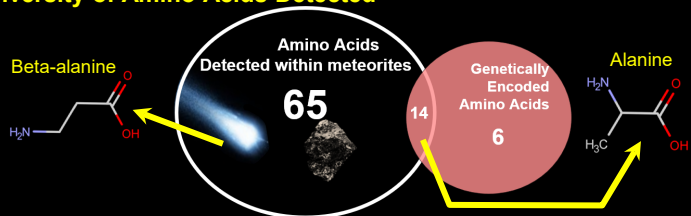


Xeno Amino Acids: A look into the biochemistry of alien life “As We Do Not Know It”

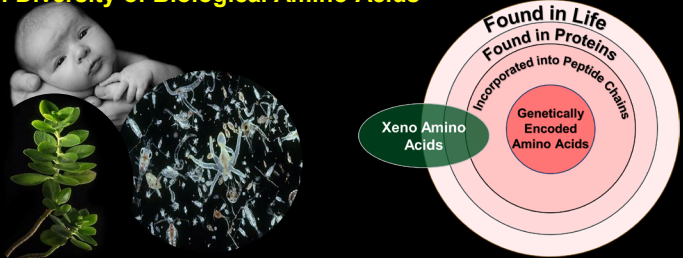
A: Diversity of Amino Acids Detected



All Earth-life uses one, genetically encoded alphabet of 20 amino acids to build proteins

Alanine, Glycine, lysine, Leucine, Arginine, glutamine, asparagine, Serine, Threonine, Methionine, aspartic acid, D, E, Cysteine, phenylalanine, Isoleucine, Histidine, Proline, Valine, tryptophan, W, Y, tyrosine, N, t, R, K, L, a, Q, N, S, T, M, A, D

B: Diversity of Biological Amino Acids



Other amino acids alphabets are possible:

- A. ABIOTIC SYNTHESIS:** beyond the canonical 20 AAs, others are found in meteorites and produced by prebiotic simulations
- B. BIOLOGICAL:** beyond genetic coding, many others are used by living organisms
- C. SYNTHETIC:** hundreds of alternatives have been incorporated via protein synthesis
- D. THEORETICAL:** advances in computational chemistry allow us to explore the functionally infinite universe of structures possible to an independent origin of life

1. Would alien life use amino acids?

The prebiotic abundance of amino acids suggests that any life might be expected to incorporate this class of molecules in its biochemistry.

1. Would alien life use monosubstituted- α -amino acids?

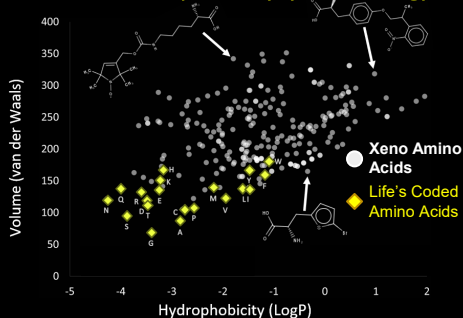
There are evolutionary reasons why life on Earth uses the (alpha-) amino acid backbone (it is the shortest and easiest to synthesize). Other backbones are possible, but may be evolutionarily disadvantageous.

1. Would alien life use side chains beyond Earth's genetically encoded 20?

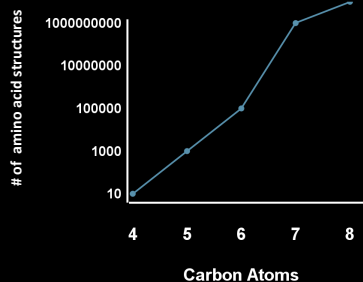
The specific choice of 20 amino acids on Earth (and the preference toward homochirality) is likely fortuitous because it obeys, at least in part, evolutionary adaptations that are inherently random and environment-specific. Biological evolution elsewhere may result in forms of life with alternative amino acid side-chains (and of the opposite chirality).

In planning future missions, it is essential to consider the broad spectrum of theoretically possible amino acids to avoid narrow perspectives and increase the likelihood of a positive result.

C: Amino acids incorporated by synthetic biology



D: Number of theoretically possible amino acid structures per Carbon atom



Brown, S.M.; Mayer-Bacon, C.; Freeland, S. Xeno Amino Acids: A Look into Biochemistry as We Do Not Know It. *Life* 2023, 13, 2281.

