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Guest Editorial

The endosymbiotic origin of organelles: an ancient process still very much in fashion

Mitochondria and chloroplasts originated via two independent endosymbiotic events from prokaryotes related to today's α-proteobacteria and photosynthetic cyanobacteria, respectively. During the transformation of once free-living organisms into interdependent cell organelles, a number of decisive steps ensured integration of the organelles into the metabolic circuits and signaling networks of the cell. Many of these central processes governing the endosymbiont-organelle transition were the focus of a FEBS Advanced Lecture course on the 'Evolution of Mitochondria and Chloroplasts' that took place in Maratea, Italy in March 2007 and that led to a series of articles presented in this issue of *Biological Chemistry*.

Massive gene transfer from the endosymbiont to the nucleus made the new organelles dependent on the host cell. At the same time, transfer of almost the entire genome from the endosymbiont to the host nucleus offered a 'once-in-a-lifetime' chance to redistribute biochemical tasks between cellular compartments or to combine enzymes from different origins into one pathway. Recent advances based on genomic, proteomic and metabolomic studies helped to shape our view of the phylogenetic patchwork of eukaryotic cell metabolism. While both organelles have retained a small number of essential genes, expression of the mitochondrial and chloroplast genomes is under tight control of the nucleus. Organellar biogenesis and function therefore require the coordinated expression of two or three genomes. Significant headway has been made in understanding this coordination network, including how organelles signal back their metabolic and developmental status to the nucleus.

The integration of endosymbiotic organelles into the eukaryotic cell not only necessitated their inclusion into metabolic pathways and signaling networks, but also required new transport systems for proteins and metabolites. The process of protein translocation had to be developed early during the endosymbiont-organelle transition, and is achieved by proteinaceous translocation machineries from a jumbled phylogenetic ancestry. Set around a few conserved proteins, two vastly different import machineries evolved, which nevertheless translocate proteins by very similar mechanisms. In the case of chloroplasts, insertion into and transport across its internal membrane system, the thylakoids, requires a variety of further translocation pathways. These appear to be descendants of ancient protein translocation machineries that are phylogenetically conserved in all kingdoms. In the same way that biogenesis and function of the endosymbiotic organelles are coordinated with the requirements of the surrounding cell, organellar division and inheritance have to be timed with cell division. To this end, division machineries were combined to create a complex system that appears to be a phylogenetic patchwork of different genetic origins.

All these different requirements had to be met to achieve successful integration of the endosymbiotic organelles into the host cell. The rapid increase in knowledge based on the availability of new techniques has opened exciting new avenues to study the enigmatic process involved in evolution of the eukaryotic cell.

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