

Complex evolutionary histories of actin, tubulins and elongation factor protein in Rhizaria based on Retaria hypothesis

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Radiolaria and Foraminifera are important pelagic organisms in the field of paleontology due to their good and long fossil record of shells. Recent molecular phylogenetic analyses have shown that these two protist groups are sister to each other (known as Retaria hypothesis) and belong to one of large taxonomic assemblages of eukaryotes Rhizaria, together with two other groups Endomyxa and Filosa.

Cytoskeletal proteins (actin, alpha-tubulin, and beta-tubulin) and translation elongation factor proteins are essential in a eukaryotic cell. Phylogenies of genes encoding actin, alpha-tubulin, beta-tubulin, and elongation factor proteins are frequently coincident with the organismal phylogeny. However, the evolutionary processes of these protein-coding genes in the rhizarian lineage remain unclear due to less availability of radiolarian gene sequences. In the present study, the genes encoding actin, alpha-tubulin, beta-tubulin, and one of elongation factor proteins were identified from diverse groups of Radiolaria, and the evolutionary histories of these genes are discussed based on the phylogenetic analyses.

Two paralogues of actin, alpha-tubulin, and beta-tubulin were identified from radiolarian species examined. The phylogenies reconstructed in this study suggest that the actin gene was duplicated in a common ancestor of Radiolaria and Foraminifera and that one of two alpha-tubulin paralogues was laterally transferred from an unknown organism to a common ancestor of Radiolaria. It is also suggested that the highly divergent one of two beta-tubulin paralogues originated from a common ancestor of Radiolaria and Foraminifera. Furthermore, the gene encoding elongation factor-like (EFL) protein, one of two paralogues of elongation factors (elongation factor-1alpha and EFL), were identified from several species of Radiolaria. Based on the EFL phylogeny the radiolarian homologues could have been vertically inherited from a common ancestor of Radiolaria, Foraminifera and an endomyxan species *Gromia*. In summary, our present study unveils the complex evolutionary scenarios of these essential protein-coding genes within the lineage of Rhizaria.

Keywords: Polycystina, Acantharia, actin, tubulin, elongation factor-like protein, phylogenetic analysis