

Earth System Evolution and Genomics

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Life is important and essential for understanding the evolution of the planet Earth. Inferences of past biospheres have been done largely based on fossils, including not only body and trace fossils, but also molecular and atomic fossils. In addition to this, historical information contained in the genomes of living organisms is coming to give new insight into the ancient life and evolution of the Life-Earth system. Genomes may contain three kinds of information: (1) genetic information, or nucleotide sequences themselves that are inherited through generations, (2) developmental program in general, including metabolic pathways, and (3) the historical information. The historical information, which can be retrieved by comparisons of more than one genome, includes phylogenetic information as well as the state of genomes (nucleotide sequences, gene orders, gene sets, etc.) that ancestral organisms possessed. The latter can be retrieved using the phylogenetic tree and the method of most parsimonious reconstruction (of the genomic character states) for each node of the tree. In considering Life-Earth evolution, histories of genes involved in metabolisms of elements or compounds that are taken from and released to the environment must be important. Most organisms are composed of 11 major elements (H, C, N, O, Na, Mg, P, S, Cl, K, Ca), and 5 minor elements (Mn, Fe, Co, Cu, Zn: as well as B, Al, Si, V, Mo, I in some organisms), and have a set of operational genes for each of those elements (and combinations thereof). I take a few examples of histories of genes that may reflect secular changes of atmospheric oxygen and carbon dioxide on the Earth, and argue that comparative genomics and retrieval of historical information inscribed in the genomes will become more and more important in earth and planetary sciences.