Exchange phenomena at elongated structures, from macro to nano — optimizing energy conversion devices based on their geometry

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Interfaces lie at the heart of many phenomena in everyday life, engineering, biology, and chemistry. The optimization of such interfacial phenomena combines the maximization of the contact area with the simultaneous minimization of the transport distances towards the interface. The contrasting geometric constraints involved in this optimization often result in elongated folds or spikes as the most efficient interface geometry. These folds appear on various length scales in the architecture of airports, the organization of German 'beer gardens', the cooling elements of engines, and the gills of marine animals.

Catalytic and electrocatalytic reactions are also interface phenomena and are therefore governed by the same constraints, however on a sub-micrometer scale. Indeed, photosynthesis takes place in plant cells at highly ordered folds of nanometer dimensions. Man-made catalysts, battery electrodes and fuel cell electrodes also feature nanostructured interfaces, albeit mostly disordered ones. Our preparative methods, on the other hand, enable us to prepare solid surfaces with highly ordered nanostructures, the structural parameters of which are accurately controlled and systematically tuneable. This platform enables us to address the geometric optimization of energy conversion devices and components such as solar cells, battery materials and electrolysis electrodes.