

The Origin of the Ribosome

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Here at the Georgia Institute of Technology, there is an organization known as The Center for Ribosomal Origins and Evolution (RiboEvo), headed by Dr. Loren Williams, in which graduate students, post-doctoral fellows and research scientists work to understand the biochemistry of early Earth. One focus of the RiboEvo group is the origin of the ribosome: a proposed ancestral version of the ribosome capable of catalyzing peptide bond formation more than 3.5 billion years ago.

The ribosome is often referred to as the “Ultimate Frozen Accident” because evolution has left the structure of the ribosome largely unaltered. When comparing the structure of the macromolecule across different domains of life, such as archaea and bacteria, the ribosome can be broken down into two subunits: the Large Ribosomal Subunit (LSU) and the Small Ribosomal Subunit (SSU). The focus of RiboEvo is on the LSU because this is the portion of the ribosome that catalyzes the formation of bonds between amino acids in a growing protein. The RNA that surrounds the site of peptide bond catalysis (the PTC) in the ribosome is highly con-

served in sequence and even more highly conserved in structure among modern ribosomes, and so is believed to be the oldest part of the ribosome. The Williams Lab has shown that their proposed ancestral PTC forms a structure very similar to that of the modern ribosome and retains the ability to interact with proteins needed for ribosome assembly.

While research on the ribosome is a primary focus of RiboEvo, the laboratories also conduct experiments on the components of the ribosome: RNA, proteins, and divalent cations such as Mg^{2+} . One ongoing project is a study of interactions between RNA, believed to be the first biopolymer on Earth, and Iron II (Fe^{2+}). Before the rise of oxygen (O_2) from photosynthesis, the Earth’s waters were rich in Iron II, a soluble form of Iron in the absence of oxygen. RiboEvo has shown that the Iron II metal interacts heavily with RNA. As the concentration of O_2 in Earth’s atmosphere increased, Iron II would have become less soluble, precipitating out of solution as Iron III, to eventually be replaced by magnesium (Mg^{2+}), the dominant divalent cation in modern

biochemical systems. In a PLoS ONE paper published last year, the Williams Lab demonstrated that Iron II can substitute for Mg^{2+} in RNA folding. A more recent paper just accepted to Nature Chemistry documents a novel function of certain RNAs in the presence of Iron II, the ability to catalyze electron-transfer.

The work of RiboEvo will have a big effect on the origin of life community. The lab’s demonstration that Iron II can replace Mg^{2+} in biochemical systems under simulated early earth conditions, and impart novel function to some RNAs, gives further support to the RNA world hypothesis, which states that RNA arose before DNA and proteins. RiboEvo will continue to impact the scientific community as research continues forward.

