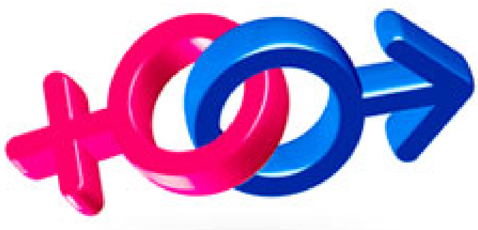
High-energy lifestyles led to evolution of the sexes

December 19 2011, By Peter Hurrell



Scientists are a step closer to explaining one of the most enduring mysteries of modern biology; why are there males and females?

Researchers at University College London have shown that by inheriting a certain set of genes from just one parent, the cells of sexually reproducing species could more efficiently produce the energy they need to survive.

"[Two] is not the evolutionary optimal number of sexes, or mating types, for a population," says Zena Hadjivasiliou, the PhD student who led the research. She adds: "You end up only being able to mate with fifty per cent of the population, so there must be some reason why it has spread."

To make their discovery, the scientists looked at one of the key differences between the sexes; during reproduction, males pass on only the genes from the nucleus of their cells. In contrast, females pass on all of the cellular components the offspring requires, including the both nuclear genes and a small extra set of genes in the tiny power-generating structures called mitochondria.

Mitochondria, which supply all of the energy the cell needs, contain a handful of genes that must work alongside the nuclear genes to control part of the energy production process.

Using a mathematical model, the UCL team found that if one parent was prevented from contributing their mitochondrial genes to their offspring, it was easier for the remaining mitochondrial genes and the nuclear genes to coordinate their activities as they evolved over several generations. The result was that the cell functioned more efficiently. Ultimately, this would favour the evolution of two sexes, only one of which, the female, would pass on its mitochondria.

The researchers' model also showed that, although the advantage of having two sexes was fairly small in simple single-celled organisms, it was more pronounced when individual cells contained lots of mitochondria. This is particularly true of organisms that have high energy requirements and are made up of many trillions of cells, like us.

In many sexually reproducing species, males and females can be distinguished by their sex cells, eggs and sperm. The female produces a few large, immobile eggs while males produce many small, mobile sperm. But even in species with no obvious differences between the sex cells, researchers can still tell them apart. The key is that only the females pass their mitochondria, and the genes they contain, to their offspring.

It was this tiny difference that Hadjivasiliou and colleagues wanted to study, to see if it was enough to overcome the disadvantage of only being able to mate with half the population. Their idea was that if an organism inherited two different sets of mitochondria – one from each parent - the nuclear genome would not be able to evolve to work efficiently with both. As a result, the organism would be less healthy than others of its species that inherited just one set of mitochondria.

Their mathematical model allowed the team to compare the effects on the fitness of a population of single-celled organisms of inheriting mitochondria from one parent with the effects of inheriting mitochondria from both.

The results clearly showed that populations in which mitochondria were inherited from just one parent were generally fitter.

Fitter individuals tend to reproduce more successfully, so they would eventually become the majority, allowing the evolution of two sexes to spread. Through billions of years of evolution, these advantages persisted, resulting in the sexual division we're familiar with today.

The research appears in *Proceedings of the Royal Society B*.

More information: Hadjivasiliou, Z, et al. Selection for mitonuclear co-adaptation could favour the evolution of two sexes. *Proceedings of the Royal Society B*. Published online: December 7, 2011, doi: 10.1098/rspb.2011.1871

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