Amino Acids, Aminoacyl-tRNA Synthetases, Molecular Self-Reference, and the origins of biology

Aminoacyl-tRNA synthetases (aaRS) implement molecular self-reference by catalyzing the chemical reactions necessary for protein synthesis and the translation of the universal genetic code. As noted elsewhere (1), the physics of proteins—linear chains built from twenty canonical amino acids, half the volume of nucleic acid bases—endow them with the ability to engineer chemistry on a nanoscale perhaps 100 million-fold more precisely than can catalytic RNA. The two aaRS superfamilies thus lie closer than other proteins to the root of the diversity of life. We are interested in how the programming language of the genetic code came to be embedded in transfer RNA simultaneously with the emergence and selection of genes written in that programming language (2). We showed recently that genetics arose by at least two distinct stages of indirect coding, first encoding amino acid size in the tRNA acceptor stem and only later encoding amino acid polarity in the anticodon (3,4). Recent experimental studies of how the two aaRS families evolved (5-10) now allow us to construct a crude but experimentally testable path for stepwise evolution of the code.

References can be found on the Biophysics Colloquia website.

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