FIGURE 9.20 Reconstructions of some of the amazing Burgess Shale animals (see Fig. 9.19). *A*: The meter-long predator *Anomalocaris*. Originally found in disarticulated pieces, its distinctive "pineapple-slice" mouth was once reconstructed as a "jellyfish" in older Burgess Shale dioramas. *B*: The bizarre *Opabinia*, with five eyes and a front "nozzle"; the original fossil is shown at the top and middle left in Fig. 9.19. *C*: The armored crawler *Wiwaxia*. *D*: The appropriately named *Hallucigenia*. Once a complete mystery that was reconstructed with the spines pointed downwards, it is now thought to be related to the living worm-like creatures known as onychophorans. *E*: The worm-like creature *Amiskwia*. *F*: The stalked "goblet creature" *Dinomischus*. G: The tiny Burgess Shale arthropod *Sarotrocercus*, swimming on its back. (*Modified from drawings by M. Collins in S. J. Gould, 1989, Wonderful life, Norton.*)

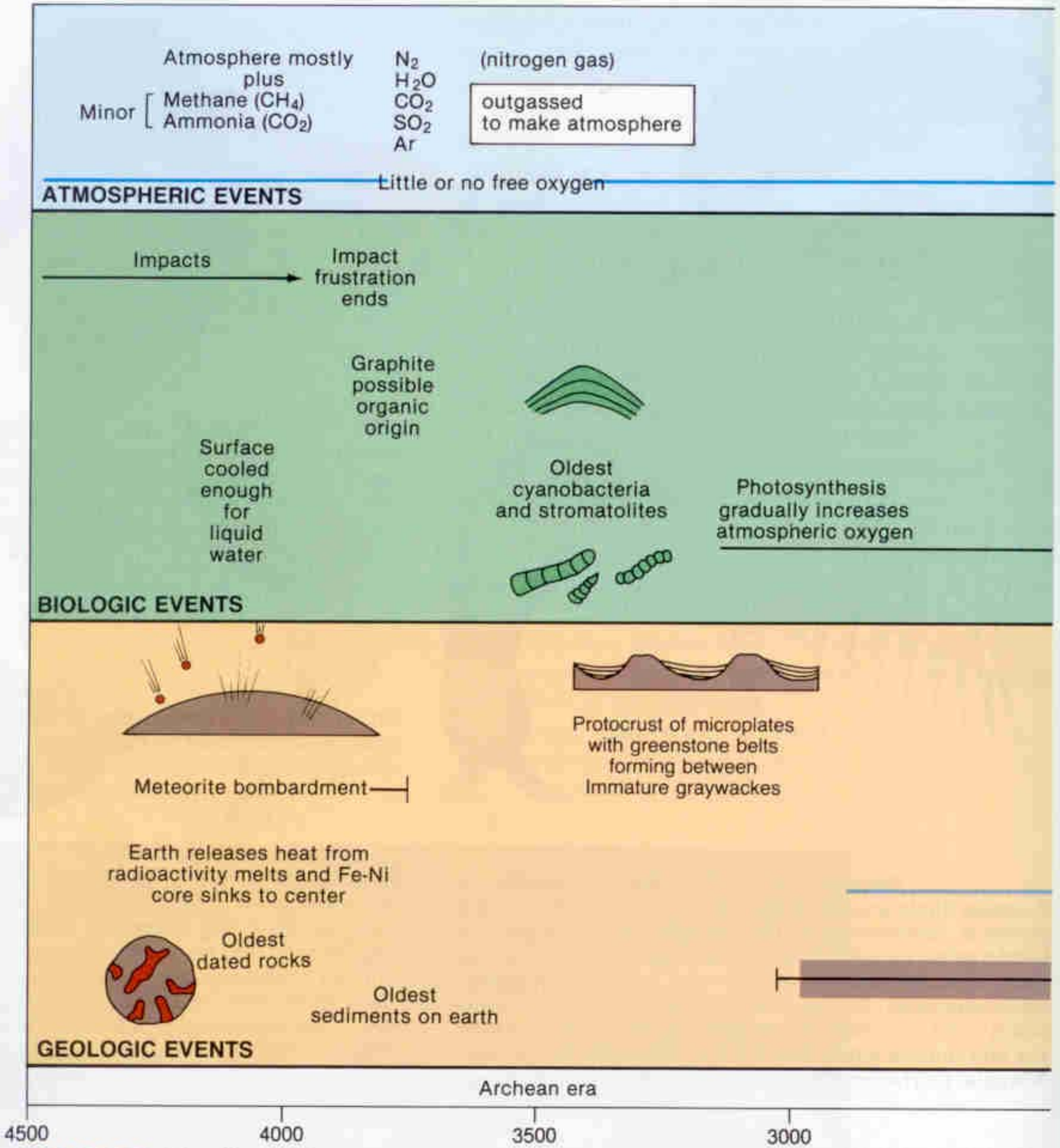
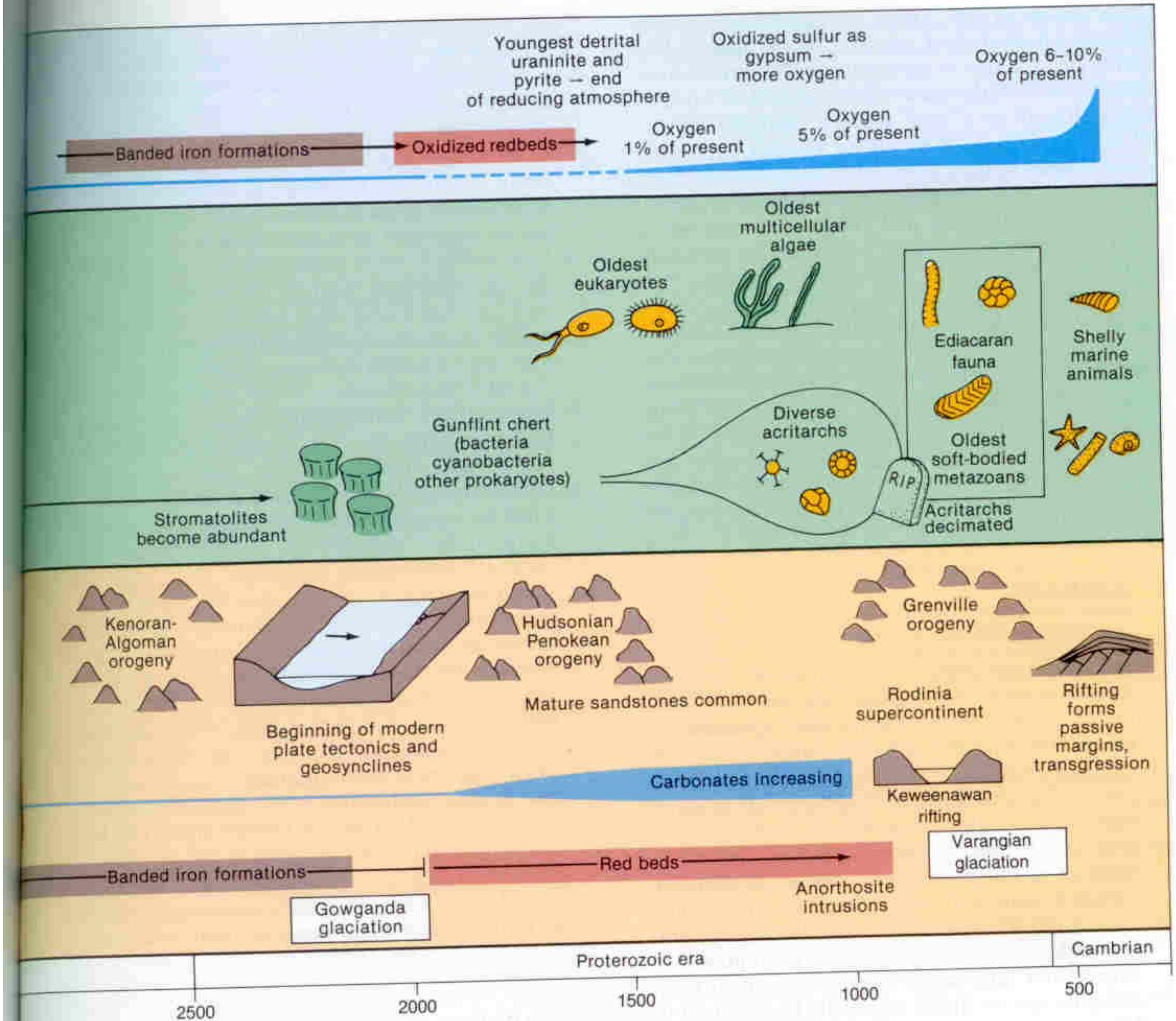
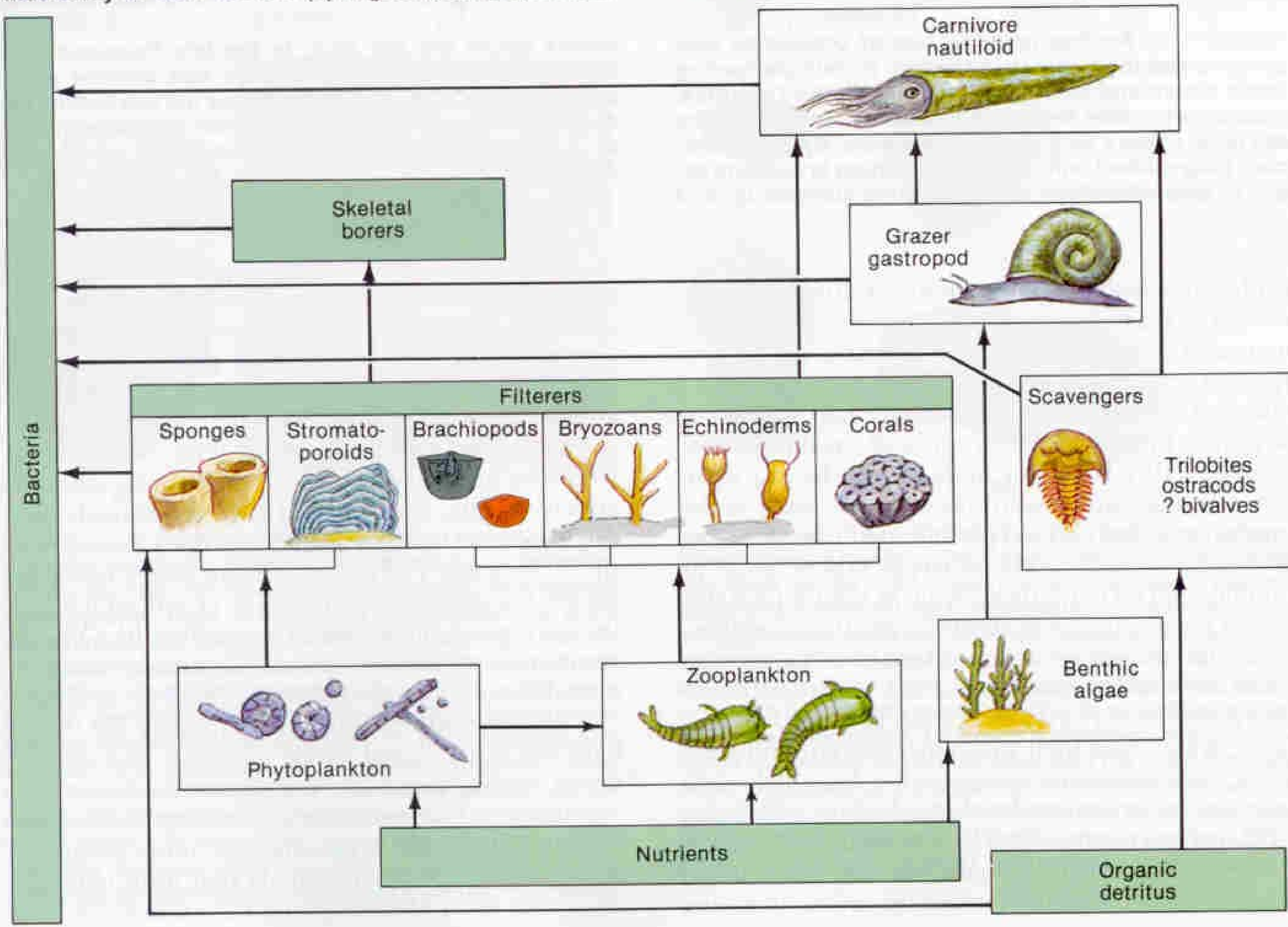


FIGURE 9.21 Time line of the early evolution of life during the Cryptozoic and Cambrian.



Youngest detrital uraninite and pyrite → end of reducing atmosphere
Oxidized sulfur as gypsum → more oxygen
Oxygen 6–10% of present
Banded iron formations
Oxidized redbeds
Oxygen 1% of present
Oxygen 5% of present
Oldest multicellular algae
Oldest eukaryotes
Ediacaran fauna
Shelly marine animals
Gunflint chert (bacteria cyanobacteria other prokaryotes)
Diverse acritarchs
Oldest soft-bodied metazoans
RIP
Stromatolites become abundant
Acritarchs decimated
Kenoran-Algoman orogeny
Hudsonian Penokean orogeny
Grenville orogeny
Mature sandstones common
Rodinia supercontinent
Rifting forms passive margins, transgression
Beginning of modern plate tectonics and geosynclines
Carbonates increasing
Keweenawan rifting
Varangian glaciation
Banded iron formations
Red beds
Anorthosite intrusions
Gowganda glaciation
Proterozoic era
Cambrian
2500
2000
1500
1000
500

FIGURE 11.4 Ordovician life showed a much higher level of ecological complexity than any previous time in geologic history. The first complex food webs developed, with a base of primary producers (algae) grazed by primitive snails, and microscopic plankton fed upon by a wide array of filter feeders (sponges, stromatoporoids, brachiopods, bryozoans, echinoderms, and corals). Trilobites scavenged the detritus on the bottom. The top predators were the giant straight-shelled nautiloids, some of which had shells over 2 meters long! When these organisms died, their nutrients were recycled back into the food chain by bacterial decay.



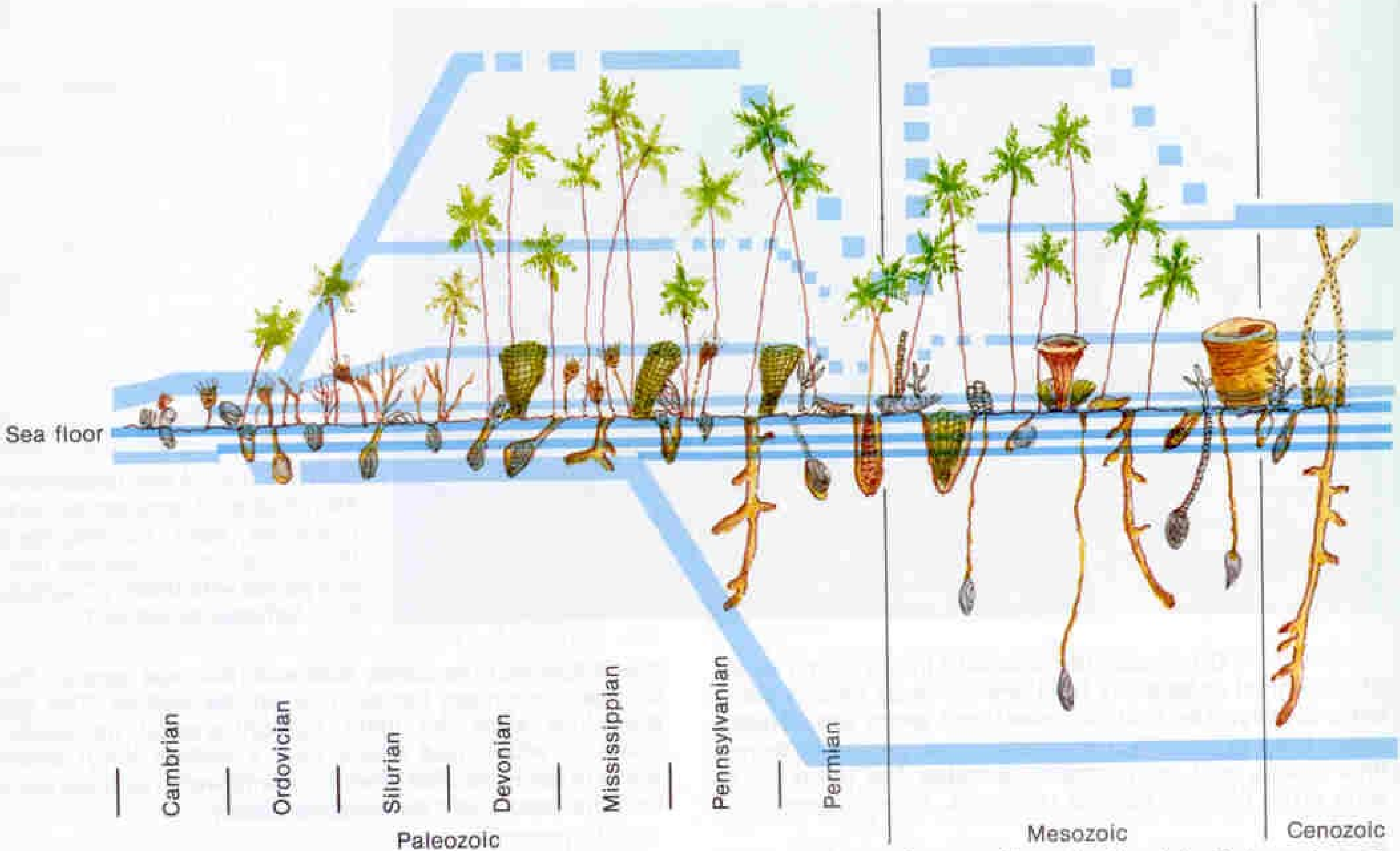


FIGURE 11.5 Another novel feature of Ordovician ecosystems was the increase in **tiering**, or multiple feeding levels above and below the sea floor. In the Cambrian, most invertebrates fed only a few centimeters above the sea floor, or were very shallow burrowers. By the Ordovician, long-stalked crinoids and branching bryozoans began to take advantage of food-bearing currents up to 3 meters above the sea floor. In the late Paleozoic and Mesozoic, these high-level feeders had become even taller, and a new tier was added below the sea bottom by deep-burrowing clams. (*Modified from W. I. Ausich and D. J. Bottjer, 1991, Jour. Geol. Education, v. 39, pp. 313–318.*)

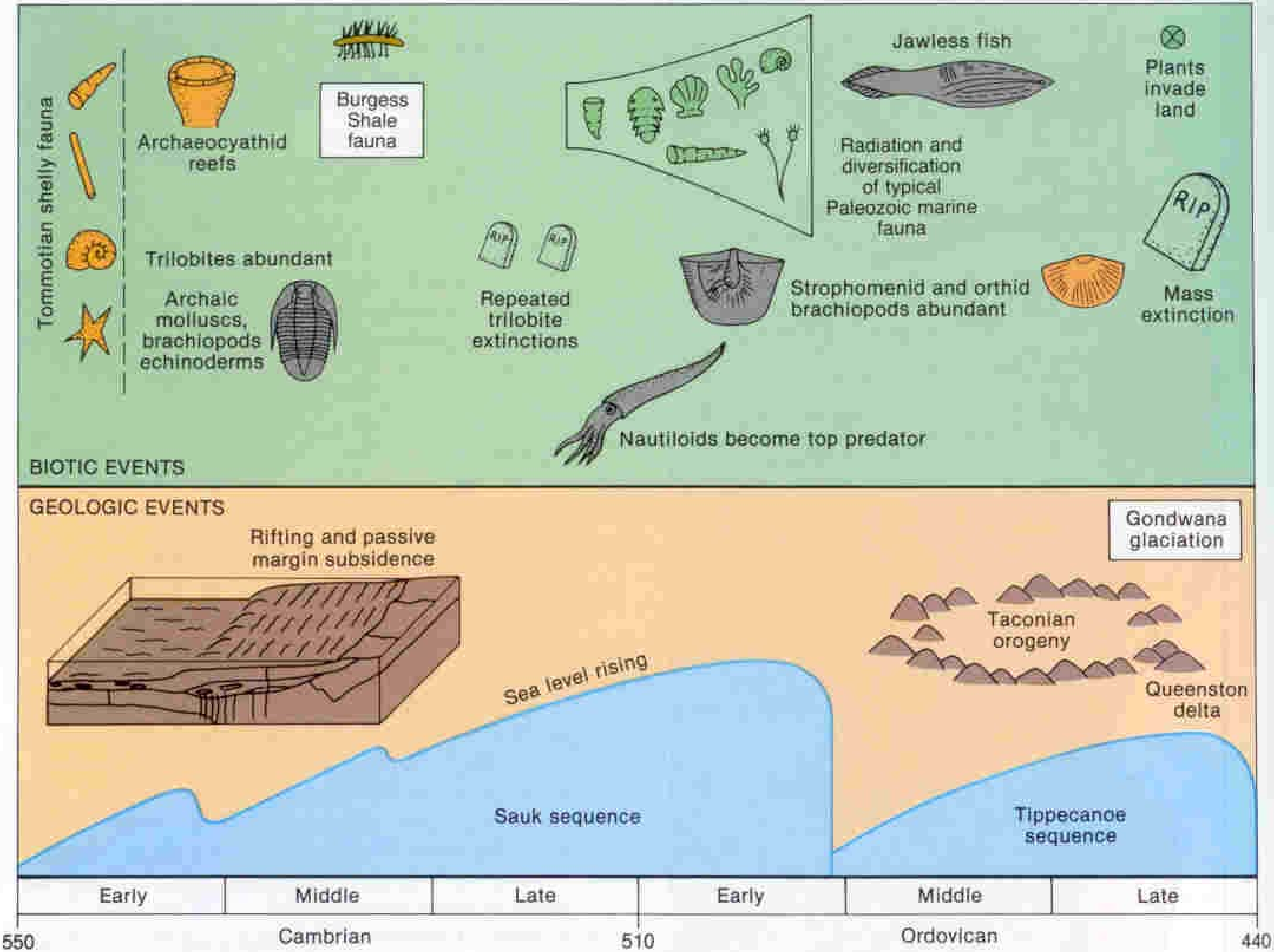


FIGURE 11.38 **Timeline of Cambrian and Ordovician events.**

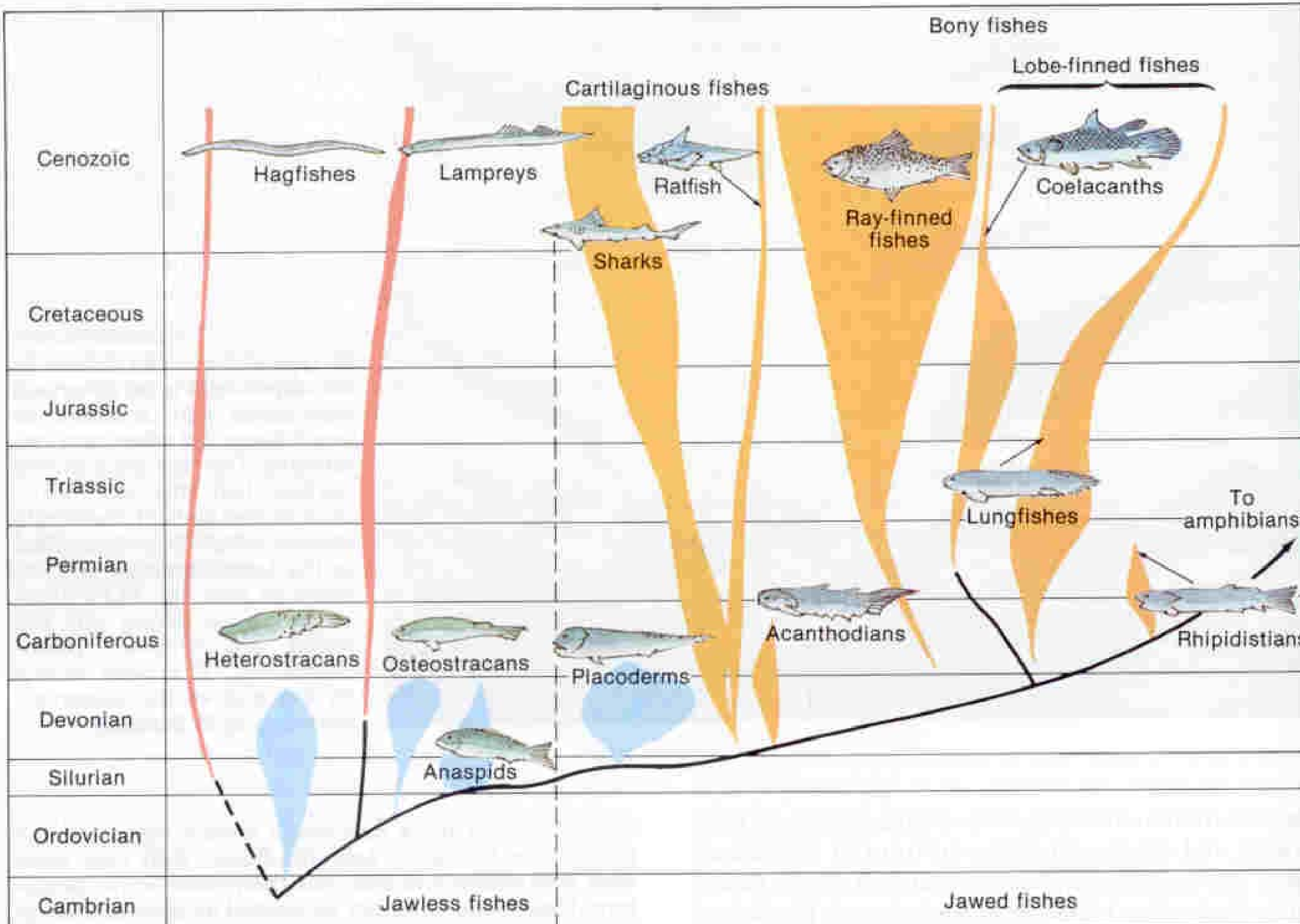
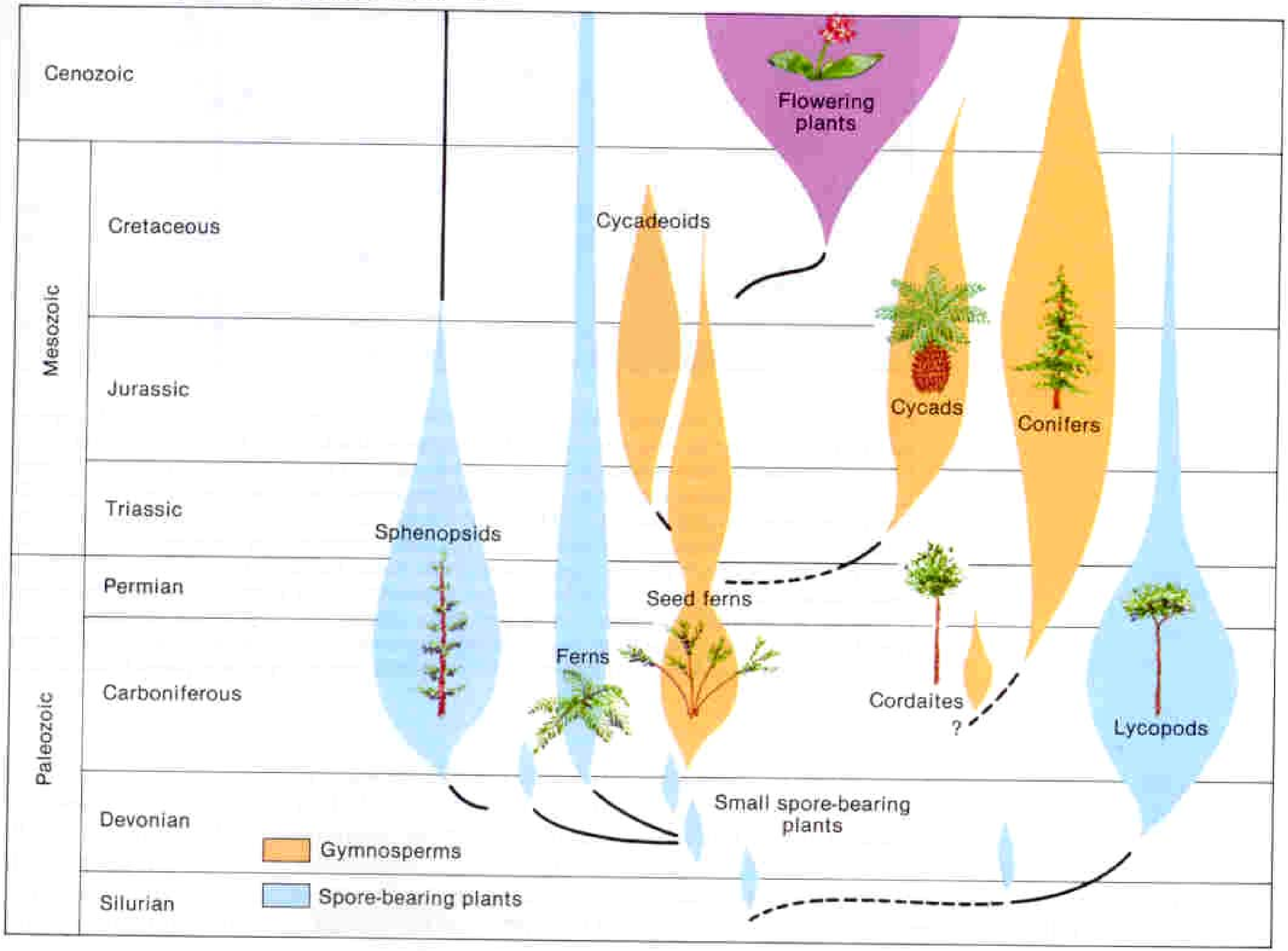


FIGURE 12.7 Family tree of the living and extinct groups of fish. The Devonian witnessed a great radiation of archaic jawless fish and jawed placoderms, both of which did not survive into the Carboniferous. There were also archaic sharks (which have living descendants), acanthodians (the earliest jawed vertebrates), and lobe-finned fishes, including lungfish and rhipidistians, the group closest to amphibians. In the late Paleozoic and Mesozoic, most of these archaic groups disappeared, to be replaced by a great radiation of bony fish.

FIGURE 12.9 **Evolutionary radiation of land plants. Spore-bearing plants were dominant in the Silurian, Devonian, and Carboniferous. By the Late Permian, seed ferns and other gymnosperms, such as conifers, had taken over the forests of the earth, and continued to prevail through most of the Mesozoic. In the mid-Cretaceous, flowering plants radiated and soon became the most successful group of plants. (*Modified from A. H. Knoll and G. W. Rothwell, 1981, Paleobiology, v. 7, pp. 7–35.*)**



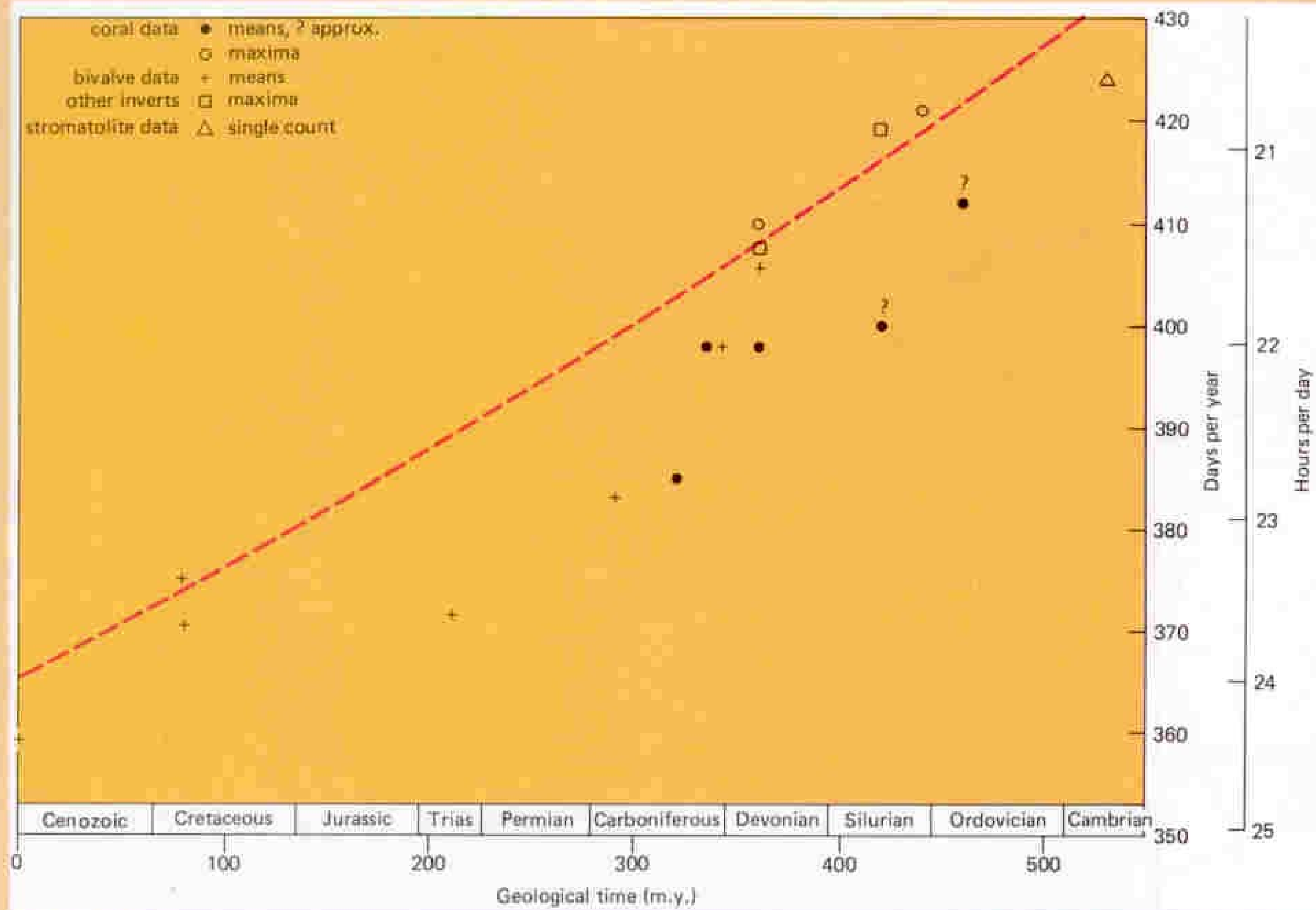


FIGURE 12.16 Changing length of day through Phanerozoic time based upon data gathered from corals, stromatolites, bivalves, and other invertebrates. The dashed line shows the gradual lengthening of the day and is based on a constant of 2 milliseconds per century. (*Muller and Stephenson, 1975.*)

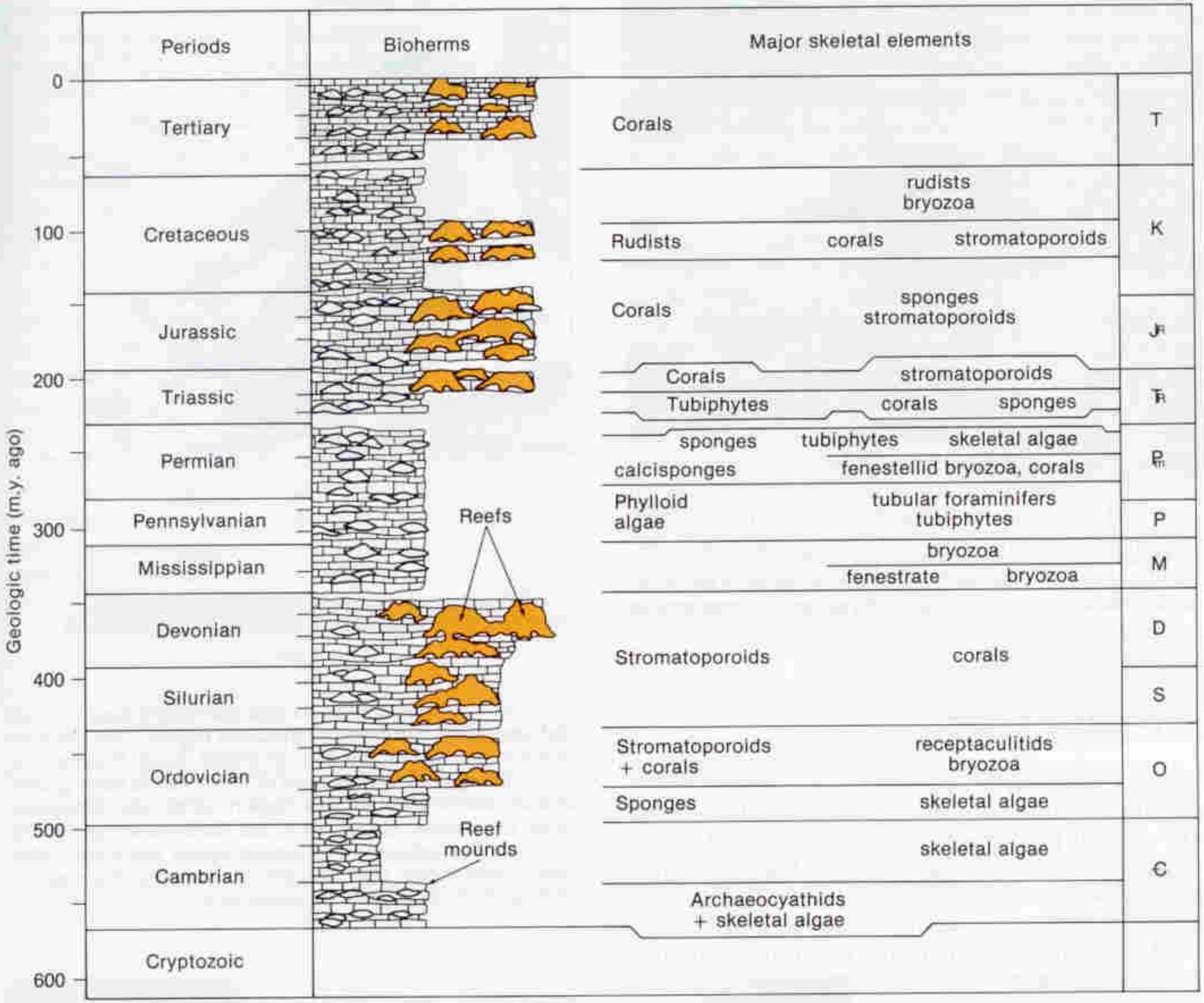


FIGURE 12.21 **History of organic buildups (bioherms) and true reefs. Although the type of reef-building organisms changed through time, the ecological patterns remained very similar. Note the great abundance of reefs (widest profiles) during the middle Paleozoic, middle Mesozoic, and late Tertiary. (*From N. James, 1984, in Facies models*, Geological Association of Canada.)**

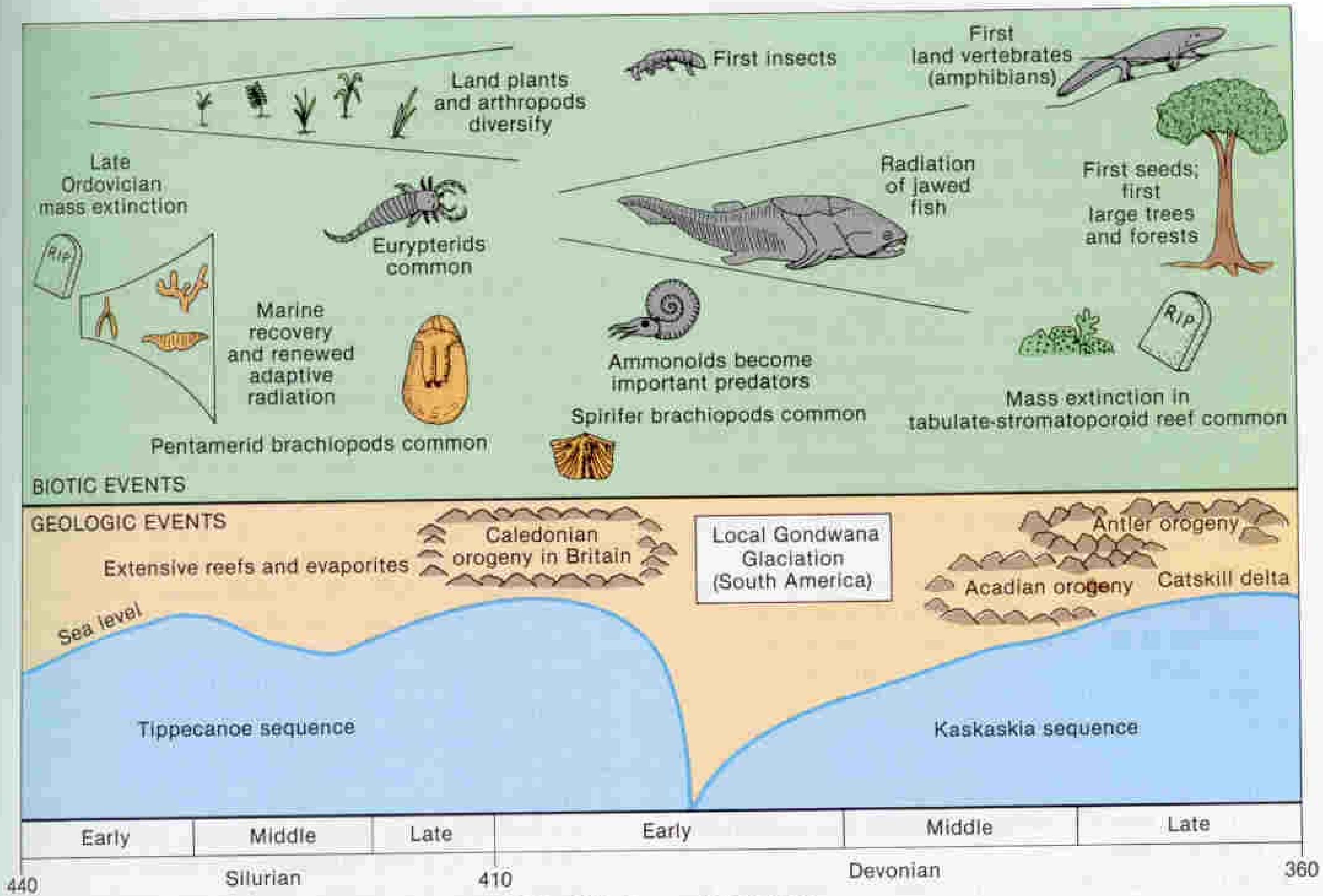


FIGURE 12.50 **Summary time line of events of the Silurian and Devonian.**

FIGURE 9.16 **A selection of typical Cambrian animals. *A-I*: A variety of shapes demonstrated by the Early Cambrian archaeocyathids, spongelike organisms which formed the earliest reefs on earth. Specialists still argue whether archaeocyathids were true sponges, or simply an extinct early experiment in spongelike body form which left no descendants. Their typical "double-wall I-beam" construction is unique to the group, and not found in any sponge. Most specimens were less than a meter in height, although some formed huge reefs that spanned hundreds of meters. *J-K*: Inarticulate brachiopods (see Fig. 9.17*A*), with simple phosphatic shells and no mechanical joint in the hinge. *L-O*: A variety of archaic molluscs, most with simple conical or cap-shaped shells, like the modern limpet. *P*: An eocrinoid, an early experiment in stalked, filter-feeding echinoderms. True crinoids replaced them in the Ordovician (see Chap. 11). Note that most of these animals are archaic or "experimental" members of their respective phyla, and most were rare after the Cambrian. (*Modified from Boardman et al., 1987, Fossil invertebrates, Blackwell; and A. R. Palmer, 1974, American Scientist, v. 62, pp. 216–225.*).**

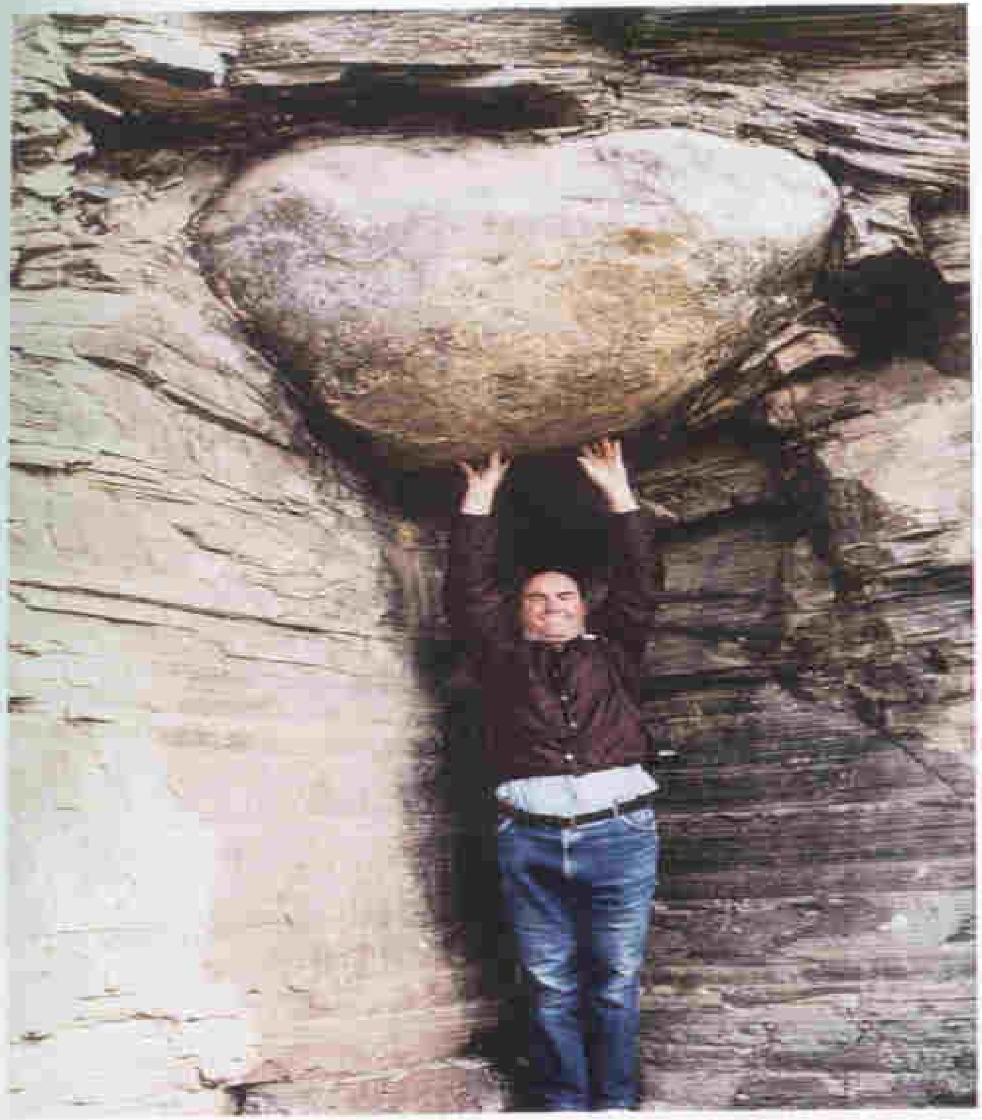


FIGURE 13.37 Giant "dropstone" released by a melting iceberg as it floated away from the Gondwana ice sheet during the Permian. Notice how the layered marine sediments were bent downward by the impact, and then smoothly buried the dropstone once normal, quiet marine deposition had resumed. From the Parana Basin, Brazil. (*Courtesy J. C. Crowell.*)

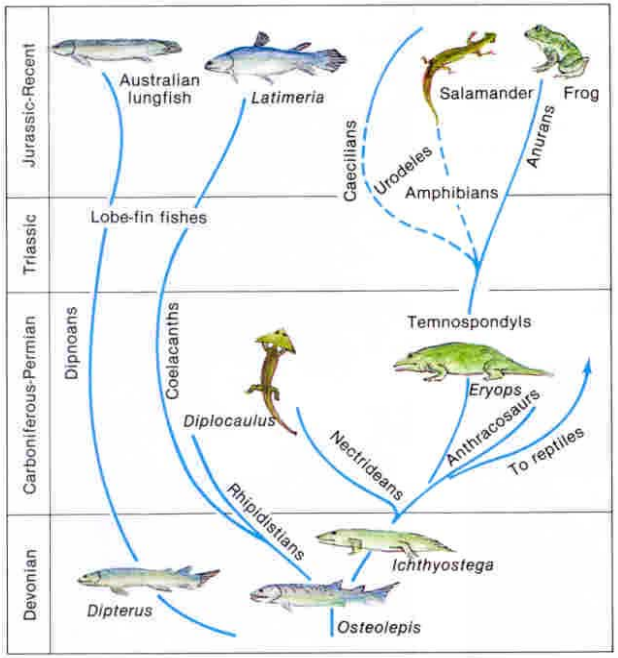


FIGURE 13.61 Family tree of late Paleozoic amphibians. Three typical groups of amphibians (all from the Early Permian of Texas) are shown. The commonest were the large, flat-bodied temnospondyls, such as *Eryops* (top), which reached 2 meters in length. A second group were the nectrideans, including the strange *Diplocaulus* (bottom), with its broad "boomerang" head and salamander-like body. The function of the flanges on its head is unknown, but they may have helped the animal swim. The third group, the anthracosaurs like *Seymouria* (center), eventually gave rise to reptiles. Indeed, some anthracosaurs are so reptilian in certain features that paleontologists still argue about where to draw the line that defines "reptile."