Fe^{2+} in Prebiotic Non-enzymatic RNA Chemistry and Early Compartmentation

Lin Jin[1, 2], Jack Szostak[1]*

[1]Howard Hughes Medical Institute, Department of Molecular Biology and the Center for Computational and Integrative Biology, Massachusetts General Hospital, 185 Cambridge Street, Boston, Massachusetts 02114, USA; [2]Department of Biomedical Engineering, Boston University, Boston, Massachusetts 02215, USA

* e-mail of Correspondence Author: szostak@molbio.mgh.harvard.edu

Iron, one of the most abundant elements on earth, has long been interested for its impact on origin of life. 30 years ago, Wächtershäuser's Iron-sulfur world hypothesis proposed that the catalytic transition metal solid surfaces in hydrothermal vents helped to form the metallo-peptides, which was considered precursors of life. However, in the RNA world hypothesis for abiogenesis, it is not obvious to find the linkage between iron and genetic materials. Inspired by the distinctive role Mg^{2+} plays in modern biology for RNA folding and catalysis, we wonder whether Fe^{2+}, with the same charge and similar ionic radius as Mg^{2+}, could potentially be the ancient RNA cofactor and catalyze non-enzymatic RNA chemistry on anoxic earth. Here, in anaerobic glove box, we study the catalytic effect of Fe^{2+} for non-enzymatic template-directed RNA polymerization and ligation, which are key reactions to achieve the RNA self-replication. We found not only could Fe^{2+} replace Mg^{2+} for these reactions, it also performs much better in near neutral to slightly acidic pH condition and still maintains its catalytic role in low concentration. On this other side, compatibility of Fe^{2+} to fatty acid vesicles is also studied for early cellularization. With the help of citric acid and amino acids as iron chelators, we are able to perform non-enzymatic RNA replication and hammerhead ribozyme self-cleavage inside oleic acid protocells. Our results highly suggest that the abundant Fe^{2+} before great oxygenation event on early earth is closely related to the RNA world and protocell function for origin of life study.