lopes and other ungulates for which the region is famous. Although Schaller's data are rich, the pattern he sees, like that emerging from so many other mammalian studies, remains complex and ambiguous. Lions appear to depress the population of some species below the carrying capacity of the grasslands, at least temporarily, and they are very effective in trimming off aged and disabled animals. But the importance of their role as population regulators cannot yet be measured quantitatively relative to disease, food supply, and other key factors.

If you have only enough time to read one book about field biology, this is the one I recommend. Schaller continues the best tradition of Fraser Darling, Paul Errington, and Adolf Murie. *The Serengeti Lion* displays a maturing of its author, measured both in deepening insight and a surer touch, since his already excellent works *The Mountain Gorilla* and *The Deer and the Tiger*. Although not a theoretician, Schaller has a strong intuitive feel for the important questions of population ecology and sociobiology, and he has organized his information with reference to some of them without departing from the traditional monographic approach. The organization and illustrations are sound, and the writing is sometimes delightful. Schaller has the master's ability to enliven his scientific report with brief personal anecdotes and expressions of personal emotion that do not lose objectivity or even noticeably digress from the data. We are told, for example, that at no time is the lion's movement "more vitally beautiful than when a lion tautly snakes toward its prey. I found that fleeting hesitation between the end of the stalk and the final explosive rush a moment of almost unbearable tension, a drama in which it was impossible not to participate emotionally, knowing that the death of a being hung in the balance."

Schaller, in fact, seems to be a Victorian who has successfully adapted to modern science. Part of the pleasure I have received from his books, as well as from such similar monographs as Valerius Geist's *Mountain Sheep*, Hans Kummer's *Social Organization of Hamadryas Baboons*, and Hans Kruuk's *The Spotted Hyena*, is the promise they imply that physical adventure has not died in science, that one can still journey to some unknown land and publish one's notebooks for the benefit of a fascinated audience. And this time there is a difference: the recent emergence of authentic theory in ecology and sociobiology has created a demand for large amounts of new information from experimental and field studies. The gap between theory and factual information is already large and is growing faster, because the latter accumulates more slowly. Schaller's study has shown us how little we knew about one of the most famous of all animal species, and it can be taken as indicative of the opportunity for original discovery that lies immediately ahead in most aspects of field biology.

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Plant Process

Biological Fixation of Atmospheric Nitrogen. E. N. MISHUSTIN and V. K. SHIL'NIKOVA. Translated from the Russian edition (Moscow, 1968) by Alan Crozy. Pennsylvania State University Press, University Park, 1972. x, 420 pp., illus. $19.50.

During this century six significant books have appeared on biological nitrogen fixation and a comprehensive treatise encompassing inorganic chemistry, biochemistry, biology, agronomy, and ecology is in preparation. The leguminous symbiotic system was emphasized in two early books—*Root Nodule Bacteria and Leguminous Plants* by Fred, Baldwin, and McCoy in 1932 and *The Biochemistry of Symbiotic Nitrogen Fixation* by Wilson in 1940. After a period of dormancy, four books on broader aspects of N_2 fixation appeared within a five-year span—*Nitrogen Fixation in Plants* by Stewart in 1966, *Biological Fixation of Atmospheric Nitrogen* by Mishustin and Shil'nikova in 1968 in Russian and in 1971 in English, *Chemistry and Biochemistry of Nitrogen Fixation* edited by Postgate in 1971, and *Biological Nitrogen Fixation in Natural and Agricultural Habitats* edited by Lie and Mulder in 1971.

There is increasing recognition of the need for additional fixed nitrogen to fill the world requirement for protein and growing concern with the possible deleterious effects of nitrogen compounds in the environment. Renewed consideration is being given to the possibilities of coupling additional atmospheric N_2 more directly to the plant. This has stimulated an unprecedented number of adventuresome suggestions in the last two or three years. These include N_2-fixing chloroplasts, domestication of N_2-fixing rhizosphere or phylloplane associations, genetic engineering, N_2-fixing *Agrobacterium*, "*Rhizobium cerealis*," protoplast fusion, and bacteriophage transduction. Many of these suggestions have been put forth by people not engaged in N_2-fixation research. It is obvious that the expanding interest in N_2 fixation is creating a need for books that assemble and evaluate the substantial literature in the field.

Biological Fixation of Atmospheric Nitrogen fills one aspect of this need in that the authors pay "special attention to the utilization of nitrogen fixation in agriculture." The biology and ecology of N_2-fixing organisms are also emphasized. The Russian literature is compiled and integrated with that of the Western world. Over 2500 references are listed (the chapter on legume symbiosis contains an estimated 1100, requiring 50 pages for tabulation), and even well-read investigators will probably discover unfamiliar information.

A general discussion of the activity of N_2-fixing organisms introduces the book, and a short discussion of the biochemistry of N_2 fixation and theories of the evolution of biological N_2 fixation concludes it. The part in between is devoted to symbiotic N_2 fixation in legumes and nonlegumes and to asymbiotic N_2 fixation by *Azotobacter*, *Beijerinckia*, *Clostridium*, blue-green algae, and other groups of organisms. The authors' chief concern is with biology. The biochemistry of N_2 fixation has developed so rapidly that most of their chapter on it is so out-of-date as to be useless. Postgate's *Chemistry and Biochemistry of Nitrogen Fixation* provides a more useful, though somewhat selective, account of those aspects.

The discussion of symbiotic N_2 fixation extends from biology to ecology, including evaluation of the effectiveness of inoculation and techniques of production and application of rhizobial inoculum. Evidence for N_2 fixation by various nonlegumes is collected, and the inconclusiveness of information on some systems such as *Mycorrhiza* is indicated.

The review of *Azotobacter* nitrogen fixation is extensive. Of possibly greatest interest is the agronomic effect of *Azotobacter* on higher plants. Azotobacterin, a fertilizer preparation con-

taining *A. chroococcum*, was introduced in the U.S.S.R. in the 1930's for improvement of nitrogen nutrition of plants. Although it is concluded that azotobacterin does not provide significantly increased nitrogen from N_2 fixation, some ten tables are used to support the conclusion that various aspects of plant growth are improved. In the words of the authors, "Taken together these findings confirm that *Azotobacter* cannot be regarded as analogous to nitrogenous fertilizer. Its favorable effect in certain conditions is connected with the production of biologically active substances. It can now be considered demonstrated that the supplementary use of these compounds favorably influences plant growth."

Findings concerning the effect of blue-green algae on yield of crops, especially rice, are assembled, and techniques for commercial production of algae for field inoculation are discussed. A short paragraph describes the wondrous merits of *Azolla*, an aquatic fern whose early applications to the soil may have yielded a female chauvinist for N_2 fixation, "the goddess of *Azolla*." It is perhaps fortunate that the authors' work preceded the abundance of oscillating results reported from attempts to determine the localization of nitrogenase either in the heterocyst or in the vegetative cells or in both.

Many other groups of N_2-fixing organisms, some of which are not yet well established as such, and most of which have been less intensively studied, are described, with information on representatives from *Azotomonas, Pseudomonas, Spirillum, Vibrio, Desulfovibrio, Derxia, Klebsiella, Aerobacter, Arthrobacter, Bacterium, Bacillus, Methanobacterium, Chromatium, Rhodopseudomonas, Rhodospirillum, Chlorobium, Chloropseudomonas, Rhodomicrobium, Mycobacterium, Actinomycetes*, and fungi. Subsequent information obtained with improved methodology suggests that N_2 fixation probably does not occur in several of these genera; in others it has been well documented, with extraction of the enzyme demonstrated in some cases. However, the authors acknowledge the inconclusiveness of their information on these matters.

We would like to have seen inclusion or amplification of certain aspects which have gained in significance since the completion of the book. Techniques receive little discussion. Of course the technique that has had the greatest impact on measurement of nitrogen fixation, the C_2H_2-C_2H_4 assay, was only first proposed at the time this book was written. Genetics also receives little attention, and advances of potentially great significance have occurred in the last two years. The associative symbioses are discussed only briefly even though their ecological and agricultural significance may be very great.

Readers are forewarned about several annoyances, some if not all of which may have been introduced in translation. These include frequent errors in references to tables and illustrations, an unusual number of typographical errors, and confusing or incomplete table headings or figure legends. A lack of subheadings impedes rapid scanning.

In spite of these limitations the book will be profitable and essential reading for the specialist who wishes to become knowledgeable about the pre-1966 world literature in the field.

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Part of Plasma Physics

Theory of the Unmagnetized Plasma. DAVID C. MONTGOMERY. Gordon and Breach, New York, 1971. xii, 400 pp., illus. $17.50.

Theory of Fully Ionized Plasmas. GÜNTER ECKER. Academic Press, New York, 1972. xvi, 344 pp., illus. $19.50.

Both these books are interesting, rather specialized accounts of one portion of plasma physics. Whereas traditional treatments of the subject give a prominent role to the effects of external magnetic fields, both Montgomery and Ecker choose to treat only the plasma in absence of such fields, a case sometimes colloquially, if inaccurately, referred to as an "unmagnetized plasma." Magnetic fields are essential for a large class of plasma phenomena, and the major portion of research in the field has concerned itself with magnetized plasmas. Nonetheless, there is much to be said for beginning a serious study of the subject with the unmagnetized case. (This reviewer, for one, has done so in his lectures for many years.) Since it is just the collective, self-consistent properties that constitute the most characteristic, and the most interesting, aspect of plasma physics, this area of the subject seems a more fitting point of introduction than the guiding center motion of single charged particles in magnetic fields which is a prerequisite to a proper presentation of the magnetized plasma theory. However, to exclude magnetic field effects entirely from a book the size of these does seem to carry a good thing rather too far. (Apparently Montgomery felt some qualms on this point, since he includes, in a brief appendix having little logical connection with the rest of the book, a short summary of the solution of the linearized Vlasov equation for a magnetized plasma.)

Both books suffer from an apparent lack of clear intent on the authors' part as to the level of their audience, the discussion in some places being geared to a reader quite unfamiliar with plasma physics and in other portions treating material that is very advanced or recondite. Aside from this, and the restriction to the unmagnetized plasma, they have not a great deal in common as regards content and still less as regards style.

Much of Montgomery's book is very crisply written, liberally seasoned with candid, sometimes trenchant, expressions of the author's prejudices. The first five chapters give a good account of what might be called the "classical" portions of the theory of unmagnetized plasmas. As is perhaps befitting such material, the presentation is somewhat dry and bloodless, emphasizing mathematical formalism more than physical pictures, but I would recommend it as a good introduction to the subject for, say, a young elementary particle theorist who wishes to learn plasma physics. The next two chapters, on nonlinear Vlasov phenomena, are perhaps too detailed and too near the frontier of research to be of maximum value for the beginner, but they should be valuable as a well-annotated guide to the literature of the subject for professional plasma physicists.

Chapters 8 through 11 present a very detailed discussion of kinetic theory. This is inherently difficult material, conceptually, mathematically, and even notationally, where clarity and simplification are an urgent necessity. Unhappily, the author has chosen to present not only the Klimontovich-Dupree formulation of this material, which he correctly recognizes as the one best suited for exposition, but also the more traditional Bogolyubov-Born-Green-Kli-