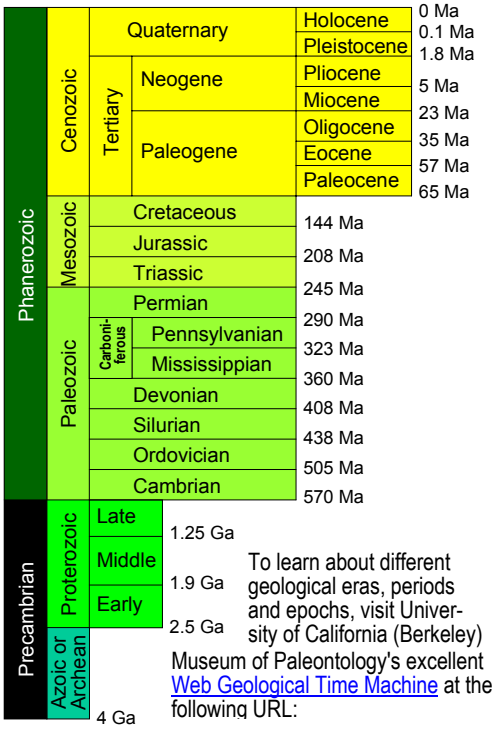
# Geological Time and the Evolution of Life




To learn about different geological eras, periods and epochs, visit University of California (Berkeley) Museum of Paleontology's excellent Web Geological Time Machine at the following URL:

http:/www.ucmp.berkeley.edu/help/timeform.html

## Life and the Geological Scale of Time

It is not clear whether life intrinsically evolved on the earth or, having originated elsewhere, proliferated on the earth after the first oceans appeared ~4 Ga ago. Based on the earliest evidence of life, the 3.7-4 Ga old stromatolites, the first 500-1000 Ma of earth's history appears to have been altogether barren.

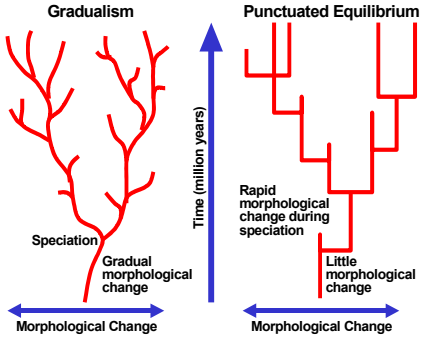
Based on the fossil evidence, the geological time is divided into

- the **Phanerozoic** (0-570 Ma) eon with a systematic record of life and comprises
  (a) Paleozoic (245-570 Ma),
  (b) Mesozoic (65-245 Ma) and
  (c) Cenozoic (0-65 Ma)
  eras of early, middle and modern life forms, respectively; and
- the Precambrian (570-4500 Ma), comprising
  (a) Archean (2.5-4.5 Ga) and
  (b) Proterozoic (570-2500 Ma)
  eons of little or no life and primitive life, respectively.

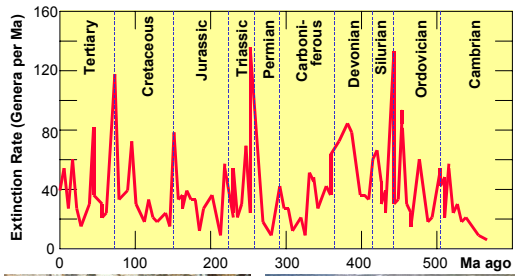
A stromatolite is a succession of thickened, domed-up layers produced by the colonies of cyanobacteria. Living stromatolites in Shark Bay, Australia are similar to those found in the 1.3 Ga old Siyeh Formation, Canadian Rockies, shown here.

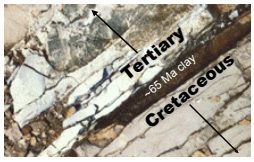
## Gradualism, Punctuated Equilibrium and Mass Extinctions:

- Evolution of life over the geological times has followed three strands:
  - evolution of new species, e.g., the end-Permian appearance of dinosaurs and mammals,
  - extinction of some existing species (e.g., the end-Cretaceous extinction of dinosaurs), and
  - proliferation of some existing species (e.g., the Cenozoic domination of mammals).
- Darwinian evolutionary model sought gradual morphological changes, leading to the evolution of new species, as would result from adaptation to the environmental change. But, compared to this '*gradualism*', the observed fossil record displays sudden appearance of new species following periods of pro-longed morphological statis. The Eldredge-Gould model of '*punctuated equilibrium*' (i.e., new species appear suddenly when, under environmental stress, portions of the gene pool of some existing species undergo rapid speciation) overcomes this problem.




See, for instance, "Punctuated Equilibrium at Twenty: A Paleontological Perspective" by Donald Prothero (*Skeptic* vol. 1, no. 3, Fall 1992, pp. 38-47): http://www.skeptic.com/01.3.prothero-punc-eq.html and "Score One for Punk Eek: The fitful evolution of bacteria supports a controversial theory" by John Horgan (Scientific American, July 21, 1996): http://www.sciam.com/article.cfm?chanID=sa004&articleID=000DFABC-A1BF-1C76-9B81809EC588EF21




- Instances of sudden mass extinction events too exist. For instance, the end-Cretaceous dinosaur extinction, ~65 Ma ago, was also when 75% of the species disappeared and, at the end of the Paleozoic, ~245 Ma ago, an estimated 90% of all the species became extinct. Indeed, as the graph alongside shows, such events have recurred with a 25-30 Ma cyclicity that matches those in the records of bolide impacts as also volcanism. Hence the controversy about *extraterrestrial catastrophism* versus terrestrial cataclysms as the source of the environmental trauma that triggered these extinction events.

Pictured on the left is the thin K/T boundary clay in Gubbio, Italy, whose high iridium content first pointed to an extraterrestrial source. The 50,000 years old Meteor crater, Arizona, is shown on the right.