EXTINCTIONS AND RADIATIONS IN THE HISTORY OF LIFE

The fossil record includes the five major mass extinctions, a number of intermediate level extinctions and many other minor ones for a total of ~30 in the last ½ billion years. The present increase in greenhouse gas emissions may lead to another major mass extinction in the near future. They are distinguished by the number of taxa (usually genera are counted) that were extinguished in relatively short geological intervals. All of these extinctions impact organisms in different systematic, functional, and ecologic groups, both on land and in the sea, thus suggesting widespread cause with general impacts on different biotas.

Many causes for extinctions have been suggested in the past, including physiological disruptions, dissolution of carbonate skeletons, failure of photosynthesis, rise of new microbes, and ecologic factors, like cooling climates, changing sea levels, or declining productivity. Another idea is that the “niche” of organisms were eliminated, which means any or all attributes of species, and then reoccupied as the biodiversity increased following the extinction events. This is incorrect. Because the environments changed, the same “niche” did not exist during or after the extinction events. The biota did not “recover”; instead it radiated from fewer organisms that did not experience extinction. Planktonic foraminifera demonstrate this well at each of several Mesozoic and Cenozoic extinction and radiation events.

What caused the extinctions? Recent discoveries and analyses indicate that relatively sudden impulses of greenhouse gases (CO$_2$ in particular) warm terrestrial and marine climates caused extinctions. But how? Certainly the organism-specific mechanisms may be involved but not as general causes. At a first order level, global warming events account for most observations. More specifically sudden greenhouse warming has its greatest effect through the constriction and elimination of major habitats and ecosystems in both marine and terrestrial ecosystems. When these are destroyed or changed, the organisms adapt or die. Radiations, which may take many millions of years, have been interpreted as the reoccupation of “empty niches” but that is wrong. Since the ecosystems changed or were eliminated, no old niches existed after an extinction. As CO$_2$ was reduced in the atmosphere by weathering and sequestration in biological materials, new ecologic opportunities developed where survivors could adapt and evolve through physical processes often interacting with biological ones, and these allowed the evolutionary radiations that followed extinction events. The survivors persisted in habitats which were little impacted by warming, anoxia, acidification or other impacts. The time of these radiations is chiefly a measure of increasing ecologic opportunities and complexity.

Earth-like planets in the galaxy and beyond with life and water would also record variations in extinctions and radiations, as well as evolutionary patterns in general, because of variations in the intensity of their greenhouse effects. Greenhouse effects should be a general phenomenon anywhere in the universe.

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**PROFILE**

**Jere H. Lipps**, Professor of the Graduate School, UC Berkeley, is a geologist, paleontologist and marine biologist (PhD Geology, UCLA). He taught marine and field geology, climate change, tropical islands, ecology, paleontology and astrobiology. Jere's research concerns paleontology, geology, evolutionary biology and ecology of modern and fossil marine organisms from places around the world (on all 7 continents; Antarctica, Arctic, Pacific and Atlantic Islands, US, Mexico, Chile, Argentina, Russia, China, Australia and others). His approach is to understand modern organisms (ecology, DNA sequencing) and apply that to interpretations of problems in the oceans of Earth, Mars, Europa and other planets. Jere published nearly 500 papers and articles.

He lectures widely on the history of life and on climate change and its impacts now and in the future. He has lectured in Mexico, England, Canada, Germany, France, China, India, UAE, Italy, Argentina, and Russia, and has been a Visiting Professor in Oxford University, the University of Georgia, the Geologisk Institut, Aarhus University in Denmark, and a Lecturer at the Institut und Museum fur Geologie und Paleontologie, Universitat Tuebingen, Germany, and the Paleontological Institute, Moscow, Russia, as well as a Visiting Scientist at the Natural History Museums in Washington DC, London and Paris. He served on NASA's Planetary Protection Committee, Human Landing on Mars Committee, and as an advisor on life on other planets.

Jere has chaired University of California departments and institutes, including as Director of the Museum of Paleontology, Berkeley and Institute of Ecology, Davis. He served as an officer or editor in many societies. Lipps received awards for his work including the Antarctic Medal of the US, the R. Moore Medal for Excellence in Paleontology, the Joseph A. Cushman Award for his work on foraminifera, Friend of Darwin Award of NCSE, and the Soaring Eagle award of Eagle Rock High School (LA) for life time accomplishments. An island in Antarctica is named for him in recognition of his work on that continent. He was elected a Fellow of the GSA, AAAS, California Academy of Sciences, and a Centennial Fellow of the Paleontological Society (US).

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**3rd Dr. M.N. BOSE MEMORIAL LECTURE**

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