A number of the papers do this very well, and for these papers alone the symposium must be considered a success; parts of the book should be read by anyone interested in these aspects of population ecology. The organizers invited papers from the fields of agriculture, nutrition, and behavior, in the hope of giving ecologists new insights from these fields. For this ecologist, at least, that attempt largely failed. On the other hand, a number of the papers by ecologists raise questions that I think would interest the nutritionist, physiologist, behaviorist, and those interested in the coevolution of plant-herbivore systems. The 24 or so papers cover a wide range of organisms —sheep, cattle, various birds, North American deer, African ungulates and hyenas, fish, aphids, various other insects, flatworms, snails, and soil amebae. The book might serve as a source of information and references for workers interested in any of these groups, or in feeding relationships in general, and this purpose will be greatly helped by the presence of four good indexes: of authors, species, geography, and subjects.

The book is divided into three sections. The first, following an introduction by David Lack, examines food selection in various groups (nine papers, 157 pages). I found this mainly dull, though an occasional fact was interesting. The trouble with most of the papers here is that they set out simply to describe the diet of animals, compared with what the animals might have available or in relation to nutritive quality. Most authors did not set out to test hypotheses or to work out population mechanisms, and unless one has a particular interest in the organisms discussed the absence of ideas soon blunts one's interest. This section, incidentally, perpetuates the myth of the Kaibab deer "eruption" and decline, a myth recently laid to rest by Caughley in *Ecology* (1970). Since this part constitutes a third of the book, it contributes to the high price that may well deter many ecologists from buying a book they would otherwise enjoy.

The other two sections deal with the importance of behavior in relating populations to their food resources, and with the effects of quantity, quality, and availability of food resources. Two features are outstanding. The first is a long paper (55 pages) by Watson and Moss giving a thorough, extensive, and excellent review of the role of territorial and other social behavior in determining the density of vertebrate populations. The paper is an object lesson for those who have participated in the controversy over whether food or territory limits bird numbers. Major protagonists of both sides have uncritically accumulated confirmatory evidence for their viewpoint and ignored or rejected contradictory evidence. Watson and Moss present a critical and remarkably dispassionate analysis of the many relevant studies. They also look at the interaction between behavior and food supply, and this, together with papers discussed below, illustrates that ecologists have pitched their discussion of these questions at much too simple a level.

The other main feature is the several discussions of food quality and the interaction between herbivores and the quality and quantity of their food supply. Hughes and Walker, in a return to that favorite habitat of ecologists, the cow pat, show that even here food quality has a profound effect on population dynamics (of flies). Miller, Watson, and Jenkins describe some preliminary but interesting experiments on the effect of food quality (heather) on grouse populations. Indeed, one of the reasons that much of this section is interesting is the experimental approach of a number of the authors. In his brief review of the long-term studies of Wytham Woods in Oxford, Varley makes reference to one of the most interesting recent findings about food quality, namely that the amount of various tannins in oak leaves changes seasonally and essentially the leaves are available as food for caterpillars for only a very brief period in the year, after which caterpillars cannot develop on them. (This has since been described in detail by Feeny [*Ecology*, 1970].) Way and Cammell show that not only is food quality important for aphids, but the density and aggregative behavior of aphids affect the quality of the host plant—the behavior often serving to improve the quality of the plant for the aphids. They discuss how behavior varies among aphid species and plays a key role in adjusting numbers to food supply.

The important message of the symposium, about food quality, behavior, and population limitation, is encapsulated in a fine, terse paper by Dixon. He provides an explanation of limitation of density in aphids caused by interactions among individuals in the population. These interactions are tied to the nutritive quality of the host plant—when quality (amino-nitrogen content) is low, individuals move more and limitation occurs at lower densities. The availability of the food is also affected by the structure or the foliage and the microenvironments this creates. At no time does "energy" (sugars) appear to be limiting. This paper and others in this section suggest that no future study of animals in relation to their food supply will be complete unless it examines food quality and availability. They also suggest that looking for explanations of population limitation in terms of single limiting factors may often be far too simple an approach. Finally, the difference between the earlier and later papers underlines the fruitfulness in ecology of looking for mechanisms and doing experiments, rather than simply describing situations. The book thus represents a significant step in formulating ecological problems.

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Biochemical Analysis

Interacting Macromolecules. The Theory and Practice of Their Electrophoresis, Ultracentrifugation, and Chromatography. JOHN R. CANN. With a contribution by Walter B. Goad. Academic Press, New York, 1970. xii, 250 pp., illus. $12.50. Molecular Biology series.

Macromolecular interactions have assumed increasing importance with the recognition of the subunit structure of large proteins and of the mechanism of allosteric reactions. Such interactions are manifested (sometimes very subtly) as anomalies in the behavior of the macromolecular system when it is subjected to the common techniques used in fractionation and characterization: that is, electrophoresis, chromatography, and ultracentrifugation. The fact that these methods are now universally used, and most of their inherent difficulties so widely understood, may be attributed in large part to the existence of a series of instructive reviews and monographs; in this tradition, Cann's book now takes its place.

The elementary theory of the transport processes is described, and Cann uses rigorous mathematical methods to demonstrate the fundamental relationships; the discussion of the Johnston-

Ogston effect in sedimentation velocity, for example, is particularly clear and informative. Students of thermodynamics will be pleased to note that the treatment of sedimentation equilibrium is in terms of the Helmholtz free energy.

The concept of rapidly attained equilibrium and its influence on the transport processes are discussed first in terms of the weak-electrolyte moving-boundary theory. The results are relevant both to moving-boundary electrophoresis (a technique now used by only a small minority of laboratories) and to sedimentation velocity. As an example in the latter field, Cann cites the work of Schachman *et al.* on aspartate transcarbamylase to illustrate the experimental approach made possible by ultraviolet scanning optics.

Great progress in the understanding of reversibly associating macromolecular systems has come from analytical solutions of the simplified conservation equations, in which diffusion is neglected. In this area, Gilbert's work is of the first importance, and Cann describes it in satisfactory detail. The examples chosen to demonstrate the conclusions of the Gilbert-Jenkins theory are an antigen-antibody reaction and a Michaelis-Menten complex, salutary reminders of the very general application of this rather recondite theory. In passing, one notes a very clear exposition of the concept of entropy-driven *association* reactions in solution.

More recently, the computer has been harnessed to provide numerical solutions of the exact differential equations of transport, retaining the diffusion term. The whole range of variation in the shapes of distribution curves may thus be explored, and Cann provides a comprehensive account of these investigations. This work is of importance, for example, in illustrating the precautions that are necessary before the results of moving-boundary and zone electrophoresis can be taken at face value.

Pressure effects in sedimentation velocity experiments on reversibly reacting systems are now recognized to be significant; these effects are analyzed in some detail, with continuing reference to the fascinating example of myosin.

The numerical methods described in chapter 5 (of which W. B. Goad is the author) will be of interest chiefly to those who are concerned with programming: this section includes a Fortran program for the calculation of equilibrium constants for a generalized macromolecular aggregation.

The emphasis throughout the book is on mass transport phenomena, and the possibilities inherent in sedimentation equilibrium are given perhaps less than their due weight. In a second edition attention will no doubt be given to recent progress in this field; such an occasion would also allow the correction of a series of trivial but distracting misprints ("Svedburg," "Faxin," "Picten," for example) confined largely to the first chapter.

To sum up, this book provides a clear and up-to-date account of a complex subject; the practicing biochemist will find it of great value in interpreting the many macromolecular systems that fall within its scope.

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Terminal Ballistics

High-Velocity Impact Phenomena. RAY KINSLOW, Ed. Academic Press, New York, 1970. xii, 580 pp., illus. $25.

This book attempts to collect, bring up to date, and summarize our knowledge concerning the very complicated subject indicated by its title. This goal is fully realized in the nine chapters, all of which are written by authorities in the special fields. The variety of technological fields to which high velocity impact is relevant is wide and is well covered in this book. The subjects treated extend from experimental methods of causing projectiles to attain high velocity, through theoretical analyses of the behavior of materials under high rates of strain and experimental observations, to engineering design. Although progress in this field was beginning about 1940, motivated by military considerations, the development of space travel in recent years has excited and demanded greatly accelerated research on the subject because of the hazard of meteoroidal collision. Some of the treatments are highly technical and mathematical, yet there is much that the general science reader can learn from the book. The specialist will find the book very useful in that it gathers together the many threads of the problem.

The theory of elastic waves in solids is given as a foundation for the more difficult nonlinear theory, and considerable space is devoted to codes useful in numerical solutions of specific impact problems. In such a difficult exercise, experiment and empirical observation play an important role, and these subjects are given extensive treatment in this book. One chapter is devoted to the equation of state for solids, centered chiefly on the beautiful work accomplished in Los Alamos over the last 20 years. The role of metallurgical and mechanical properties of materials in crater formation is discussed. And finally, as is discussed in the last chapter, the engineer is faced with the problem of designing hardware on the basis of incomplete theory and limited data.

One of the valuable features of the book is the very extensive bibliographies included at the end of each chapter. The serious worker will find these references invaluable, but the history of the subject is such that a great many of the citations are to reports of limited circulation.

The statement is made in the preface that terminal ballistics has been the subject of formal study for more than two centuries. No attempt is made, however, to review this history. Such a review would have revealed that almost nothing was learned about the subject before 1940. In fact the very words "terminal ballistics" did not to my knowledge occur in the English language before they were introduced by R. A. Beth in 1941. Perhaps the omission of any history is excusable, as so little was accomplished until recently, particularly in the very high velocity range.

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Mach's Views

Ernst Mach. Physicist and Philosopher. Based on an AAAS symposium, Washington, D.C., Dec. 1966. ROBERT S. COHEN and RAYMOND J. SEEGER, Eds. Reidel, Dordrecht, and Humanities Press, New York, 1970. viii, 298 pp., + plates. $11.50. Boston Studies in the Philosophy of Science, vol. 6. Synthese Library.

The rich contents of this collection of essays by 12 authors deal historically, biographically, systematically, and critically with the multifaceted work of one of the truly great and influential thinkers of the 19th century. I hesitate to single out those essays that fascinated me most. As is well known, Mach's ideas greatly influenced the young Einstein. But Einstein dissociated himself soon after from the radi-