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books

Mitochondrial amazement

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Power, Sex, Suicide: Mitochondria and the Meaning of Life
by Nick Lane
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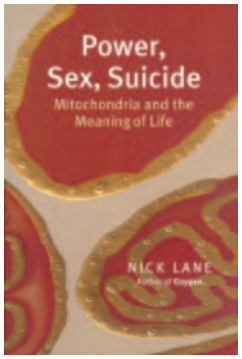

Mitochondria are the powerhouses of our cells. Of course, they are involved in calcium signalling and some other metabolic pathways, but their main role is to produce energy in the form of ATP. Once free-living bacteria, mitochondria were engulfed by some sort of primitive phagocytosing eukaryote. Apart from the nucleus, the mitochondrion is the characteristic feature of eukaryotic cells.

If you took all this for granted, you might be in for a shock if you read Nick Lane's book, *Power, Sex, Suicide: Mitochondria and the Meaning of Life*. Traditionalists beware, for you might not like what you see: you will be taken on an extraordinary journey, from the depths of time to the present and ultimately to where the Grim Reaper rules.

None of the ideas put forward by Lane are fully accepted scientific hypotheses, which is fine; if there is anything scientists should be wary of, it is dogmatic views. Some have used the word 'fringe' to describe Lane's ideas. 'Provocative', in the most positive of meanings, is the word I would use. Reading the book is a thought-provoking exercise that could invigorate mitochondrial research.

One of the questions that Lane poses is why it took so long for eukaryotes to evolve. For several billions of years, the earth was ruled by prokaryotes, or, should we say, promitochondriates? Why did it take so long for eukaryotes to evolve and why did prokaryotes not evolve true multicellularity? As you might imagine, mitochondria are the reason, according to Lane. Prokaryotes cannot get much larger than their present size, as constraints enforced by the ratio of volume to membrane surface area prevent them from generating enough energy. If they were to become too large for their membrane surface, energy limitations would ensure that they lose out against smaller competitors. The evolution of mitochondria is one way around this problem; these internalized membranes provide an increased area of respiratory membrane that, because there can be many mitochondria in a single cell, solves the problem of volume versus surface area.

When talking about the origin of the mitochondria, Lane trashes the textbook version in which a prokaryote was gradually converted into a phagocytosing proto-eukaryote that took up another prokaryote, according to the theory of Lynn Margulis. Although the basic tenets of this theory are in place, the players could not have been more different. Instead, Lane champions Bill Martin and Miklós Müller's hydrogen hypothesis, which states that a methanogenic archaebacterium 'took up' a facultative anaerobe that was able to produce molecular hydrogen. This hypothesis, now eight years old, is rather appealing and avoids having to explain why the mitochondrial endosymbiosis was based on a *Rickettsia*-like bacterium that liked to throw around its ATP.

One problem in explaining the rise of multicellularity and sex is why any single-celled organism would give up its freedom for the greater good of the collective. Again, mitochondria come to the rescue; their role in activating apoptosis is proposed as the ultimate punishment for cells leaving the collective. Nonetheless, this leaves us with the question of why they wanted to be together in the first place. In a fragile endosymbiotic relationship, it would be in the interests of both cells to coordinate their cellular divisions if the symbiosis was based on mutual benefit. If the host could not divide due to some kind of damage to its DNA, then the mitochondria would be trapped unless they could stimulate the host to fuse with another cell. Free-wheeling mitochondria generate free radicals, and an increase in free radicals has been shown to be a signal to reproduce sexually in certain cells. So, Lane proposes, following Neil Blackstone, what if a free radical signal from the mitochondria stimulated cell fusion (sex) in order to survive? The fusion would result in repair of the damaged DNA by recombination, and mitochondria would have escaped their deathtrap.

Strangely enough, this explanation for the origin of sex does indeed relate to ageing and, ultimately, to death. Although sex apparently has the potential to repair damaged genes, it might not be able to repair irreversibly damaged cells. Considering that it might be too costly to repair such cells, the mitochondria might now use the same free radical signal to induce apoptosis to eliminate damaged cells.

Lane discusses further topics such as the battle of the sexes and how fused cells solved the problem of two mitochondrial populations; the origin of the first cells as proposed by Mike Russell; why people indigenous to colder climates are inclined to suffer from male infertility; and why birds and bats live longer than they should. The common denominator? You guessed it: mitochondria, or perhaps more specifically, chemiosmotic membranes. *Power, Sex, Suicide* is an interesting story and an enjoyable read.

As mentioned before, many of the views put forward in this book are not mainstream science. Nonetheless, they are based on observations published in the primary literature. Therefore, do not dismiss Lane's book out of hand, but keep an open mind. Think of the amazement of a young child, such as my eight-month-old daughter Iris, who is delighted by the simplest of things. Let such innocent wonder be your guide when reading this book.

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