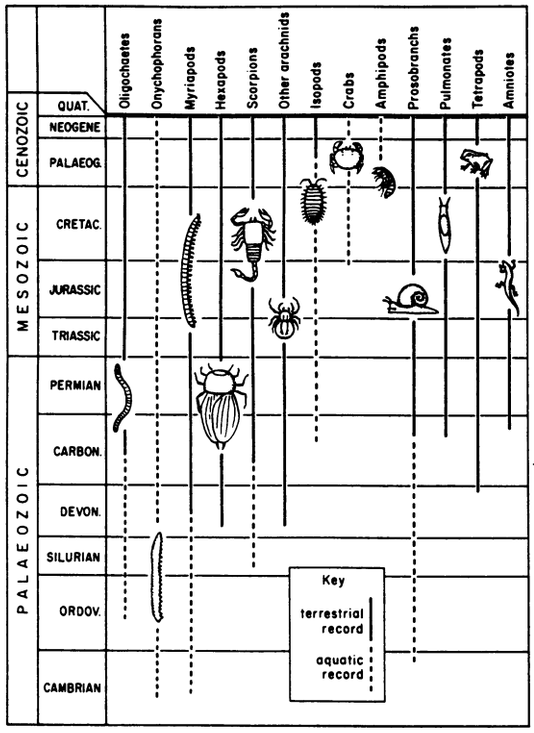
Metazoan Transitions

Invasions of the Land. The Transitions of Organisms from Aquatic to Terrestrial Life. MALCOLM S. GORDON and EVERETT C. OLSON. Columbia University Press, New York, 1995. xix, 312 pp., illus. $65 or £49.

Few events during the history of life on Earth have had greater impact on organismal design than the transition from aquatic to terrestrial habitats. In part because of the radically different physical characteristics of air and water as media, the biomechanical problems faced by terrestrial plants and animals differ radically from those present in aquatic environments. On land, gravitational loads must be resisted and problems of buckling circumvented. Water loss on land may occur very rapidly, diel temperature variation is much greater than in the water, and waste products must be disposed of by different methods from those available to aquatic organisms. Both sensory and motor systems of animals on land must function in a medium that is substantially less dense and viscous than the ancestral aquatic habitat, and modes of reproduction that allowed dispersal of young in the water must be altered to accommodate constraints imposed by the terrestrial environment.



"Approximate sequence of major events in the invasions of the land by animals, as known from the fossil record. Dotted lines indicate aquatic record; solid lines terrestrial record." [From *Invasions of the Land*; after Selden and Edwards, 1989]

Comparative biologists are fortunate that the invasion of land has occurred multiple (independent) times during the history of life. This allows the analysis of convergent solutions to problems of life on land and facilitates the search for general evolutionary responses to the invasion of a novel and stressful habitat. However, successful investigation of aquatic-to-terrestrial transitions is predicated on our ability to identify clades in which such transitions have been made and to obtain sufficient phylogenetic resolution within those clades to compare close relatives that differ in habitat. Without adequate phylogenetic control, comparisons of grade groups suffer from the conflation of primitive and derived traits, lack the ability to isolate habitat as the primary dependent variable, and do not permit the reconstruction of historical sequences by which novel structural and functional traits were acquired during the transition from one habitat to another.

In this volume, Malcolm Gordon and Everett Olson (with contributions by David Chapman on plants) review the many "invasions" of land that have occurred during the evolution of multicellular life. The book begins and ends with a general overview and synthesis of the authors' views of the problem of terrestrial invasion. The body of the book is divided into two main parts: an overview of the fossil record and what it tells us about metazoan transitions, and an analysis of the physiological literature on extant organisms that belong to clades in which environmental transitions are presumed to have taken place. The authors describe clearly the difficulty of identifying from the fossil record alone the extent to which any clade has achieved completely terrestrial life and the relative paucity of information that can be retrieved on physiological evolution. Thus, successful treatment of the literature on extant taxa is especially important for a volume on this transition to be of general utility. Unfortunately, the coverage of this topic here is uneven conceptually and is made difficult to follow by the lack of illustrations and the tendency to review many studies without considering any in depth. A more successful strategy would have been the presentation of general principles followed by the illustration of each principle by detailed discussion of a few specific examples. Of greatest concern is the assumption by the authors of the polyphyletic origin of many taxa (including amphibians, reptiles, arthropods, and pulmonate gastropods), a view arrived at as a result of failing to consider the relevant recent primary literature on the phylogenetic relationships of these clades and by an over-reliance on outdated secondary sources. Also disappointing is that the very conceptual tools most likely to have offered new insights into this critical issue in metazoan evolution have been ignored, as though the last 20 years of progress in systematic biology and its continuing integration with comparative physiology (to form the new subdiscipline of evolutionary physiology) had never happened.

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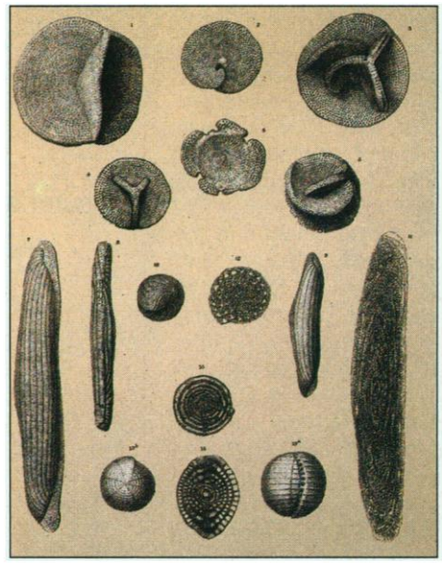
A Famous Dredge Haul

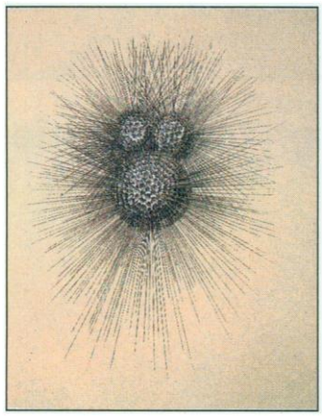
The *Challenger* Foraminifera. ROBERT WYNN JONES. Oxford University Press, New York, 1994. x, 151 pp., illus., + plates. $275 or £175.

The HMS *Challenger* set sail from Portsmouth, England, in December 1872 and, after circumnavigating the world, returned in May 1876. This scientific expedition marks the beginning of the discipline of oceanography. Our comprehension of



Orbitolites and *Alveolina* as assigned by H. B. Brady. One of the 115 plates from the 1884 *Challenger* volumes on foraminifera.

the deep sea was altered forevermore. Dredgings from abyssal depths demonstrated that the sediments at great depth were not uniformly composed of "*Globigerina* ooze" as previously thought. Instead, vast areas, which are below what today we understand as the calcium carbonate compensation depth, are covered by clay. Dredge hauls demonstrated that life not only existed in this environment but existed with species of "animals high in the zoological series." The vast amount of dredged material was parceled out to 76 taxonomic specialists. In all, 50 volumes were published on the scientific results of the voyage of the *Challenger*.



Globigerina bulloides d'Orbigny; after a drawing made by J. J. Wild aboard the *Challenger*.

The abyssal plains of the deep-sea make up the largest biotope on Earth. Among the most abundant and ubiquitous inhabitants of this vast area are the foraminifera. This group was assigned to H. B. Brady (1835–1891), a highly successful pharmacist who retired from that profession in 1876 to devote himself fully to the study of foraminifera. In 1884 he published his classic two-volume "Report on the Foraminifera Dredged by *H.M.S. Challenger*, during the years 1873–1876." He described hundreds of species, which were magnificently illustrated under his supervision by A. T. Hollick with 115 color plates. The quality of these plates has not been surpassed before or since.

Over a hundred years later, Brady's work remains a fundamental reference on the deep-sea foraminifera. However, the "British school" of foraminiferal taxonomy, of which Brady was a prominent member, took a very broad view of the species concept (that is, were lumpers). This viewpoint, when combined with the results of research that has gone on since severely limits the usefulness of Brady's work. In *The Challenger Foraminifera* Jones provides us with a fresh revision. The revision is based on Brady's specimens lodged in the Natural History Museum, London, and material figured in cited references. In all, 875 species including 238 type species belonging to 362 genera are treated. This monumentalrevision removes the taxonomic tarnish and, once again, illuminates Brady's masterpiece.

Brady's volumes are often unavailable to most researchers. When they are, their aged condition, especially that of the volume of plates, which is most thumbed by taxonomists, requires the researcher to proceed with care and trepidation. Jones's volume reproduces all 115 color plates and adds a couple more to elucidate particular specimens. I compared Jones's plates with the originals and am astonished at the fidelity of the reproductions.

Jones also provides us with a short history of the expedition. The purpose, the results, and the people involved are summarized (with pictures). His writing style is refreshing, and the text is a joy to read.

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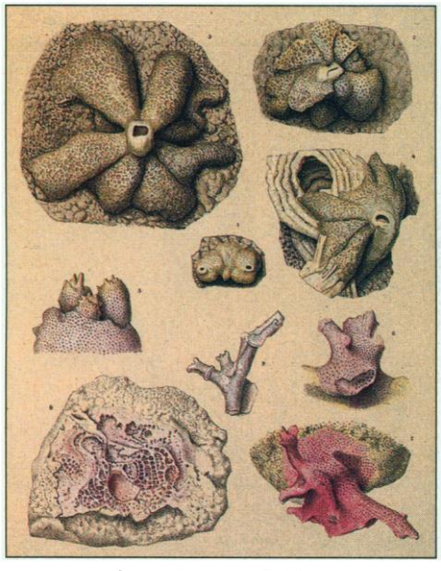
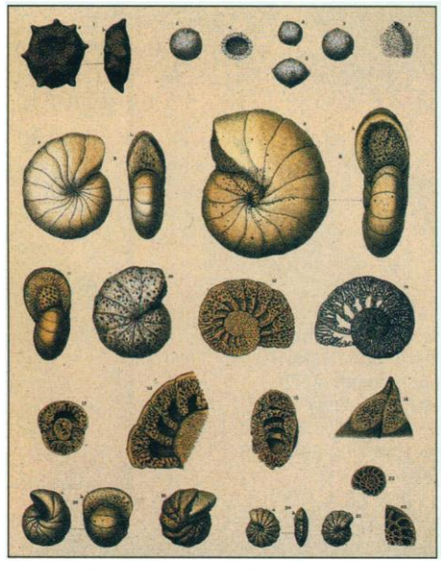


Carpenteria and *Polytrema*.



Thurammina and *Cyclammina*.

[Illustrations on these pages from the original *Challenger* Reports, reproduced in *The Challenger Foraminifera*; Natural History Museum, London]

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The Symbiotic Perspective

Evolution by Association. A History of Symbiosis. JAN SAPP. Oxford University Press, New York, 1994. xvii, 255 pp., $49.95 or £37.50; paper, $24.95 or £18.95.

In these pages in 1993 I reviewed a book by L. N. Khakina chronicling the contributions of Russian botanists to theories of symbiogenesis (the role of symbiosis in evolution). Khakina's book (*Concepts of Symbiogenesis*, Yale University Press) was not intended as a complete history of symbiosis research and theory, and the review ended with the remark that the book "whets the appetite for a thorough treatment of the modern era in the West." The wished-for book has now appeared, in the form of a thorough, balanced, and readable account of symbiosis research and theory from the 19th century to the present day.

In every generation biologists are fascinated by the phenomena of symbiosis. The remarkable adaptations of organisms to each other are irresistible subjects of study, however the phenomena are defined and filtered through prevailing doctrine. The study of symbiosis has never been recognized as a discipline and has not been as respectable as research on more orthodox topics such as fruit fly genetics. Ironically, from the eclectic body of knowledge that does exist about symbiosis has emerged one of the most profound conceptual revolutions in biology of the 20th century—the recognition that organelles of eukaryotic cells (mitochondria and chloroplasts) have their origins as symbiotic bacteria. Symbiosis is now taken quite seriously as a potential source of evolutionary innovation, and the topic has acquired a status and a corps of researchers that would have been hard to imagine half a century ago. The story of this remarkable turnaround is the subject of Sapp's book.

Many practicing scientists are impatient with the notion that doctrinal biases, the disciplinary organization of science, or, worse yet, philosophical and political ideas can profoundly influence the development of scientific knowledge, preferring to regard science as the inexorable triumph of sound data over error. Sapp accomplishes the delicate task of providing a competent account

(*Continued on page 1212*)