ertheless, many biologists have begun to assert with facility that isolation in Pleistocene forest refuges was a primary cause of lowland tropical species diversity. Such an unquestioned acceptance does not yet seem warranted. It is important to remember that the original studies were at the taxonomic level of superspecies or below. Haffer has been careful to point out that Pleistocene events caused extinctions as well as differentiation. Tropical rain forests were biologically diverse before the Pleistocene. There may have been no net change in the number of species over the last few million years. The major effect of climatic fluctuations may have been to alter distributions of species and to cause intraspecific differentiation rather than speciation.

As a whole, the volume is engrossing and mandatory reading for students of the Neotropics. Many of the studies have heretofore been published only as theses or technical bulletins (for example, Lamas, Toledo) or in journals that are difficult to obtain in the United States (Ab'Sáber). The authors themselves and the data they present point out the strong and weak points of the refuge theory and the need for more geological and biological work bearing on it. Prance is to be commended for his fine editing and for allowing the tropics to be revealed to be as enigmatic as ever.

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Chilopoda

The Biology of Centipedes. J. G. E. LEWIS. Cambridge University Press, New York, 1981. viii, 476 pp., illus. $69.95

Although most animals are basically mobile digestive systems, I can think of no organism whose structural plan is more dominated by the front end than centipedes. The head is often the broadest part of the body, and if the actual mouthparts are of modest size they are overcompensated by a pair of formidable poison fangs modified from the first pair of legs (unique in the animal kingdom), and the entire muscular and flexible creature strikes even the most dispassionate observer as the epitome of frenetic rapacity (an impression abundantly confirmed by its behavior).

Looking beyond this unpromising facade, one finds that centipedes are at once among the most fascinating and least known of all animals. Like many other residents of the soil and litter milieux, they have been neglected by all but a few investigators, and what has been published on them has generally been widely scattered through a polyglot literature. The last general survey of centipede biology appeared nearly six decades ago and has long been obsolete. Unquestionably the lack of a modern authoritative synthesis has been the major deterrent to potential investigators of chilopods, and it is gratifying that this obstacle has now been removed by an internationally respected specialist on these animals.

The Biology of Centipedes follows a traditional organization, treating anatomy, function, behavior, ecology, and systematics in 24 chapters. The author has carefully selected and balanced the subject matter and illustrations. Moreover, his writing style is pleasant. Under each major subject heading the condition is covered in centipedes generally and then for each of the four orders. There is a bibliography of 561 references cited in the text.

One expects centipedes to be somewhat outlandish, but even having some familiarity with the group I found myself repeatedly astonished by Lewis's accounts of their structure, function, and general life-styles. What intriguing animals, and how little is actually known about them! Nearly every page repeats the admission that we are seeing only bits and pieces of a grand pattern. Here is a large group (an arthropod class with over 2500 known species) in which the taxonomy remains chaotic (even the families are not adequately defined), much of the simplest gross anatomy unstudied (let alone its macromolecules), and almost all information about its natural history anecdotal. If ever a group cried out for study on all fronts, it must be the Chilopoda. Whatever the past difficulties with literature may have been, Lewis's book now provides an elegant prelude for a more mature stage of chilopodology.

A critic may be forgiven for wishing to see more of a good thing. If I had jurisdiction over the second edition, I would propose the following changes: adoption of a smaller type size and more compact format, which would yield up to 20 percent more space for text without increasing pagination or decreasing readability; the addition of an introductory chapter on the history of chilopod study and another on biogeographic patterns; and last, but of foremost importance, expansion of the three chapters on systematics. The author states that the inadequate state of the group's taxonomy justifies only superficial treatment, but the same argument could have been used in the case of the other chapters as well. What better place to present a synopsis of the current classification of all supraspecific taxa than in a general reference work? A brief diagnosis for each family or subfamily, with a list of published generic names and pertinent literature, would have given aspiring students access to this difficult subject and placed its coverage on a basis equivalent with the other aspects of the group's biology.

En fin: there can no longer be any justification for any graduate student to pick away at fruit flies, milkweed bugs, and marine invertebrates, splitting molecules and inventing bizarre experiments in an attempt to wring yet another dribble of information from these already exploited creatures. Lewis's book provides a wide-open field for exploration, with a megaproblem per page, and fascinating problems at that, whether one's bent is holistic or molecular, experimental or systematic.

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Circannual Rhythms

Biological Clocks in Seasonal Reproductive Cycles. Proceedings of a symposium, Bristol, England, March 1980. B. K. FOLLETT and D. E. FOLLETT, Eds. Halsted (Wiley), New York, 1981. xii, 292 pp., illus. $49.95. Colston Papers, vol. 32.

Many organisms have seasonal reproductive cycles, presumably to ensure optimal conditions for the survival of offspring and to minimize the costs of maintaining the reproductive system during unfavorable conditions. However, such a strategy entails considerable risk, in that a single mistake in timing could prove extremely costly to entire populations. Thus it is hardly surprising that organisms have adopted a variety of strategies to prevent such mistakes. In many, although not all, cases, however, the seasonal change in daylength (photoperiod) serves as the most reliable and therefore most important signal for the initiation or termination of reproduction.

Most of the contributions in this volume offer reviews of progress since the 1960 Cold Spring Harbor symposium on biological clocks as well as some new empirical findings. The advances are characterized not so much by new ideas as by the elaboration and refinement of earlier hypotheses. Simple hourglass timers may be the main or sole mediators of photoperiodism in some plants, certain insects, and a lizard (*Anolis carolinensis*). On the other hand, a particular phase in the circadian cycle may coincide with light only when the photoperiod reaches a critical value (external coincidence; a more explicit version of Bünning's hypothesis), or changes in photoperiod may produce changes in the phase relations among two or more endogenous circadian oscillations (internal coincidence). A substantial portion of the book is devoted to the formal analysis of circadian rhythms and their role in photoperiodism.

One cannot fail to be impressed by the ever-increasing sophistication of models based on oscillator theory and the proliferation of experimental designs now widely used to test predictions derived from such models. In addition to traditional resonance experiments (in which light signals are omitted for multiples of 24 hours), single-pulse perturbations (for example, to map phase response curves), T cycles (entrainment by one light pulse per cycle), and symmetrical and asymmetrical skeleton photoperiods (two light pulses per cycle) have become standard tools for probing the functional properties of the circadian system as well as its mediation of the photoperiodic response.

The opening chapter (by C. S. Pittendrigh) provides an elegant modern version of the circadian system, involving a system pacemaker and coupled slave oscillators. Though the model evolved primarily from data on the *Drosophila* emergence rhythm, its basic features have general applicability. The important feature of the model with regard to seasonal reproduction is the inevitable change in phase relations among coupled oscillators as the photoperiod changes. Thus, the modus operandi for internal coincidence exists in any organism with more than one circadian pacemaker.

Whereas for mammals the evidence increasingly seems to favor internal coincidence, strong evidence for external coincidence (with a little help from an hourglass) is presented for insects. Of course, such mechanisms need not be mutually exclusive. Two chapters present evidence for a complementary system, a thermoperiodic response with formal properties quite similar to photoperiodism in certain insects. The possible existence of a circannual clock, which is not simply based on frequency demultiplication of circadian oscillations, is indicated by the testicular response of starlings and garden warblers.

Progress in elucidating the physiological bases of photoperiodism and circadian rhythmicity has been much slower. Nevertheless, there is increasing interest in physiological variables, ranging from plant enzymes to patterns of gonadotropin secretion in quail, hamsters, and sheep. Attempts to localize and study circadian pacemakers both in vivo and in vitro are also reviewed. The complex role of the pineal gland in the mediation of circadian rhythms and in photoperiodism is discussed in several chapters. The effects of pinealectomy (and of lesions of the suprachiasmatic nucleus) seem to vary considerably from species to species, and, given the number of suspected circadian oscillators in insects, one wonders (with Aschoff, who presented the Annual Colston Lecture, the text of which concludes the volume) how many "clocks" have yet to be discovered in vertebrates.

Overall, the main virtue of the book is that it conveys the variety and diversity of mechanisms used by organisms to regulate seasonal reproduction. Although much of the information presented here can be found in other sources, it is of great value to have it all in one place. This book serves as a handy reference for anyone interested in seasonal reproduction and offers much to those with more than a passing interest in biological rhythms in general.

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Elementary Particle Physics

To Fulfill a Vision. Proceedings of a symposium, Jerusalem, March 1979. YUVAL NE'EMAN, Ed. Addison-Wesley Advanced Book Program, Reading, Mass., 1981. xxxiv, 280 pp. $39.50.

This volume, the proceedings of half of the Jerusalem Einstein Centennial Symposium, is a companion volume to the proceedings of the Princeton Einstein Centennial Symposium, published as *Some Strangeness in the Proportion* (Harry Woolf, Ed., Addison-Wesley, 1980). The proceedings of the other half of the Jerusalem symposium, published as *Albert Einstein: Historical and Cultural Perspectives* (G. Holton and Y. Elkana, Eds., Princeton Univ. Press, 1982), covers the historic impact of Einstein's ideas in politics and international security, philosophy and linguistics, art, and psychoanalysis and sociology. Together the three volumes present the best-informed and most compact review of Einstein's impact to emerge so far out of his centenary year.

The volume reviewed here contains short summaries of the current situation in quantum chromodynamics (QCD) by Y. Nambu, G. 't Hooft, R. Dashen, and H. J. Lipkin and in quantum flavor dynamics (QFD) by S. L. Glashow, H. Harari, and R. Gatto. There are long reviews of the program for grand unification of electroweak and strong interactions (GUT's) by S. Weinberg and J. C. Pati and of supergravity by D. Z. Freedman. These are all excellent, generally nontechnical reviews by authors who helped to create and continue to be at the center of activity in QCD, QFD, and GUT's.

The two most promising possibilities for completing the theoretical structure of fundamental particle physics are GUT's and supergravity. GUT's neglect gravity and aim to unify QCD, the unbroken symmetry of strong interactions, and QFD, the broken symmetry of electroweak interactions. The theoretical possibilities are so constrained that only three separate local gauge theories are possible: spin 1 gauge particles (electrodynamics and its non-Abelian generalization, Yang-Mills theories), spin 2 gauge particles (general relativity), and spin 3/2 gauge particles (supergravity). Supergravity is the gauge theory of local supersymmetry transformations connecting bosons and fermions. Freedman shows how supergravity incorporates Einstein's three precepts: symmetry of physical laws (supergravity is the only known invariance compatible with quantum field theory that unifies spin and internal symmetry); geometrization of physics (the four-dimensional space-time geometry is extended to a superspace parameterized by four Bose coordinates and four anticommuting Fermi coordinates); and unification (gravitation can be unified with the other two gauge interactions only via a spin 3/2 gauge particle, the gravitino). Y. Ne'eman reviews work on affine or Poincaré gauge theories.

These papers are masterly summaries of the present situation in the rapidly developing areas of QCD, QFD, GUT's, and supergravity. Of more permanent value are papers by C. N. Yang, P. G. Bergmann, and F. Gürsey on unified field theories and the geometrization of physics. Einstein's pursuit of unification of gravity and electrodynamics was motivated by his search for nonsingular solutions to the field equations, by his wish to explain the spectrum of particles and interactions, and by his search for a