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Evolution of protists

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Most eukaryotes are single-celled protists that do not fossilize at all; their fossil record nevertheless is good and contains hundreds of thousands of species over nearly 2 Ga. Molecular data provide a scaffold on which to place the major features of protist evolution while fossils provide the details of their phylogenetic and ecologic histories. Eukaryotes are known from biomarkers at 2.7 Ga. For most groups (foraminifera, ciliates, dinoflagellates, etc) molecular data indicate a long Precambrian presence without fossils. Acritarchs, chiefly algal cysts, left a record, starting at 1.8 Ga, although protists, likely abundant and diverse in the seas, were surely important components of Precambrian biotas, especially as primary producers. Ten major events characterize protist evolution:

1) Their origin, inferred from molecular sequences, occurred very early (>3Ga). They are a chimera of different symbiont-derived organelles, including possibly the nucleus. The hypothetical ancestral eukaryote resembled certain prokaryotes but possessed their own unique characteristics. More than 10 hypotheses exist for their origin.
2) The initial diversification of eukaryotes may have occurred quickly in geologic time. Six supergroups, each with fossil groups known chiefly from the Phanerozoic, are recognized molecularly.
3) The origin of sex, considered an important event, may have been inherited from bacteria. Sexual populations avoid selection in fluctuating environments, while asexual ones build populations in benign or favorable environments.
4) Precambrian fossilized protists indicate a pelagic existence for cyst-bearing taxa, although other forms were probably quite diverse and abundant.
5) Protists gave rise to animals long before 600 Ma through the choanoflagellates, for which no fossil record exists. Choanoflagellates share a common ancestor with sponges, the sister group for all other animals. They or their ancestors acquired genes that allow the cohesion

of cells, first as colonies then as more complex sponges. Once animals diversified, they and protists interacted ecologically to drive evolution of both groups in part.

6) Acritarchs and skeletonized protists (foraminifera, radiolaria, tintinnids) radiated in the Cambrian (544-530 Ma) in a trophic cascade initiated either by protists or metazoans. From then on, protists radiated and became extinct at all the major events recorded in the metazoan fossil record, suggesting links through environmental factors.
7) Protists began to dominate major environments (shelves and reefs) starting with a significant radiation in the Ordovician, followed by extinctions and other radiations until most died out at the end of the Permian. Fusulinid foraminifera became the dominant group during this interval.
8) In the Mesozoic, dinoflagellates, diatoms, coccolithophorids, silicoflagellates, radiolaria, and planktic foraminifera appeared and radiated in pelagic environments and foraminifera were abundant and diverse in benthic habitats.
9) The modern protist biota reflects an important role at all trophic levels in marine environments. A huge number of largely unknown terrestrial, parasitic and symbiotic protists must have existed for much of geologic time as well. These were surely important, as indicated by the impact of disease-causing forms in humans and other organisms.
10) The future of protists is likely in jeopardy, just like most reefal, benthic, and planktic metazoans. For many groups, we know well what happens to them under certain changing environmental conditions (green- or ice-houses, oceanographies, or sea levels), but we do not know how human pollution and disruption of trophic structures may affect the protistan biotas that may contribute significantly to the health and welfare of biotas everywhere. This urgent need to understand the role of protists in modern threatened oceans should be addressed soon.