Ingredients for a habitable Earth: Tracing C/N Ratios from interstellar space through planet formation

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We will present work explroing the use of the C/N ratio to monitor the delivery of carbon and nitrogen to nascent terrestrial worlds. We will discuss the total elemental C and N contents, and their ratio for the interstellar medium, comets, chondritic meteorites, and terrestrial planets. As part of this work we present an updated estimate for the Bulk Silicate Earth (C/N = 49±9.3). Based on kinetic chemical models of disk chemistry we will argue that organics and refractory organic material are the likely initial C and N carriers. Thus, chemical reactions in the disk can produce nebular C/N ratios of ~1-12, comparable to those of comets and the low end estimated for planetesimals. We further discsus the evidence for an increase of the C/N ratio between volatile-rich pristine bodies and larger volatile-depleted objects subjected to aqueous alteration and thermal/accretional metamorphism. The C/N ratios of the dominant materials accreted to terrestrial planets should therefore be higher than those seen in carbonaceous chondrites or comets. During planetary formation, we explore scenarios leading to further volatile loss and associated C/N variations owing to core formation and atmospheric escape. Key processes include relative enrichment of nitrogen in the atmosphere and preferential sequestration of carbon by the core. The high C/N BSE ratio therefore is best satisfied by accretion of thermally processed objects followed by large-scale atmospheric loss. These two effects must be more profound if volatile sequestration in the core is effective. The stochastic nature of these processes hints that the surface/atmospheric abundances of biosphere-essential materials will likely be variable. We will end with a discussion on how current and future ALMA observations can be used to set contraints on the initial stages of these processes.