Coacervate-Based Protocells: Integration of Life-Like Properties in a Droplet

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ABSTRACT

The formation of compartments with life-like properties from abiotic origins is one of the most drastic, yet least-understood transitions in the emergence of cellular life. Similarities between the protoplasm of modern cells and liquid droplets formed by condensation of oppositely charged macromolecules led Oparin to postulate in the 1930s that primitive protocells might have formed by coacervation. However, in order to proliferate, protocells must be stable, preserve their identity, and be capable of fuelled growth and division. At the time, it was not clear how passive coacervate droplets made from large polymers could fulfil these requirements. Recent advances in systems chemistry and physics of active droplets have revived the idea that various life-like properties could be integrated in a single droplet. The challenges on the way for coacervates to become viable protocells are being addressed one by one, and coacervate systems with increasing complexity and emergent properties are being developed. Here, we review the recent developments aimed at providing coacervates with the characteristics required to become self-sustained. Our discussion includes the incorporation of genetic material in coacervates, their stabilization by interfacial membrane assembly, and ways to achieve growth and division by fuelled reactions. From a distance, coacervates may be far from the complexity of modern cells, but they represent a promising systems chemistry approach to create protocells with properties beyond the sum of their parts [1].

Keywords: coacervates, protocells, self-organization, active systems, droplets.

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