BIOTIC CRISES IN ECOLOGICAL AND EVOLUTIONARY TIME

Edited by
Matthew H. Nitecki

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MATTHEW H. NITECKI

Department of Geology
Field Museum of Natural History
Chicago, Illinois

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CONTRIBUTORS

Numbers in parentheses indicate the pages on which authors' contributions begin.

Stanley M. Awramik (83), *Department of Geological Sciences, University of California, Santa Barbara, Santa Barbara, California*

Robert A. Feldman (231), *Department of Anthropology, Field Museum of Natural History, Chicago, Illinois*

Alfred G. Fischer (103), *Department of Geological and Geophysical Sciences, Princeton University, Princeton, New Jersey*

Larry G. Marshall (133), *Department of Geology, Field Museum of Natural History, Chicago, Illinois*

Michael E. Moseley (231), *Department of Anthropology, Field Museum of Natural History, Chicago, Illinois*

Charles R. Ortloff (231), *Nuclear Energy Systems Division, General Electric Company, San Jose, California*

David M. Raup (1), *Department of Geology, Field Museum of Natural History, Chicago, Illinois*

Hugh M. Raup (39), *Harvard Forest, Harvard University, Petersham, Massachusetts*

David N. Schramm (13), *Department of Astronomy and Astrophysics, University of Chicago, Chicago, Illinois*

Daniel S. Simberloff (53), *Department of Biological Science, Florida State University, Tallahassee, Florida*

Lawrence B. Slobodkin (269), *Ecology and Evolution Department, State University of New York at Stony Brook, Long Island, New York*

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PREFACE

The purpose of the Field Museum Spring Systematic Symposia are (1) to establish a regular forum for the exchange of ideas and methodologies among all systematists, (2) to stimulate new and better research projects in systematics and related fields, and (3) to disseminate information about new techniques and theories in systematic biology.

The first symposium, Systematics and Ecology: Adaptive Morphology and Life-History Strategies, was held in 1978, the second, Origin and Maintenance of Diversity, in 1979, and the third, Biotic Crises in Ecological and Evolutionary Time, in May 1980.

The news media frequently bombard us with stories about political and economic crises around the world. Scientific journals and magazines often carry articles on actual or impending crises such as the increase in atmospheric carbon dioxide, destruction of tropical rain forests, explosive growth of human populations, natural disasters, and so forth. Clearly, "crisis" means different things to different people. In this symposium, "crises" are defined as major instabilities that occur with sufficiently low frequency so that species cannot adapt to or compensate for them. Such events can take place in relatively short time frames (ecological time) or in longer ones (evolutionary time). The disasters can be physical or biological in origin (for example, flooding or a viral epidemic). This symposium explored the causes and effects of these infrequent and unpredictable natural disasters. A basic question is, Are the cumulative effects of rare phenomena more significant biologically than normal phenomena?

The speakers have presented previously unpublished material. It is hoped that the present volume will engender increased exchange and cooperation among systematists, paleontologists, ecologists, and anthropologists, and will also provide a stimulus for new research activity, cooperative research programs, and graduate research studies.

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Individual manuscripts in the present volume were reviewed by Drs. Elso S. Barghoorn, William C. Burger, Karl W. Butzer, Glen H. Cole, Robert K. Colwell, Robert E. DeMar, Bruce G. Gladfelder, Carl B. Huffaker, Robert F. Inger, Virginia C. Maiorana, Lynn Margulis, Hermann W. Pfefferkorn, David M. Raup, George G. Simpson, Richard H. Tedford, S. David Webb, and Bertram G. Woodland. Dr. Mairoana, in addition, helped many a barbaric slip of pen over a grammatic stile. Miss Elizabeth Moore, who unwaveringly typed the camera-ready copy many times over is responsible for the fine format that was achieved. To all those for their time and patience—I offer my deep and tender thanks.

M.H.N.

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INTRODUCTION: WHAT IS A CRISIS?

David M. Raup

Department of Geology
Field Museum of Natural History
Chicago, Illinois

INTRODUCTION

The symposium at Field Museum that led to this volume was inspired by a growing awareness that ecological and evolutionary systems are often perturbed (or disturbed) and that these disturbances may have profound effects on the systems' subsequent development. A growing number of biologists and paleobiologists are convinced that natural systems cannot be understood nor fully interpreted without taking disturbance into account. This view is in sharp contrast to the gradualistic or uniformitarian dogma that has dominated the biological and geological sciences for a century and a half.

The new view stems from two main causes: (1) the lack of success of some of the more elegant gradualistic models -- particularly those calling for a slow progression toward an equilibrium or steady-state condition, and (2) new evidence of sudden perturbations in natural systems over a wide range of temporal and spatial scales.

In the first category, there are several models based on gradualism that have proven resistant to convincing proof.

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In evolution, the fossil record has never provided clear evidence for the pure Darwinian thesis that present day diversity can be explained by the gradual accumulation of minute changes. Darwin was aware of this problem, of course, but excused it (as others have) on the basis of the incompleteness of the fossil record. But since the publication of a seminal paper by Eldredge and Gould (1972), we have a large body of opinion (though it is by no means unanimous!) that evolution of species and higher taxa is, in fact, a jerky or spasmodic process with periods of stability (stasis) interrupted occasionally by short-lived events of great change: speciation and/or the origination of major new Baupläne.

In ecology, the model of ecological succession has also resisted general applicability to actual cases. Although for many years even-aged stands of forest trees have been interpreted (incorrectly) as the steady-state condition predicted by succession theory, it is becoming increasingly clear that stochastic elements (including disturbance from fire, wind, *etc.*). are often essential to a satisfactory interpretation. It has even been argued (H.M. Raup, this volume) that an even-aged forest simply reflects the fact that a pre-existing forest was blown down or burned over at a time corresponding to the age of the present forest. There is a feeling among ecologists now that the succession model would work in nature if only the system were left alone but that the frequency of disturbance is so high relative to the time necessary to reach steady-state that the probability is negligible that the system will be left alone for long enough to attain that stability.

Other models in ecology are currently at risk of falling by the wayside. As argued by Simberloff (this volume), some basic theories of community dynamics (especially island

biogeographic theory and the theory of limiting similarity by interspecies competition) are difficult or impossible to prove with actual data and that purely random events may play a large role in community composition.

In the category of new information (2, above), several discoveries in the past few years have forced practitioners in several disciplines to accept the importance of sudden change. Much of this has come from earth science. Spontaneous reversal of the Earth's magnetic field has been shown to be a relatively common occurrence geologically. The continents and ocean basins are no longer seen as fixed and permanent: it is now clear that continents have been in motion since their formation and that this motion has been anything but uniform, the variation being due to changes in the rates of mantle convection (Fischer, this volume).

In evolution, perhaps the most dramatic example of new evidence of sudden change is the recent work of Alvarez, *et al.* (1980)(discussed by Schramm, this volume) on a possible collision between the Earth and a large meteorite at the end of the Cretaceous period and its implications for mass extinctions. Although the idea of extra-terrestrial causes of extinction is not new (see, for example, Schindewolf, 1962, and Urey, 1973), the Alvarez, *et al.* work shows promise of providing geochemical evidence for the collision event itself. Although not yet fully established, the Alvarez *et al.* scenario could solve a long-standing puzzle regarding the Cretaceous-Tertiary extinctions and might by extension help to explain other large and small extinctions in the history of life. And this may, in turn, suggest why large scale evolution shows little evidence of having reached an equilibrium or steady-state condition with regard to composition of faunas and floras (see D.M. Raup, 1978, for