



## Precambrian Skeletonized Microbial Eukaryotes

Jere H Lipps

Museum of Paleontology, University of California, Berkeley, CA 94720 USA (jlipps@berkeley.edu)

Skeletal heterotrophic eukaryotes are mostly absent from the Precambrian, although algal eukaryotes appear about 2.2 billion years ago. Tintinnids, radiolaria and foraminifera have molecular origins well back into the Precambrian yet no representatives of these groups are known with certainty in that time. These data infer times of the last common ancestors, not the appearance of true representatives of these groups which may well have diversified or not been preserved since those splits. Previous reports of these groups in the Precambrian are misinterpretations of other objects in the fossil record. Reported tintinnids at 1600 mya from China are metamorphic shards or mineral artifacts, the many specimens from 635-715 mya in Mongolia may be eukaryotes but they are not tintinnids, and the putative tintinnids at 580 mya in the Doushantou formation of China are diagenetic alterations of well-known acritarchs. The oldest supposed foraminiferan is Titanotheca from 550 to 565 mya rocks in South America and Africa is based on the occurrence of rutile in the tests and in a few modern agglutinated foraminifera, as well as the agglutinated tests. Neither of these nor the morphology are characteristic of foraminifera; hence these fossils remain as indeterminate microfossils. Platysolenites, an agglutinated tube identical to the modern foraminiferan Bathysiphon, occurs in the latest Neoproterozoic in Russia, Canada, and the USA (California). Some of the larger fossils occurring in typical Ediacaran (late Neoproterozoic) assemblages may be xenophyophorids (very large foraminifera), but the comparison is disputed and flawed. Radiolaria, on occasion, have been reported in the Precambrian, but the earliest known clearly identifiable ones are in the Cambrian. The only certain Precambrian heterotrophic skeletal eukaryotes (thecamoebians) occur in fresh-water rocks at about 750 mya. Skeletonized radiolaria and foraminifera appear sparsely in the Cambrian and radiate in the Ordovician. Tintinnids first appear in the mid-Mesozoic, like other modern planktic groups, including planktic foraminifera, new types of radiolarians, and a host of skeletal micro-algae. Microbial eukaryotes track algal eukaryote and metazoan evolution—none or very few in the Precambrian, some in the early Paleozoic with radiations in the later Paleozoic, Mesozoic and Cenozoic, with extinctions (~30) reducing their biodiversity at particular times in the fossil record—thus indicating strong environmental selection on all marine groups.