The nature of organic matter in samples from the carbonaceous asteroid Bennu

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The study of organic matter in astromaterials reveals clues about early solar system chemistry and the origin of molecules important to life [1], but terrestrial exposure complicates interpretation. Samples returned from asteroid Bennu by the OSIRIS-REx mission [2,3] enable us to study pristine carbonaceous astromaterials with geological context and without uncontrolled exposure to Earth's biosphere [3]. Aggregate samples from Bennu are volatile-rich, with elevated abundances of carbon, nitrogen [3], and ammonia compared to samples from Ryugu [4,5] and most meteorites [6,7]. Deuterium and nitrogen-15 isotopic enrichments indicate that some of the organic compounds in Bennu (or their precursors) formed in a cold environment such as a giant molecular cloud or the outer protoplanetary disk. We identified amino acids (including 14 of the 20 standard amino acids used in terrestrial biology), amines, formaldehyde, carboxylic acids, polycyclic aromatic hydrocarbons, and N-heterocycles (including all 5 nucleobases found in DNA and RNA), along with ~10,000 N-bearing chemical species. All chiral and unbound amino acids were racemic or nearly racemic within measurement uncertainties, indicating an extraterrestrial origin. The distribution of amino acids and other soluble organics suggests that they were formed and altered by chemical reactions during low-temperature aqueous processing on the parent body, in NH_3-rich fluids. Volatile-rich asteroids like Bennu could be the remnants of icy bodies from the outer solar system and a source of prebiotic molecules available for the emergence of life.

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