burger), and antipredator behavior (Gochfeld). Also, Morrison presents selected results of the extensive Canadian surveys, which provide much new information on shorebird migratory stopovers and wintering areas in the Western Hemisphere.

Overall, I was impressed by the thoroughness of the reviews and by the quality of ideas presented in these papers. By examining the link between theory and existing data, they quickly bring the reader to the frontier of the subject, elucidate the questions that need answering, and in many cases suggest approaches to providing the answers.

RICHARD T. HOLMES
Department of Biological Sciences,
Dartmouth College,
Hanover, New Hampshire 03755

Modes of Reproduction

Fish Reproduction. Strategies and Tactics. G. W. POTTS and R. J. WOOTTON, Eds. Academic Press, Orlando, Fla., 1984. xiv, 410 pp., illus. $49. From a symposium, Plymouth, England, July 1982.

A large proportion of the major recent advances in our understanding of evolutionary processes have come from the study of species with unusual and even bizarre (to a tetrapod chauvinist) methods of reproduction. Haplodiploidy in the social insects is one of the most obvious cases.

Though there appear to be no haplodiploid fishes, this group, with over 20,000 species, exhibits an extraordinarily broad range of reproductive modes. The diversity of sex allocation patterns alone rivals that of plants. Fishes exhibit gonochorism, both kinds of sequential hermaphroditism (protogyny and protandry), simultaneous hermaphroditism, androdioecy, and two kinds of partheno-genesis. In gonochores, both autosomal and heterogametic sex determination occur. Fertilization is external in most species, but internal fertilization occurs in several groups. Though most fishes abandon eggs after spawning, a wide variety of male and female parental care patterns occur, including guarding, mouth brooding, incubation in brood pouches, and various stages of viviparity. The range of mating systems is enormous, from mass spawning to haremic and lek-like assemblages to long-term monogamy (including the bizarre male parasitism seen in ceratioid angler fishes). Current evidence indicates that most of these reproductive modes have evolved several times independently.

It is surprising, given the potential this diversity offers for investigating evolutionary processes, that there have been few attempts to provide a general synthesis of reproductive patterns in fishes. The classic *Modes of Reproduction in Fishes*, by C. M. Breder, Jr., and D. E. Rosen (Natural History Press, 1966), has been enormously useful, but it is largely a compendium of references.

Though not itself constituting a synthesis, *Fish Reproduction* is a step in the right direction. The book is a collection of papers from an international symposium held by the Fisheries Society of Great Britain. Given the subject and format, it is not surprising that the range of both topics covered and usefulness of papers is large. The topics covered include life history models, sex reversal, the genetics of sex determination, parental care, timing of reproduction, progenesis in deep sea fishes, reproduction in estuarine fishes and in particular taxonomic groups, and the significance of reproductive ecology for fisheries. Both reviews and original research papers are included, though almost all papers report some original work. The papers are generally too short to provide thorough reviews, and they are not generally aimed at defining or illuminating current issues of critical importance. Two exceptions are a discussion of life history models by S. C. Stearns and R. E. Crandall and a report on alternative reproductive strategies in fishes by M. R. Gross. The main usefulness of the book is in giving the biologist interested in fish reproduction a good feeling for the diversity of approaches and topics in the area and in providing an introduction to the current literature. Its bibliographic usefulness is seriously compromised by the exclusion of titles from the listings of citations, however. There are also some important omissions among topics covered. There is no coverage of internal fertilization or