AN ESTIMATE OF THE ELEMENTAL COMPOSITION OF LUCA. Aditya Chopra[1] and Charles H. Lineweaver[1], [1]Planetary Science Institute, Research School of Earth Sciences and Research School of Astronomy and Astrophysics, Australian National University, aditya.chopra@anu.edu.au, charley.lineweaver@anu.edu.au

A number of genomic and proteomic features of life on Earth, like the 16S ribosomal RNA gene, have been highly conserved over billions of years. Genetic and proteomic conservation translates to conservation of metabolic pathways across taxa. It follows that the stoichiometry of the elements that make up some of the biomolecules will be conserved. By extension, the elemental make up of the whole organism is a relatively conserved feature of life on Earth [1,2].

We describe how average bulk elemental abundances in extant life can yield an indirect estimate of relative abundances of elements in the Last Universal Common Ancestor (LUCA). The results could give us important hints about the stoichiometry of the environment where LUCA existed and perhaps clues to the processes involved in the origin and early evolution of life [3].

We conducted a meta-analysis of historical and recent studies which examined the elemental abundances in various taxa; for example, those presented in [4,5]. Our compilation samples eukaryotic, bacterial and archaeal taxa across the extant tree of life. Based on the elemental abundances therein and the phylogenetic relationship between the taxa, we derived our best estimate for the elemental composition of LUCA (Fig. 1).

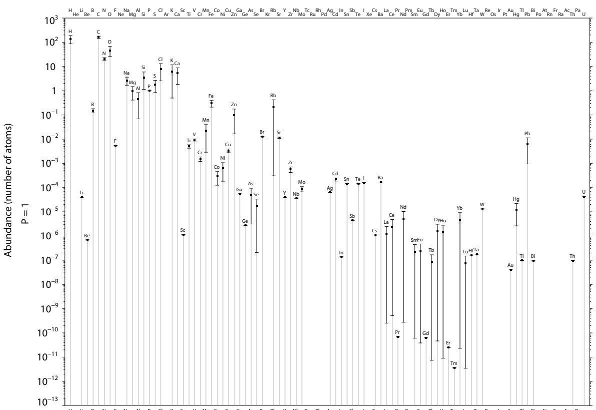

Fig. 1: The bulk elemental composition of LUCA estimated from abundances in extant taxa.

Previous work dealt mostly with single species or was limited in the breadth of elements considered [6]. We used abundances for almost all of the biologically relevant elements, including the major elements (H, O, C, N, P, S) and minor elements (e.g. Na, K, Mg, Ca, Fe, Cu, Zn). In establishing an average elemental composition of life, we attempt to account for differences in composition between species and other phylogenetic taxa (Fig. 2) by weighting datasets such that the result represents the root of prokaryotic life (LUCA). Variations in composition between data sets that can be attributed to different growth stages or environmental factors are used as estimates of the uncertainty associated with the average abundances for each taxa.

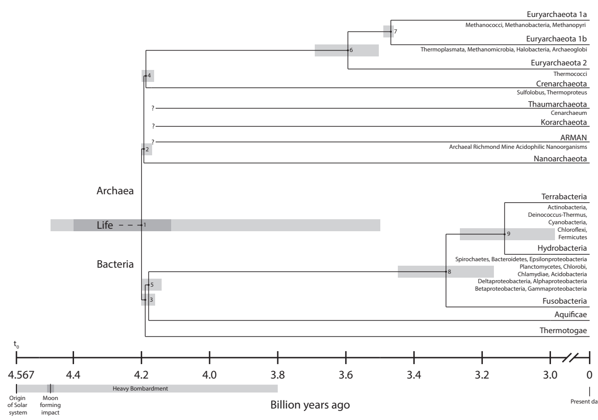

Fig. 2: The earliest divergences in the phylogenetic tree of life used for weighting elemental abundances by phylogeny. Overlapping relative uncertainties in emergence time of taxa are indicated by grey bars [7].

Over the past ~4 billion years, the habitats occupied by life forms have changed in composition as previously inhabited environments became colonized. The extent of conservation in the elemental composition since LUCA, and how elemental abundances in life change in response to environmental changes provide a means to study both the origin and evolution of life [8].

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