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Chirality and Physical Autocatalysis

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Introduction: In an autocatalytic reaction, the product of reaction acts as a catalyst for its own formation, rendering the product a self-replicator.[1] In the case of *physical* autocatalysis, the catalyst is typically a micelle or vesicle composed of amphiphilic species. These structures can catalyse the formation of the amphiphilic product molecules at the interface between organic and aqueous phases (Figure 1).[1] Such self-replicating systems, with their ability to form aggregated, membrane-like structures, have clear relevance in research into the origins of life. For example, the coupled self-replication of these membranous compartments with the self-replication of their contents is required for the design of protocells.[2,3]

The search for asymmetric autocatalysis: In the search for bond-forming (and therefore complexity-inducing) examples of physical autocatalysis the group has been successful.[4,5] For a further increase in complexity we now aim to establish asymmetric variants and examine the role that stereochemistry can play in physical autocatalysis.[6,7] Common to multiple examples of the amplification of chirality is the formation of supramolecular structures, from the aggregation of catalysts in the Soai reaction,[8] to the formation of large supramolecular helical structures.[9] Such aggregates often lead to the emergence of non-linear effects, amplifying chirality from a nearly racemic mixture and offering one mechanistic basis for the emergence of homochirality.[10,11] In examining chirality in the micellar aggregates we form via physical autocatalysis we link, to some extent, two prominent themes on the origins of life – the production of a compartment[2] and the possible requirement for homochirality.[10]

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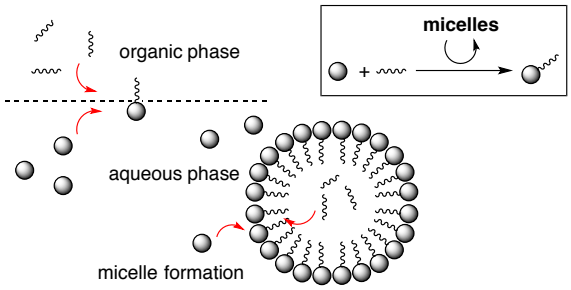

Figure 1 – Physical Autocatalysis: Hydrophobic species in an organic phase and hydrophilic species in an aqueous phase meet slowly at the interface and react to produce an amphiphile. Above a critical concentration, the amphiphiles aggregate into micelle structures. These aggregates allow increased mixing between the phases and therefore an increased rate of reaction; the micelles are self-replicating.