

Effects of Protein Non-Specificity in a Doublet-Codon Environment in the Young Earth

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Proteins continue to function when different amino acids are substituted at non-invariant sites. The non-specificity factor Q , i.e. the number of distinct polypeptides which can perform the task of any given protein, can greatly reduce the size of the protein phase space compared to cases where all sites are invariant. The size of RNA phase space associated with the corresponding gene is also reduced by the factor Q . Given the size of the reduced RNA phase space for a group of n_p genes, we ask: how densely could this phase space have been sampled by reactions in aqueous solution on the young Earth during ≈ 0.1 Gy? Formally, if Q is large enough ($Q > Q_{ra}$), the RNA phase space could have been sampled densely. However, the formal solution $Q = Q_{ra}$ is of no practical interest if Q_{ra} exceeds a well-defined upper limit Q_{max} determined by protein properties. For the current genetic code, based on *triplet* codons, we find that Q_{ra} exceeds Q_{max} . In such conditions, the sampling of RNA phase space in 0.1 Gy was too sparse to be of practical interest. However, the genetic code may have evolved through a *doublet* phase. For genetics based on *doublet* codons, a qualitatively different conclusion emerges: Q_{ra} is definitely less than Q_{max} . Such an RNA phase space *could have been* sampled densely in ≈ 0.1 Gy provided that n_p is not too large. We discuss this conclusion in the context of the minimal requirements for a functional proto-cell in the young Earth.