Wissenschaftskolleg zu Berlin

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Víctor Sojo, Ph.D.

Evolutionary Biology

Ludwig-Maximilians-Universität München

Born in 1980 in Manchester, United Kingdom

Studied Chemistry and Computer Science at the Central University of Venezuela, and Evolutionary Biology and Biological Modelling at University College London

FELLOWSHIP

College for Life Sciences

PROJECT

Why Do Eukaryotes Have Bacterial Membranes?

There are three types of organisms on Earth today: Archaea, Bacteria and Eukaryotes. Essentially all those we can see (plants, mushrooms, animals) are Eukaryotes.

Phylogenetic evidence shows that Eukaryotes arose much later than the other two, from a merger of bacterial cells into an archaeal host. The internal bacteria would go on to become mitochondria, providing power for the whole cell, while the archaeal genome became the basis of what now is the nucleus.

Interestingly, the membranes of archaea and bacteria are drastically different. No archaea has ever been found with a bacterial membrane, or vice versa. The ancestral eukaryotic cell thus likely had an archaeal outer membrane but bacterial inner membranes. Yet all modern eukaryotes have only bacterial membranes, both internally and peripherally. At some point eukaryotes swapped their outer membranes from archaeal to bacterial.

Perhaps one set of phospholipids disrupted the membranes built with the other, creating pressure to be rid of one. But why did eukaryotes choose bacterial?

Genes for making archaeal phospholipids were already in the (proto)nucleus, while in modern eukaryotes, bacterial phospholipids have taken their place, transferred from the mitochondrial genome. Both the archaeal counterparts and the bacterial originals inside mitochondria were lost or repurposed. Eukaryotes went through the evolutionary trouble of replacing the perfectly functional archaeal originals with bacterial analogues. Why?

Mitochondria produce most of the power of the eukaryotic cell (as ATP), and they do so with ancestrally bacterial membrane proteins that sit on ancestrally bacterial membranes. Mismatches are lethal, as gravely demonstrated by mitochondrial diseases in humans. I suggest that this means bacterial lipids had to be kept, and I will use a combination of computational methods to test it.

As a second project, I will develop educational resources for teaching and learning anything, anywhere, in any language, for free.

Recommended Reading

Sojo, V., C. Dessimoz, A. Pomiankowski, and N. Lane (2016). "Membrane proteins are dramatically less conserved than water-soluble proteins across the tree of life." Molecular Biology and Evolution 33, 11: 2874-2884.

Sojo, V. (2015). "On the biogenic origins of homochirality." Origins of Life and Evolution of Biospheres 45, 1-2: 219-224.

Sojo, V., A. Pomiankowski, and N. Lane (2014). "A bioenergetic basis for membrane divergence in archaea and bacteria." PLOS Biology 12, 8: e1001926.

COLLOQUIUM, 21.03.2019

1+1=3: Membranes, proteins, and the intertwining branches of the Tree of Life

All the fascinating diversity of organisms living on the Earth today can be classified into three distinct groups: bacteria (microscopic organisms), archaea (much like bacteria, but belonging to a separate family), and eukaryotes (essentially every organism that we can see with the naked eye - such as plants, mushrooms and animals - plus quite a few microscopic lineages).

While the groups are quite distinct, it is also clear that they are closely related to each other. But how exactly?

I will discuss the idea of the Tree of Life, and how our view has changed over time regarding how the three domains relate to each other. I will do this by focusing on membranes.

Why membranes? Because all life on Earth is by definition cellular, and membranes are the most obvious trait that define a cell: they are the boundary between the inside (the cell) and the outside (the environment, i.e. not the cell).

So, if all cellular life on Earth is related, we would expect them to share the very thing that makes a cell a cell, i.e. the membranes. Yet that is not the case. Archaea and bacteria typically have utterly different membranes, and eukaryotes, which seem to have arisen at least partly from within the archaea, actually have bacterial membranes.

I will discuss these puzzles, how I go about helping to solve them, and what they can tell us about life (how it started), the universe (is there life elsewhere?), and everything (how do we all relate to each other?).