RIBOSOME EVOLUTION HAS IMPLICATIONS FOR THE ORIGINS OF THE GENETIC CODE AND CHIRALITY. G. E. Fox., University of Houston (fox@uh.edu)

The modern ribosome is very complex and its evolutionary history has clearly been extensive. Given that many of the components are universal in all three Domains of life, it is likely that many of the major events in ribosome origins occurred before the last universal common ancestor. However, ribosomal evolution likely did not occur in independently of other early developments such as coding and chiral synthesis. The essence of coding depends on the interaction between the tRNA and the mRNA which occurs in the 30S subunit of the modern ribosome. Knowledge of ribosome history allows one to address the seldom considered issue of when coding first occurred relative to other developments instead of the more commonly addressed issue of where the codon assignments came from. Thus, current thinking suggests that the peptidyl transferase reaction and the site that catalyzes it came first, thereby implying that coding as found in the modern system had a relatively late origin. In fact, the initial addition of the mRNA to the machinery may have simply enhanced the peptidyl transferase reaction with coding then being a fortuitous consequence of the availability of a template that initially exclusively served a different purpose.

In the case of chirality, it will be argued that chiral peptide synthesis co-evolved with the ribosomal machinery and likely was one of the major advantages offered by the early ribosome over alternative prebiotic approaches to peptide synthesis. Evidence will be discussed that shows that even in the modern ribosome, neither the tRNA charging reaction nor the peptide bond synthesis reaction are exclusively chiral. Instead, a variety of mechanisms are employed to prevent eventual incorporation of D-amino acids into modern proteins. Such mechanisms would not have been available to the ancestral ribosomal machinery. Hence, it is likely that that the first peptides made would have included both D and L amino acids thereby making synthesis of complex catalytic sites that characterize modern proteins difficult at best. If the first peptides made were of mixed chirality, they would have been largely devoid of complex structure. Such peptides would not have been without value, as modern peptides largely devoid of structure are in fact found in the interior of the ribosome where they stabilize RNA structure. If the early charging and peptide bond synthesis steps both favor the same chiral form, e.g. L-amino acids, then the frequency of the L-amino acid incorporated into the final product depends on the extent of partial selectivity at both steps. This is a product relationship and quickly leads to a nearly homochiral product. Thus, if 70% of the tRNAs are charged with L amino acids and only 30% of the tRNAs charged with D-amino acids are used in the synthesis step, then the final peptide product will be expected to be 91% L-amino acids. Thus, the emerging ribosomal machinery would quickly offer nearly homochiral proteins. It is quite likely that peptides containing a few amino acids of the wrong chirality would have a decent chance of forming catalytic centers. Future studies of such partially chiral peptides may provide insight to the nature of the early protein based biochemistry.