from the same shortcomings, the estimation procedure used by the authors provides them with a means of differentiating degrees of dispersed and nucleated residence.

This study underscores the contributions that settlement reconnaissance and the regional perspective can make to unraveling human prehistory. The authors have done an excellent job in producing a technical yet highly readable reconstruction of demographic processes in the southern Valley of Mexico that will be a valuable reference for many years to come.

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The Rotation of the Earth

Tidal Friction and the Earth's Rotation II. Proceedings of a workshop, Bielefeld, Germany, Sept. 1981. P. BROSCHE and J. SÜNDERMANN, Eds. Springer-Verlag, New York, 1982. xvi, 346 pp., illus. Paper, $28.

To emphasize the fascination of the subject of tidal friction is to risk the charge of banality. Yet it needs to be done, for few subjects in the earth sciences require that such a breadth of disciplines be mastered before a complete understanding can be approached. This volume attests to the continuing appeal of an old problem: the search for an understanding of the orbital evolution of the moon and the spin history of the earth. But, one may ask, why one more volume on the subject? What, for example, has been learned since the publication of its predecessor in 1978 or, for that matter, my own book on the subject in 1980?

Evidence for the tidal acceleration of the earth's spin and the moon's orbital motion comes from quite diverse and even unexpected sources: from telescope observations of relatively recent times, from ancient and medieval records of times or places of astronomical phenomena such as eclipses and occultations, and, further back in time, from the paleontological clocks. All sources have been much explored in recent years, and all point to a day that was shorter in the past than it is now and a moon that was closer to the earth than it is now. Dispute lies not here, but in exactly where the moon was at specified times in the geological past. If present-day values are used to extrapolate the motion back in time—there is a useful review of this problem by F. Mignard in this volume—the unpalatable conclusion is reached that the earth and the moon must have barely escaped from a collision course some 2 to 1.5 billion years ago. This close encounter is sometimes referred to as the Gerstenkorn event. (Incidentally, this book is dedicted to Gerstenkorn.) The event conjures up planet-disrupting tides (W. Munk, *Q. J. R. Astron. Soc.* **9**, 352 [1968]) in which, to borrow a phrase from the Prayer Book of 1662, "the earth shall melt away." Yet the moon escaped unscathed. If the event occurred, it must be pushed back to the darkest ages of the solar system. Still, the Gerstenkorn event pervades the volume, possibly because it is an event that can be evaluated to a degree by celestial mechanicians, possibly because the book has a startling lack of discussion of chemical considerations of the lunar origin. Only one paper, by H. Wänke and G. Dreibus, discusses the lunar chemistry, and it is tucked away at the end of the volume. Yet the chemical evidence that the moon formed near or out of the earth at a very early stage (A. E. Ringwood, *The Origin of the Earth and Moon*, Springer-Verlag, 1979) must form the essential boundary condition on spin and orbit evolution calculations.

How then is the mathematics reconciled with the chemistry? That the bulk of the tidal energy is dissipated in the oceans is now established beyond any serious doubt. But with "continental drifters and pole twisters" ruling the earth sciences, unpredictably changing the ocean's tides, the assumption of constancy of tidal friction can hardly be sustained for any length of time. The problem of time scale cannot be solved unless we can establish geological markers of the moon's journey in space or past tidal patterns on earth.

Paleontological time keepers, the growth rhythms of corals and bivalves, heralded a new set of such markers, but after the initial enthusiasm no new results have appeared. The growth habits of even ordinary cockles are more complex than initially thought, as is emphasized by T. Ohno. Several authors refer to the stromatolite evidence for past tidal cycles. But here the evidence is tenuous indeed. Certainly the living Hamelin Pool algal mats do not appear to obey the tides in their growth habits.

To reconstruct ocean dissipation models back in time, the mechanism by which dissipation occurs must be known and past configurations of the oceans must be charted. Surprisingly little attention is given in this volume to the actual manner in which energy is dissipated. Common wisdom still has it that it is by bottom friction in shallow seas. But mathematical solutions rely on linear friction models or on internal friction laws to maintain numerical stability. This contradiction is largely ignored in the search for quantitative estimates of past dissipation. Two approaches have been used. D. J. Webb demonstrates with a simple geometrical model how the resonance frequencies of the oceans can change with the shifting of the orientation of much simplified ocean basins relative to the lunar orbit. The essential result is that there is little difficulty in keeping the moon away from the earth. More ambitious models are proposed by J. Krohn and J. Sündermann, who attempt to model the tides from paleo-ocean reconstructions, although two papers warn about the inadequacy of the paleogeographic maps. Perhaps the final subsection of a long and otherwise mostly irrelevant paper by J. D. A. Piper is a useful reminder that the present ocean-continent configuration is unusual, that for long time intervals the continental crust was concentrated in high latitudes and characterized by restricted shorelines. Such a geometry will lead to much reduced dissipation, as is emphasized by Webb. Quite clearly, protagonists of an early formation of the moon near the earth need not lose sleep over the implications of this volume.

On the shorter time scale, of millennia rather than eons, the evidence for tidal friction comes from the myths, literature, and history of humanity. The debate here deals with which category a particular record falls into. F. R. Stephenson and L. V. Morrison discuss this in what is, in my mind, the outstanding paper in the volume. They note that Fotheringham's classic analyses are based on eclipse records that are now believed to fall into the category of myths, or are based on erroneous interpretations of the date and place. Yet the irony is that Fotheringham's result for the accelerations is not that different from that obtained by these authors. Have we all been fooled by a classicist? Stephenson and Morrison contribute some important new data in the form of timed lunar eclipses for the period 700 to 50 B.C. They also report on some new observations for the period A.D. 1620 to 1860 to supplement the older analyses of telescope observations. On these time scales tidal friction is not expected to undergo any significant change. Rather, these observations point to changes in the earth's rotation on the time scale of centuries and decades. Some indirect reference to the geophysics of this prob-

lem is given in papers by R. Hide and M. Stix. I think that it is here that exciting results can be expected in future years.

In hindsight it was probably premature to publish this follow-up volume to the generally more successful earlier collection. But the book is worth perusing as an indication of how this science progresses and digresses.

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Interactions Among Species

Interaction and Coevolution. JOHN N. THOMPSON. Wiley-Interscience, New York, 1982. x, 180 pp. $27.50.

Ecology and evolutionary biology are going through a difficult period. During the last few decades, interdisciplinary syntheses and mathematical models provided new conceptual foundations and stimulated much empirical research. As the data have accumulated, however, they have served mainly to demonstrate the inadequacy of the theories to account for the complexities of the natural world. At present the disciplines seem uncertain of their direction: they have neither reconciled the troublesome gaps between theory and data nor abandoned these problems to pursue promising new lines of investigation. It is a hazardous time for anyone to attempt a synthesis, especially when the topic, coevolution, lies right at the interface of ecology and evolutionary biology.

In this well-written, scholarly little book a relatively young investigator reviews many recent studies of competition, predation (including herbivory and parasitism), and mutualism in a brave effort to synthesize available information on how these interspecific interactions affect the evolution of populations and the organization of communities. The approach is almost exclusively empirical, qualitative, and inductive. The author draws on examples from a wide variety of organisms from diverse habitats and geographic regions in order to describe what he believes to be general patterns of interaction and association among species that presumably reflect the operation of basic coevolutionary mechanisms. He uses this approach to try to answer such difficult questions as: What determines the degree of specificity in the different kinds of interspecific interactions? What circumstances favor the evolution of mutualistic associations from antagonistic interactions? How do spatial and temporal environmental heterogenity affect the coevolution of interacting species? Under what conditions are parallel speciation patterns of host and exploiter species most likely to be observed? I do not think Thompson manages to provide very satisfactory answers to these questions, but then I doubt that anyone could answer them convincingly. Perhaps, given the present state of our knowledge, these are not even the kinds of questions we should be addressing with high expectations.

As a review of recent field studies of interspecific interactions and coevolution the book is successful and valuable. It is impossible to do justice to all the important studies in a book of this size (or probably of any reasonable size), but Thompson's treatment is broad, deep, and well balanced. After developing the concept of coevolution in the introductory chapter, he devotes successive chapters to predation (including grazing and parasitism), competition, mutualism, environmental and life history constraints, evolution of mutual dependence, cospeciation, and community structure. Thompson's command of the recent literature is impressive, and he shows excellent taste in selecting interesting, well-documented examples to illustrate his points. These examples include fungal disease resistance in wheat, dietary selectivity of grasshoppers and grazing mammals, flower specificity of pollinating bees, moths, and hummingbirds, oviposition behavior of butterflies on plants, and adaptations of fleshy fruits for seed dispersal by birds. For one who wants to be introduced to the diversity of interspecific associations in the natural world or to obtain important references to catch up on recent developments in the field, this book is an excellent place to begin.

A reader who stopped his or her study of interactions and coevolution after reading this book would, however, be left with a misleading impression of contemporary evolutionary ecology. In my opinion in Thompson's attempts at analysis and synthesis he completely fails to convey any sense of the conceptual ferment that now pervades the field. There are those who question whether any but the most trivial patterns in nature can be attributed to interspecific interactions and coevolutionary processes. These skeptics will hardly be convinced by Thompson's qualitative treatment; there are only two graphs and a few quantitative tables in the entire book. Mathematical models are hardly mentioned, so their seminal role in stimulating much of the empirical research and in revealing the shortcomings of the models themselves cannot be appreciated. There is little recognition of the contributions of controlled, manipulative experiments and statistical analytical techniques in transforming descriptive natural history into the rigorous sciences of ecology and evolution.

I suspect that another forthcoming book on coevolution (D. J. Futuyma and M. Slatkin, Eds., *Coevolution*, to be published by Sinauer Associates) will tackle some of these thornier issues, but I doubt that it will be much more successful in answering the fundamental questions. Contemporary evolutionary ecology is full of controversy as investigators attempt to use different approaches to reconcile the discrepancies between rigorous mathematical models and sound quantitative data. I suspect that many of the questions eventually will be answered, but many others may prove insoluble, at least in the short term, and the discipline will have to bypass them and go on to other, more productive lines of investigation. Thompson may have set himself an impossible task in trying to identify the conceptual bases of a discipline that does not have many, but his book fails to do justice to the quantitative developments that have carried it to its present precarious state.

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Equids

Horse Behavior. The Behavioral Traits and Adaptations of Domestic and Wild Horses, Including Ponies. GEORGE H. WARING. Noyes, Park Ridge, N.J., 1983. xii, 292 pp., illus. $35. Noyes Series in Animal Behavior, Ecology, Conservation and Management.

Horse Behavior by George H. Waring is a book that will be useful to a wide audience. For the student of animal behavior the book integrates the findings of hundreds of international researchers who have worked with domestic as well as feral horses. For the veterinarian or student of veterinary science the book provides a baseline of typical equine behavioral traits that can be compared to the abnormal behaviors encountered in veterinary medical practice. (In addition, the appendix contains 12 pages of equine behavioral symptoms that are correlated with their possible causes.) For the horse breeder and avid horseman or horsewoman the book discusses guidelines for