Intracellular Organization in Cochlear Inner Hair Cells by 3D Electron Microscopy

Authors: Roland Fleck (1), Gema Vizay-Barrena (2), Anewn Bullen (3)
1. Centre for Ultrastructural Imaging, King’s College London, London, UK
2. Centre for Ultrastructural Imaging, King’s College London, London, UK
3. Centre for Auditory Research, UCL Ear Institute, London, UK

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Corresponding email: roland.fleck@kcl.ac.uk
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The ways in which cell architecture is modelled to meet cell function is a poorly understood facet of cell biology. However, the compartmentalization of mutually exclusive reactions in different regions of cells by membrane-enclosed organelles or by self-assembling macromolecular complexes is a basic mechanism of life. Fluorescent tags can display proteins confined to compartments in living cells, but provides no glimpse of the underlying ultrastructure. The electron microscope has the resolution to display cellular ultrastructure. Transmission electron microscopy (TEM) tomography of thin slices (~100-300nm depth) can reveal complex subcellular cellular ultrastructure. Serial Block Face Scanning Electron Microscopy (SBFSEM) can provide ultrastructural resolution throughout a much longer (µm to mm) sample depth, enabling quantitative analysis of ultrastructural features throughout the length of most complex cells.

We have studied the cytoarchitecture of a cell with highly specialised organisation, the cochlear inner hair cell (IHC), using multiple hierarchies of 3D electron microscopy analyses. We have shown that synaptic terminal distribution on the IHC surface correlates with cell shape, and the distribution of a highly organised network of membranes and mitochondria encompassing the infranuclear region of the cell. Structural linkages between organelles that underlie this organisation were identified by high resolution imaging. Together these techniques have the potential for clarifying functionally specialised cytoarchitecture of other cell types. Strategies employed to improve data quality will be discussed.