Chemical Complexity: Implications for Bio/Technosignatures

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Abstract

One of the biggest difficulties of defining technosignatures is to think about how to accurately distinguish biosignatures and technosignatures. In order to distinguish them, we need to further advance our understanding of what biology and technology are fundamentally doing. In this work, we introduce big data approaches to statistically investigate universal patterns within all biological life on Earth. We measure chemical complexity produced by life and investigate how universal or different biology is. Revealing universality of biology can help clarify the properties unique to biological life and help distinguish technosignatures from biosignatures.

Chemical Complexity: Implications for Bio/Techno signatures

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Key message

Big data approaches to statistically investigate universal patterns of biology and technology enable new directions in bio/techno signature science. Statistical patterns of compounds used by biological/technological life can inform us of how to distinguish biosignatures from technosignatures.

Questions

- How does biological/ technological life change chemical complexity on the planet?
- Within biology, what kind of differences can be observed?

Introduction

- In this work, we compare three domains of life to clarify the universality and diversity within biological life

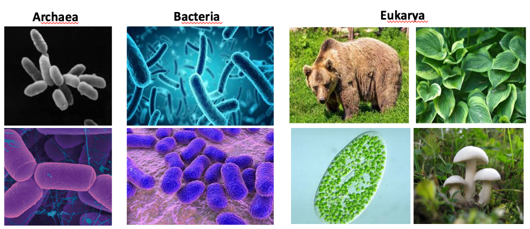

Figure 1: Three domains of life: archaea, bacteria, and eukarya

- Using molecular weight as a measure of chemical complexity since (1) it is a good proxy of chemical complexity and (2) it is a useful variable to explore for life detection.
- Data construction of chemical compounds used by each taxon: We combine the enzyme classes encoded in the genomes of each taxon with the reactions (compounds) they can catalyze

Universality among biology

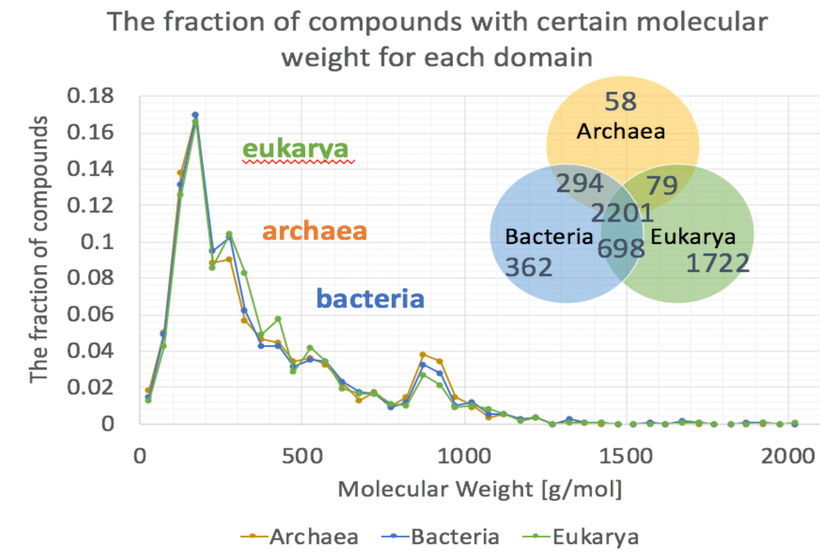

Figure 2: The figure shows the distribution of molecular weight of compounds used by taxa in the three domains of life: archaea, bacteria, and eukarya. The domains share the similar distribution patterns, having peaks around 100 – 200 g/mol and 900 g/mol.

Discussions & Conclusions

We have shown that there are shared universal patterns for all biological life regardless of the rich diversity of life we have on Earth. Such shared patterns can be useful to distinguish byproducts of biological life from those of technological life.

The uniqueness to each domain within biology can tell us how much deviation from the universality we can expect for Earth-life, which can infer potential difference for non Earth-life.

Clarifying such universality and uniqueness within biological life can be the first step to distinguish biosignatures from technosignatures by understanding the fundamental differences between the two.

References - *[1] Furukawa, H. et al.. (in prep)*

Differences within biology

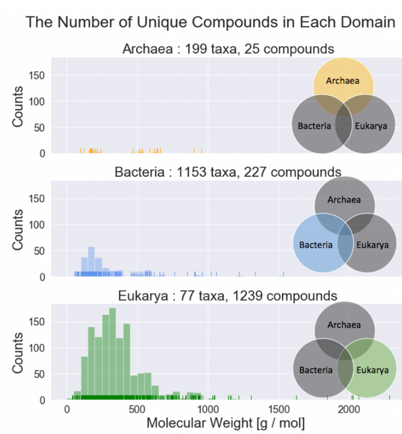

Figure 3: The figure shows the number of compounds unique to each domain. The number (variety) of compounds is increasing for Eukarya across a range of different molecular weight

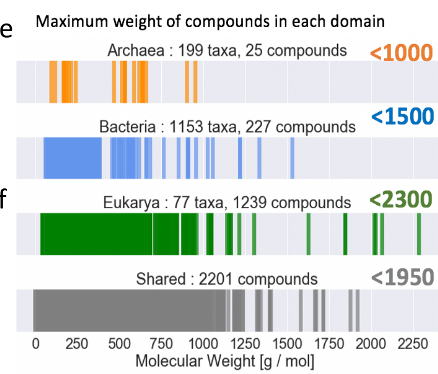

Figure 4: The figure shows the maximum weight of compounds unique to each domain. The heaviest compound Eukarya can use is heavier than that of bacteria and archaea.