Brief comment on ”Genetics Indicates Extra-Terrestrial Origin of Life: The First Gene”:

Horizontal movement of genetic information during early evolution of life and the timescale for the origin of the first gene

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Joseph and Wickramasinghe argue in their paper ”Genetics Indicates Extra-Terrestrial Origin of Life: The First Gene” that genetic evidence supports the idea that the first gene formed before the formation of Earth.

The idea in itself is intriguing and mind stimulating. The pre-Earth origin of genetic information is a possible scenario and therefore worth of scientific consideration. Indeed, this universe appears to be abundant with planets and it is thus justified to ask whether it is likely that the life we have on Earth actually emerged elsewhere. Yet, reliable evidence siding either terrestrial and extraterrestrial origin of life is difficult to produce and thus all attempts are welcome to clear the picture. However and regardless of the fact that I personally think life might have emerged multiple times independently in our universe, I want to point out some matters that should be taken into consideration when genetics of contemporary organisms are applied on primordial life forms. There are several aspects in the presented analysis that could be further discussed, but I decided to restrain this brief comment on one specific aspect of early evolution that appears to be relevant for the line of reasoning used in the paper.

In their paper the authors refer to the work of Carl Woese. Woese has argued that the early forms of life appear to have been evolving mainly horizontally by sharing and swapping genes between proto-cells (instead of the evolving vertically in the manner of contemporary cellular organisms) (e.g. Woese, 2002). The authors ask ”where the first gene of the proto-cells came from and how did the their genes acquire the ability to replicate?” Their paper does not attempt to answer this question as it is not relevant to the presented analysis. Notwithstanding the actual mechanism by which first genetic information emerged, what is still relevant is the way by which primordial proto-cells were likely to have evolved.

If we allow the consideration of the terrestrial origin of life, then term *proto-cell* is often referring to primordial containers in which early genetic information was maintained and replicated. Proto-cells themselves were possibly some sort of fixed abiotic formations like pores in alkalic vents or more dynamic vesicle-like structures. Regardless of the exact nature of the early proto-cells, the early genetic information was supposedly encapsulated into some sort of compartments (or bound to surfaces) that allowed the system to retain integrity. This is because genetic replication might be impossible to be sustained, if the required resources and information could diffuse and dilute freely within, e.g., a large body of water. Nevertheless, what Woese and others have argued (based on, e.g., genetic evidence) is that the genetic information within any particular primordial proto-cell was likely to come from *multiple directions*. In other words, genes travelled more or less freely within the system that comprised essentially unrelated proto-cells. For a modern analogy of such horizontal evolution we can think a bacterial conjugative plasmid that can transfer itself into various types of bacteria in its present environment. The plasmid can be prevalent among the community and have a major impact on the phenotypes and genetic content of the cells, yet it might be impossible to track down the cell which served as the source for bringing the plasmid to the system. Authors acknowledge that the effect of horizontally transferred agents may have an effect on the evolution of genomes, but it is not really taken into account.

The authors use in their analysis the genetic content of a cell as the variable that changes in respect to time due to gene and genome duplications. By extrapolating the rate of duplications, the authors deduce the timeframe for the origin of the first gene. However, it is important to realize that the variable indicates the rate by which the genome expands in any particular vertically evolving cell lineage. In other words, we can look at the genetic content of a single cell at different times and see the genome growing at certain rate. (Naturally, ”single” cell here indicates that the cell has divided numerous times in the between and it is likely to have plenty of sisters that can be equally well considered as the descendants of the ancestral cell.) However, this line of reasoning might be ill-suited for primordial proto-cells that evolved mainly horizontally (partly because genetic information supporting independently reproducing cells were yet to emerge). Therefore, when we observe any given proto-cell, its genetic information grows not only because there are genes or genomes duplicating but also because genes enter the proto-cell from external sources. Of course horizontal transfer of genes still occur among modern organisms as viruses, plasmids and other independent genetic elements travel between different cell-lineages. They do contribute to the evolution of the cellular chromosomes, but apparently in lesser extent than they did in primordial times. The critical difference is, at least partly, the ”Darwinian threshold”, term coined by Woese, which indicates the point of time in the evolution of cellular genomes when vertical evolution took the lead over the horizontal evolution. Therefore applying the rates of genomic evolution deduced by studying organisms of post-Darwinian threshold times might simply not apply to pre-threshold organisms. Gene and genome duplications might have been less relevant in the growth of the size of the genetic entities in pre-threshold period of evolution in comparison to events where various horizontally moving and independent genetic elements incorporated to form larger replicons.

Authors write ”Unless we wish to believe a minimal gene set of 382 life-sustaining genes were created ex-nihilo, or that the first gene underwent an accelerated rate of duplication only to dramatically slow down after life was established, then the only other alternative is the first gene was established prior to the creation of Earth.” *Life* can be difficult to define when very early organisms are considered and primordial evolutionary processes are still poorly understood. Nevertheless, it is possible that extensive horizontal gene movement may have been fundamental feature during the early development of life, and it can allow the system to evolve more collectively, letting genetic innovations that emerge separately in different proto-cells to get rapidly merged into a single genetic entity. The horizontal nature of evolution of primordial proto-cell communities might indeed accelerate the rate of duplications of early replicons as well as eventually generate minimal set of genetic information able to support self-reproducing cells. To conclude, if life actually did emerge on Earth, then the hypothesized early forms of life were most likely different from our contemporary life and therefore we may be unable to convincingly deduce the timeframe for the origin of first gene by studying contemporary life.

REFERENCES

C. Woese, 2002. On the evolution of cells. Proc. Nat. Acad. Sci. U. S. A, 99: 8742-7.