son with trunk length. This may suit them well for squatting-feeding on the ground. But we need not infer that in gorillas long forelimbs and short hindlimbs evolved entirely during a term of terrestriality. Orangutans, which are highly arboreal, possess much longer forelimbs and shorter hindlimbs than gorillas do. Further, the structure of the shoulder, thorax, hands, and feet of gorillas attests to a prolonged arboreal heritage in their lineage. It is most likely that knuckle-walking, the characteristic terrestrial hand posture of gorillas and chimpanzees, is a compromise adaptation of elongate, previously flexible, arboreally adapted hands to terrestriality. The giant gelada that Simons favors as a base of inference (in lieu of overwhelming evidence from living hominoids that he dismisses as "dogma") had fingers approximately as long as those of Recent baboons. They could hardly be associated with knuckle-walking.

Simons concludes that the antecedents of man may have been bipedal from the moment they left the trees (p. 282), but he does not discuss evidence that leads him to this view. As I have argued previously in *Science* (**166**, 953–61 [1969]), we might indeed profit by digressing from exclusive consideration of open-country paleohabitats in order to search hypothetical arboreal contexts for the origins of hominid bipedalism.

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Biogenesis

The Origin of Life by Natural Causes. M. G. RUTTEN. Elsevier, New York, 1971. xx, 420 pp., illus. $34.50.

The Life Puzzle. On Crystals and Organisms and on the Possibility of a Crystal as an Ancestor. A. G. CAIRNS-SMITH. University of Toronto Press, Toronto, 1971. viii, 166 pp., illus. $6.50.

The origin of life is a very broad topic, drawing information from nearly all fields of science. A book on that subject can be expected to take up most of the following topics: the history of the problem, the origin of the solar system, meteorites, the primitive atmosphere and its transformation to one containing molecular oxygen, pre-Cambrian geology and microfossils, prebiotic synthesis of small molecules, polymerization, organization of polymers into the first living organism, early evolution and metabolism, and life in other solar systems. This is almost too much for one author to cover adequately, and so most books in this area emphasize only a few of these topics.

Rutten's volume emphasizes pre-Cambrian geology. It is an updated and greatly enlarged version of the late author's 1962 book, *The Geological Aspects of the Origin of Life.* The chapters dealing with geology are excellent, at least from the standpoint of the nongeologist. The early pre-Cambrian microfossils are discussed in some detail and with suitable caution. There is a clear account of the states of oxidation of the banded-iron formations and the uranium-gold–bearing reefs and their implications about the presence of O_2 in the atmosphere. The history of molecular oxygen in the atmosphere is taken up at some length with a strong input of the author's ideas. This is a very speculative subject, and at present one model seems as good as another. The material in the nongeological chapters is not covered adequately, nor is the same standard of caution evident as with the geology.

This book is a good introduction to geology and the geological aspects of the origin of life for the nongeologist. For the geologist, it brings together various aspects of pre-Cambrian geology as they bear on the origin of life and the history of the atmosphere. It gives only a brief account of prebiotic chemistry and how the organic polymers organized into the first living organism.

The second volume deals almost entirely with the problem of how the first organism arose from the primitive soup. It is an expanded version of a paper by the author (*J. Theoret. Biol.* **10**, 53 [1966]). It is written in a very simple style, as if the author intended it for the general public. However, nonscientists will find this book difficult reading.

The most popular model of the first living organism is a molecule of nucleic acid with the associated apparatus (presumably protein enzymes) that can self-replicate and synthesize a few enzymes. Cairns-Smith discusses at length the impossibility of making a significant amount of an enzyme by a random synthesis, even if the synthesis took place rapidly over the entire earth, because of the extremely large number of possible isomers. And if this improbability were overcome by some nonrandom synthesis, then even larger improbabilities would arise in organizing a simplified version of the present nucleic acid protein synthesizing system. A simplified version is not likely to be very accurate in its self-replication, but a very accurate system is required or the organism will mutate itself out of existence. On the other hand, if the replication is too accurate then no evolution can take place. An example of this is the production of crystals from a supersaturated solution (such as aqueous NaCl) with a seed crystal. The reproduction is extremely accurate in this case, but little or no variability is possible in the product. But the crystallization of clay minerals is not so accurate or uniform. Some clay minerals with suitable cation substitutions do not have these substituted cations distributed at random. The substituted cations instead form patches between the silicate layers of the clay mineral. The patchy areas in one layer are said to determine the composition of the layer above and also the succeeding layers. A pattern of patches might therefore be reproduced rather easily, and a "mutation" in the pattern might also be reproduced. From there on the discussion becomes rather vague, especially as to how the reproducing and "mutable" clay mineral system could evolve into the present nucleic acid protein system. Nevertheless, this is an interesting idea. Unfortunately, no experiments have been done to test it. Perhaps this book will stimulate some.

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Geoscience

The Nature of the Solid Earth. A symposium, Cambridge, Mass., April 1970. EUGENE C. ROBERTSON, JAMES F. HAYS, and LEON KNOPOFF, Eds. McGraw-Hill, New York, 1972. xvi, 678 pp., illus. $13.50. McGraw-Hill International Series in the Earth and Planetary Sciences.

During the past 25 years, only a few Americans have had an impact on the earth sciences comparable to that of Francis Birch, who retired from full-time teaching duties as Sturgis Hooper Professor of Geology at Harvard University two years ago. Birch's contributions have been mainly in the physics of the earth's interior, physical properties of rocks, heat flow from the earth's interior, and evolution of the solid earth, but no field of earth science has been immune from his powerful influence. It is appropriate, therefore, that this volume should be dedicated to him.

The Nature of the Solid Earth is a collection of 23 papers presented at a symposium conceived to honor Birch. A secondary purpose of the symposium was to set forth the achievements of the United States program for the Upper Mantle Project. Of the 36 contributing authors, who probably include a majority of the most creative and productive earth scientists of the English-speaking world, about one-third are former students or associates of Birch. The volume itself is a documented record of Birch's influence on modern earth science.

The papers in *The Nature of the Solid Earth* present a sample of what we knew two years ago about chemical and physical models of the earth, plate tectonics, regional geophysics, and physical properties of rocks. Some of these papers merely present updated versions of previous work by the authors, but some are original contributions. All are worth reading.

In the lead paper, Sydney P. Clark, Jr., Karl K. Turekian, and Lawrence Grossman present a new model for the early history of the earth. They propose that most of the earth was formed rapidly, in no more than 10^5 years, after which followed a slower accretion of a veneer of more volatile material of up to 20 percent of the mass of the earth in an additional period of 10^5 to 10^7 years. Don L. Anderson, Charles Sammis, and Tom Jordan review evidence on the composition of the mantle and core and conclude that the properties of the upper mantle are consistent with those of pyrolite and that the lower mantle contains more FeO than the upper mantle. A discussion by A. E. Ringwood reveals that many of the phase transformations in the mantle proposed by Birch in 1952 have been verified by laboratory and recent seismological evidence. Frank Press infers from a family of models based on a Monte Carlo analysis of travel times, density, eigenperiods, and surface waves that the density of the lithosphere is near that of eclogite, but that the underlying asthenosphere is less dense. Discussions by Edward Bullard of geomagnetic dynamos, an analysis by Richard R. Doell and Allan Cox of the Pacific geomagnetic secular variation and lateral uniformity in the lower mantle, and other papers by Paul W. Gast, by Robert M. Garrels, Fred T. Mackenzie, and Raymond Sievers, by Freeman Gilbert, by Anton L. Hales, by Eugene Herrin, and by Louis B. Slichter round out the papers on earth models.

The five papers on the implications of plate tectonics by D. P. McKenzie, David T. Griggs, William M. Kaula, H. W. Menard, and James Gilluly are stimulating, especially the paper by Gilluly on tectonics involved in the evolution of mountain ranges. Gilluly accepts the basic concepts of plate tectonics but argues forcefully and successfully that the supposedly rigid plates of the earth's lithosphere have been subjected to rather intense internal deformation and that many mountain ranges are formed far from the sea and within plates rather than at plate boundaries. If this were not so, continental geology would be pretty dull and continental landscapes would be almost featureless.

A series of concluding papers on regional geophysics and physical properties includes a review by G. P. Woollard of regional variations in gravity, a discussion by Robert F. Roy, David D. Blackwell, and Edward R. Decker of continental heat flow, and an analysis by Orson L. Anderson of patterns in elastic constants of minerals. W. H. Diment, T. C. Urban, and F. A. Revetta, L. Knopoff and J. N. Shapiro, and Eugene C. Robertson also contributed papers to these sections.

Editor Robertson, associate editors James F. Hays and Leon Knopoff, and all 36 contributing authors have honored Birch with a splendid book.

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Fossil Amphibia

Tertiary Frogs from Central Europe. Z. V. Špinar. Junk, The Hague, and Academia, Prague, 1972. 286 pp. + plates. $34.90.

Few frog families are well represented in the fossil record, and at least six of the known families are not represented at all. Existing fossils are usually isolated finds, and population samples are extremely rare. This monograph is therefore quite significant for herpetologists, paleontologists, and other biologists interested in frogs, for the major part of it is an exhaustive study of the only known extinct frog family, Palaeobatrachidae, from the Oligocene and Miocene of Czechoslovakia and other areas in central Europe. Excellent rare material of the Pelobatidae is also described, as are fragmentary remains of two other families, but it is the palaeobatrachids that are of greatest interest, because of their primitive structure and their relationship to the living family Pipidae.

This study has been in progress for 20 years, during much of which time Špinar worked with this difficult material without adequate equipment and comparative specimens and with only limited possibility of outside contacts. In spite of these difficulties he has produced an amazingly thorough and well-documented study of these unusual frogs, including aspects of their ontogeny, sexual dimorphism, and ecology, as well as morphology, systematics, and phylogeny. Particularly useful is the extensive documentation of individual variation; at least 1100 adult and 80 tadpole specimens are preserved. Nearly half the book is composed of photographs of the individual specimens, and 96 text figures are included as well. Much of the significant work on frog systematics has been in English (at least in recent years), and we may be grateful to Špinar for having this book make its initial appearance in translation. The translation has led to some obscurities, most of them not significant.

Known since 1858, palaeobatrachids were the subject of early studies that included unrelated forms; the resulting confusion has led to subsequent (and unfortunate) ignoring of this group in studies on frog systematics. Nearly 30 species have been described, which Špinar reduces to 6 (including 2 new ones), placed in one genus with three subgenera. Two of these species are well defined and based on many specimens; the others are relatively rare and are based on rather minor features.

Since tadpole evolution in frogs is essentially unknown owing to the absence of tadpoles in the fossil record, analysis of the palaeobatrachid tadpoles is one of the most interesting aspects of this monograph. Špinar has been able to interpret an ontogenetic series, showing the timing of bone ossification, the presence of five pairs of ribs, and the participation of at least six vertebrae in formation of the urostyle. The tadpoles are very similar to those of living pipids in general appearance as well as in structure of the mouth. Many soft structures not ordinarily preserved are found in the palaeobatrachid fossils, including nerves and sense cap-