minating section of the work is the treatment of the sterile character of Cambridge University, from which Newton insulated himself well; the way he responded at an advanced age to administrative challenges he faced as Warden and Master of the Mint and to the new foreign social environment in the capital; and the masterly way he brought the pieces of his celestial and terrestrial dynamics together when called upon to write the *Principia*. Here, as elsewhere, Westfall knows how to use the writings and analyses of other scholars to fashion a brilliant synthesis. Significantly, the least satisfying section is the discussion of the *Opticks*, a topic that is not well treated by others and is in need of more study. I was left puzzled by the way Newton was able to juxtapose his color theory with several periodic optical phenomena discussed on the basis of his excellent observations. That is just one of many subjects that have not been exhausted. But Westfall will surely have brought its discussion to a new and higher plane with this magnificent biography.

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Particle Physics

Proceedings of the Fifteenth Rencontre de Moriond. Les Arcs-Sovoie, France, March 1980. J. TRAN THANH VAN, Ed. Editions Frontières, Dreux, France, 1980. In two volumes. Vol. 1, Elementary Constituents and Hadronic Structure. 706 pp., illus. $65. Vol. 2, Electroweak Interactions and Unified Theories. 606 pp., illus. $65.

Over the past five years experimental evidence has steadily mounted in support of what are now the standard descriptions of three fundamental forces in nature: the strong, short-range interactions between hadrons (for example, protons and neutrons); the weak, short-range interactions common to hadrons and leptons (for example, electrons); and the familiar long-range electromagnetic interactions between charged particles. The implications of these three theories are often best tested in very high energy collisions. One of the numerous conferences at which new results are reported is the Rencontre de Moriond, held in the French Alps each March for two weeks. The papers presented at these meetings are less formal than those published in the research journals but not as pedagogical as the lectures at summer schools. The two volumes of 1980 proceedings contain 95 research papers of varying lengths.

Volume 1 is devoted to the structure of hadrons. Roughly half the papers treat hadronic collisions. Particularly impressive here are the data on massive muon pair production presented by D. Decamp, which fit the Drell-Yan model and yield structure functions that agree with those measured in completely different types of experiments. The one puzzle is that the experimental cross sections are twice as large as the simple model predictions. E. L. Berger gives a theoretical overview of dilepton experiments. Several papers discuss high momentum leptons as signals for charm or other new quarks, and P. Charpentier puts rather strong limits on the production of B mesons from trimuon and like-sign dimuon events. There is a rather standard assortment of papers on hadronically induced jets and on photoproduction.

New data are presented on deep inelastic muon scattering by J.-M. Thenard, K. Rith, Y. Sacquin, and R. Johnson and on deep inelastic neutrino scattering by D. Schlatter and P. Fritze. At momentum transfers as large as 200 GeV^2 the scaling violations at large x are as expected but are slightly ambiguous at small x. Unfortunately, the data presented are preliminary.

A. Petersen, D. Schmidt, G. Mikenberg, and H. B. Newman, each representing one of the four major groups at PETRA, display very beautiful results on hadronic jets produced in e^+e^- collisions. Each of the four reports is quite thorough and presents solid evidence for the existence of three-jet events at energies of 30 GeV (center of mass). The significance of these events and theoretical expectations for the future are thoroughly discussed in a 40-page report by S. Wolfram.

Volume 2 deals with the electroweak interactions and unified theories. B. Gittelman, P. Skubic, and S. Herb from CESR as well as J. K. Bienlein and K. R. Schubert from DORIS report on the first measurements of the $b\bar{b}$ bound state system. The masses and leptonic widths of three very narrow states and one broad one are measured and agree with theoretical models as described by A. Martin. M. Oreglia, D. Aschman, and G. J. Feldman from SPEAR each present very precise results on radiative transitions between states of the lighter mass $c\bar{c}$ system. They see evidence for only one pseudoscalar state that does not decay into two photons and are able to measure the angular momentum of the χ states from the angular distribution of the photons associated with their production and decay. R. Marshall, W. Bartel, H. Spitzer, F. Vannucci, and D. H. Saxon from PETRA each report on the search up to 35 GeV for $t\bar{t}$ states, heavy leptons, weak electromagnetic interference, and free quarks. From 2-GeV measurements at Orsay, A. Cordier presents evidence for the ϕ' resonance partner of the ρ'. In a section on muon and neutrino physics there are several papers on beam dump experiments and dimuon events and a nice review by M. Strovink of multilepton production. J. Trischuk presents the results of several emulsion experiments that measure charmed meson lifetimes.

The small collection of theoretical papers on grand unification provides a useful review. K. Kang introduces the SU(5) model and then follow two papers of more than 40 pages each—a lucid and practical discussion by D. V. Nanopoulos of the SU(5), SO(10), and E_6 grand unified models and a pedagogical gem by K. D. Lane and M. E. Peskin on dynamical symmetry breaking.

These volumes are not intended to provide an overview of the field. They are extremely topical and in many instances the reports may already be superseded by journal articles.

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Developmental Biology

The Development of the Vertebrate Limb. An Approach through Experiment, Genetics, and Evolution. J. R. HINCHLIFFE and D. R. JOHNSON. Clarendon (Oxford University Press), New York, 1980. xvi, 268 pp., illus., + plates. $59.

This excellent book is the first to attempt a comprehensive review of vertebrate limb development. It draws together information and ideas from the fields of evolutionary biology, genetics, and experimental embryology. In many ways the book is inconclusive, and it raises as many questions as it answers. But it is just this kind of bold statement that will contribute to the process of getting some of the loose ends tied up.

The book has a pleasing symmetry in that it both begins and ends with evolutionary considerations. In between are chapters on adaptation and diversity, embryology, regeneration, and pattern formation. Throughout the book the authors attempt to discuss as many different vertebrates as possible, although the experimental sections concentrate on the chick wing. This is not a criticism of the

book, but a consequence of the fact that the bulk of experimentalists in recent years have chosen to study the chick limb. Nevertheless, I find the authors' opinions about the drawbacks of working with amphibian embryos curious. They think it is a disadvantage that amphibians regulate for limb parts that are removed, since this obscures the effects of the absence of the parts. Quite to the contrary, it can be argued that in order to elucidate the control of patterning and the nature of positional information in limbs it is necessary to look at forms that regulate for tissue removal and rearrangement and rather dangerous to extrapolate from data obtained from forms that do not.

By and large the authors do a good job of presenting the known facts about limb development as well as the results of experiments. Although it makes the book less tidy, in most instances they wisely refrain from presenting an overall interpretation of their own. The limited attempt they make at the end of the book to develop some general principles is not particularly successful, and their closing statements about the possible role of compartments (analogous to those demonstrated in insects) in vertebrate limbs do not add anything and are in fact misleading. The chapter on limb regeneration presents a reasonable if brief summary of what is known, although it overlooks some important work, most notably that of Tassava and his colleagues on the relationship of injury, epidermis, and nerves to blastemal cell cycles.

The least satisfactory part of the book is the chapter on pattern in the limb. This is unfortunate, since this is a subject of growing interest in limb development, and it is also the one that causes the most confusion to those outside the immediate discipline. The chapter does not work well because the formula that is successful for the rest of the book, an almost neutral reporting of facts, is not successful in dealing with a subject about which there are contradictory and partially overlapping ideas and because the authors fail to distinguish clearly between morphogenesis and pattern formation. Morphogenesis is generally considered to be distinct from pattern formation, in fact to be an expression or an interpretation of it, in much the same way in which cellular differentiation is not pattern formation but a consequence of it.

The treatment of limb evolution and adaptive radiation side by side with limb development is the strongest feature of the book. The opening page of the book pays homage to Darwin's appreciation for the fascinating ways in which limb structure has been modified during evolution. It is probably variety in limb structure more than in any other structure that has enabled the vertebrates to diversify into so many different habitats. The book does an excellent and appropriately cautious job of tracing the ancestry of the vertebrate limb and its various modified forms. Of more than historical interest is the authors' contention that some of our views of limb development have been subtly influenced by long-discarded notions of ontogeny recapitulating phylogeny. One could wish that the authors had explored the lingering but vaguely defined notion that urodeles are somehow a separate tetrapod line. This possibility is mentioned several times in the book, and it is high time that the strengths and weaknesses of this view were brought out and evaluated.

Overall the book is very readable, and it has some amusing imagery, such as a description of *Pteranodon* as having "all the easy grace of a partially furled umbrella." It will be valuable to students and researchers in the fields of limb development and evolution. And maybe as a result of the ideas in these two fields being juxtaposed in a book primarily about limb development the long-recognized parallel between ontogeny and phylogeny, which over the last hundred years has been used in various ways to bolster evolutionary theory, can now be viewed from a different angle. Maybe this book will stimulate developmental biologists to take from phylogeny what they need to understand ontogeny.

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Rodents and Evolution

Les Rongeurs et l'Evolution. J. CHALINE and P. MEIN. Doin, Paris, 1979. xii, 236 pp., illus. Paper, 118 F.

Traditionally in the study of nonhuman fossil vertebrates the spotlight has been on large or unusual taxa or new evidence bearing on the origin of some group. When an example of an evolutionary trend in fossil mammals has been selected for a textbook, it has almost invariably been that of the horse (and still is: see *Evolution of the Earth* by R. H. Dott, Jr., and R. L. Batten, third edition, McGraw-Hill, 1981). But in potential for supplying data about the patterns and processes of evolution in the geologic record it is becoming increasingly clear that fossil rodents have much more to offer. The numbers of living individuals and species are said to exceed those of all other orders of mammals taken together. Though earlier collections gave little indication that such diversity would ever be found in the geologic record, more meticulous surface coverage and employment of hydraulic screening operations are gradually resulting in larger statistical samples of small mammal populations than have been attained for large forms. For much of the Cenozoic, rodents are forming the bulk of these assemblages.

The authors of this fascinating book about the evolution of rodents have been important contributors to rodent paleontology in Europe. Their book is a carefully integrated and in part tutorial work that starts with a discussion of the circumstances under which rodents become fossilized and ends with a critique of the present controversy about the mode of evolution. Three separate bibliographies, on methods and taxonomy of Recent rodents, evolutionary history of the rodents, and modes of speciation, are included. A thorough glossary is also provided.

The range of subject matter is surprisingly wide for a book of this size. In addition to the major themes of evolutionary history and modes of evolution, the book includes shorter treatments of such topics as concepts of the species, the diversity of adaptations in rodents, and biometric techniques. The structures that have played important roles in the study of the relationships and evolution of rodents are carefully explained and illustrated. The role of chromosome evolution, a matter rarely treated in the paleontologic literature, is given special attention. The abundant evidence of evolution in the rodents, especially the voles, from the Pleistocene makes possible the integration of karyotypic or biochemical with dental data in interpreting speciation and changing geographic distributions.

The longest chapter describes the major events in the evolutionary history of the higher taxa, usually down to superfamily but sometimes to family or even genus. The origins and phyletic relationships, characteristic features, and morphologic evolution are briefly but clearly outlined. Illustrations of skeletal structures, especially the critical dental patterns, as well as sketches of Recent representatives, are abundantly supplied. The treatment of groups is uneven, with greatest emphasis placed upon those with important European records, but bias is inevitable owing to the magni-