

Life in a Nutshell: Complex chemical mixtures and the consciousness of molecular diversity in BioGeosystems and Extraterrestrial Materials

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Understanding on a molecular level complex organic mixtures in Bio- and/or Geosystems is a huge challenge in modern sciences and implies constant development and adaptation of modern ultrahigh-resolving analytical technology with innovative solutions for their resolved analysis. We aim to present concepts for the consciousness of chemical diversity of chemical mixtures subjected to biotic and abiotic processes. With complex systems we need high resolving analytical technologies to disentangle chemical complexity into its elementary parts (i.e. compositional and structural resolution) in a global integrated approach termed *systems chemical analytics*. The “complex” systems, phenomena or objects are various and related to our direct environment such as *life, ecosystems, nature, universe, human, brain, food, flavours* or even *wine*. Complex chemistry involves the interactions of elements, their adaptation – and their organization to reach homeostasis.

Life and Living systems (Biomes) from ubiquitous microbiomes through higher organisms to entire ecosystems, are involved in their specific interactions and more general ecosystems adaptations. Chemical complexity ruled by the genomes can be found in interkingdom interactions at the macrolevel of the ecosystems or at on the organism level when taking account of supersystems such as Holobiontes.

After-life involving generally globally transformed organic matter on short term or geological time scales to complex organic matter and geopolymers in diagenetic processes lead to a highly diverse and complex chemistry not found in any chemical database.

Pre-Life complex chemistry involves prebiotic chemistry following the only rules of abiotic chemical reactions. These complex mixtures will be found in many meteoritic samples and especially from return samples such as from Ryugu or Bennu, considered as chemical witnesses of processed geomaterials (former planets or asteroids) in extreme temperatures, pressures and water alteration processes. From this highest diverse and complex chemistry emerged molecules crucial for the early steps of life.

We present here concepts and experimental results for the awareness of chemical complexity/diversity, with examples form the interfaces in *Biome* and *Abiomes* of (bio)geochemical systems in Life, after-Life and pre-Life stages that sets huge challenges for analytical chemistry to describe the dynamic chemistry herein.

References:

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