THE FOSSIL RECORD OF EVOLUTION:
DATA ON DIVERSIFICATION AND EXTINCTION

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Understanding of the evolution of complex life, and of the roles that changing terrestrial and extraterrestrial environments played in life's history, is dependent upon synthetic knowledge of the fossil record. Paleontologists have been describing fossils for more than two centuries. However, much of this information is dispersed in monographs and journal articles published throughout the world. Over the past several years, I have been surveying this literature and compiling a synoptic data base on times of origination and extinction of fossil genera. The data base, which now holds approximately 32,000 genera, covers all taxonomic groups of marine animals, incorporates the most recent taxonomic assignments, and uses a detailed global time framework that can resolve originations and extinctions to intervals averaging three million years in duration. These data can be used to compile patterns of global biodiversity, measure rates of taxic evolution, and test hypotheses concerning adaptive radiations, mass extinctions, etc. Thus far, considerable effort has been devoted to using the data to test the hypothesis of periodicity of mass extinction.

Rates of extinction measured from the data base have also been used to calibrate models of evolutionary radiations in marine environments. It has been observed that new groups, or "clades," of animals (i. e. orders and classes) tend to reach appreciable diversity first in nearshore environments and then to radiate in more offshore environments; during decline, these clades may disappear from the nearshore while persisting in offshore, deep water habitats. These observations have led to suggestions that there is something special about stressful or perturbed environments that promotes the evolution of novel kinds of animals that can rapidly replace their predecessors. The numerical model that is being investigated to study this phenomenon treats environments along onshore-offshore gradients as if they were discrete habitats. Each habitat contains a set number of genera (as observed in the fossil record). During any time interval, genera within a habitat can become extinct with a probability that varies among clades (as measured from the data base) and increases toward the nearshore (as also observed in the fossil record). Extirpated genera are replaced either by speciation within the habitat or by immigration of genera from adjacent habitats. Solutions of the model demonstrate that extinction-resistant clades will replace extinction-prone clades and that this replacement will proceed along the onshore-offshore gradient regardless of where new clades originate. Thus, patterns of replacement are not dependent on special evolutionary properties of stressed environments. Instead, they reflect radiations of clades whose species are more successful in weathering environmental perturbations. This is the same pattern that is observed in taxonomic selectivity at mass extinctions (including the Cretaceous-Tertiary event): clades that are characterized by low rates of extinction during normal times appear to preferentially survive the abnormal times of mass extinction.