

Early beginnings - the emergence of complex signaling systems and cell-to-cell communication

Stephan M Feller

The protein universe is currently still expanding [1] and so is the realm of cellular signaling proteins. Although in selected cases the genome size and number of genes in a species may substantially decrease as a reflection of a very narrow ecological niche and specialised lifestyle [2], overall there is an ever-increasing complexity in cellular signalling networks clearly evident throughout evolution.

For example, tyrosine kinases, phosphotyrosine-recognition domains (SH2 s etc.), and also the ancestral forms of large multi-docking proteins with folded N-termini and long 'intrinsically disordered' tails, like the p130Cas, Gab or IRS family proteins [3-5], which mediate high molecular weight signal transduction and integration complexes, emerged early during metazoan evolution [6]. Later on, genome duplications occurring during vertebrate evolution [7] allowed the emergence of small families of signaling proteins from single ancestor proteins. So compared to *Drosophila* and *C. elegans*, which typically have still one prototype protein, *Homo sapiens* has often three or four close relatives.

But why, when and how did signaling pathways and networks emerge in the first place? Clearly, the key to survival for all cells and organisms is to sense and respond appropriately to their natural surroundings. The sensing of the environment and signaling are very intimately linked, so it does not seem unlikely that a prokaryotic chemotaxis system [8] represents the first form of a cellular signaling system. The earliest presumed fossil records (stromatolites) seem to indicate that cellular life forms may have evolved over three billion years ago and it is hard to imagine that these early life forms would have been able to thrive for long without an environmental recognition and response system.

And when did multicellular organisms, which needed more complex signaling systems, including cell-to-cell communication, actually start to emerge? A new study now suggests a point in time over 2 billion years ago [9].

* Correspondence: stephan.feller@imm.ox.ac.uk

¹ Cell Signalling Group, Weatherall Institute of Molecular Medicine, University of Oxford, Oxford OX3 9DS, UK

Full list of author information is available at the end of the article

Macroscopically visible fossil records of up to a dozen centimetres in size found in equatorial Africa (southeastern Gabon), if interpreted correctly, point to the emergence of multicellularity relatively soon after the onset of the 'great oxidation event' [10]. These newly reported fossils form flat sheets with scalloped margins and noticeable radiating structures that seem to indicate coordinated growth. They seem to be unlike any known prokaryotic species, begging the question of whether they may actually represent very early eukaryotes.

Obviously we will be unable to query any ancient nucleic acids in this matter, but further analyses of these fossils may still eventually yield more insight into the very early days of cell - cell communication.

Author Details

Cell Signalling Group, Weatherall Institute of Molecular Medicine, University of Oxford, Oxford OX3 9DS, UK

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