Amino Acids in Asteroids and Comets: Implications for the Origin of Life on Earth and Possibly Elsewhere

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Meteorites provide a record of the chemical processes that occurred in the early solar system before life began on Earth. The delivery of organic matter by asteroids, comets, and their fragments to the Earth and other planetary bodies in our solar system could have been an important source of the prebiotic organic inventory needed for the emergence of life. Amino acids are essential components of proteins and enzymes in life on Earth and these prebiotic organic compounds have been detected in a wide variety of carbon-rich meteorites, the majority of which have been determined to be extraterrestrial in origin. In addition, many amino acids are structurally chiral (they possess handedness) and with a few very rare exceptions, only left handed (L) amino acids are found in biology, while all known abiotic syntheses of amino acids result in equal mixtures of left and right handed (L~D) amino acids. The discovery of a significant left handed amino acid imbalance of up to 20% in several different carbonaceous meteorites, could point toward a possible prebiotic contribution to the origin of biological homochirality by the exogenous delivery of extraterrestrial organic material to the early Earth. In this talk, I will focus on recent state-of-the-art measurements of the distribution, chirality, and isotopic composition of amino acids in meteorites and cometary samples carried out at the Goddard Astrobiology Analytical Laboratory. Results from the analyses of a variety of Antarctic meteorites, samples from comet Wild 2 returned by the STARDUST mission, and meteorite fragments of asteroid 2008 TC_3 called Almahata Sitta recovered from northern Sudan will be discussed.