Sustainable Process Systems through Nature-Inspired Chemical Engineering

Marc-Olivier Coppens

UCL Centre for Nature-Inspired Engineering (CNIE) & Department of Chemical Engineering, University College London, United Kingdom

Tackling Grand Challenges in energy and sustainable manufacturing, framed by the UN Sustainable Development Goals (SDGs), but also economic requirements, requires step-changes through transformative approaches and interdisciplinary thinking, beyond incremental variations on traditional designs. We turn to nature for inspiration, because nature provides us with examples of solutions, perfected over the eons, to similar challenges as those we encounter in technology, such as scalability, efficiency, and resilience. However, such solutions from nature cannot be copied: their underpinning mechanisms need to be understood, before adopting and adapting them to the different context of industrial applications. This can be achieved via a systematic, nature-inspired solution (NIS) methodology, developed and applied at UCL's Centre for Nature-Inspired Engineering (CNIE), to accelerate innovation and sustainable development.

This approach will be illustrated with examples related to chemical engineering (NICE) for process intensification, from fluidized beds to hierarchically structured catalysts, fuel cells, and membrane separations. The broader applicability of NICE and the versatile NIS methodology will be touched upon as well, with applications in biomedical and healthcare engineering, as well as materials for space technology and the built environment.

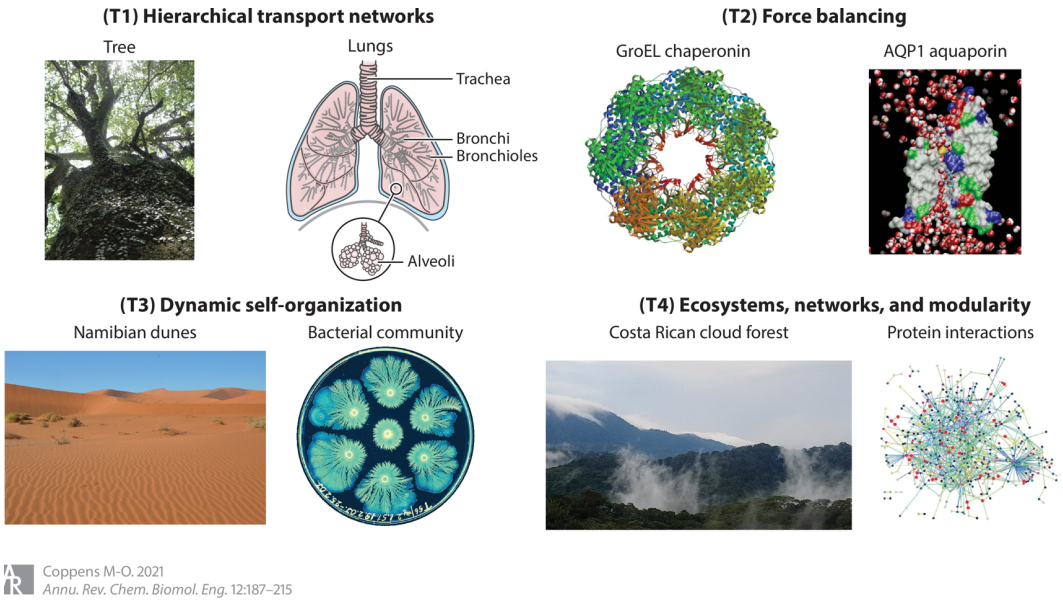

Figure 1 : Ubiquitous fundamental mechanisms in nature, underpinning NICE applications

Literature cited

Coppens, M.-O. Nature-Inspired Chemical Engineering for Process Intensification. *Ann. Rev. Chem. Biomolec. Eng.* 2021, 12, 187-215.

Coppens, M.-O.; Weissenberger, T.; Zhang, Q.; Ye, G. Nature-Inspired, Computer-Assisted Optimization of Hierarchically Structured Zeolites. *Adv. Mat. Int.* 2021, 8(4), 2001409.

Coppens, M.-O. A Nature-Inspired Approach to Reactor and Catalysis Engineering. *Curr. Op. Chem. Eng.* 2012, 1, 281-289.

Francia, V.; Wu, K.; Coppens, M.-O. Dynamically Structured Fluidization: Intensification of Gas-Solid Fluidized Bed Operation by Using an Oscillating Gas Flow. *Chem. Eng. Proc. Proc. Int.* 2021, 159, 108143.

Jiang, S.; Wang, J.; Feng, L.-F.; Coppens, M.-O. Fractal Injectors to Intensify Liquid-Phase Processes by Controlling the Turbulent Flow Field. *Chem. Eng. Sci.* 2021, 238, 116616

Liu, Y.; Coppens, M.-O. Cell Membrane-Inspired Graphene Nanomesh Membrane for Fast Separation of Oil-in-Water Emulsions. *Adv. Func. Mat.* 2022, 2200199.

Trogadas, P.; Cho, J.I.S.; Neville, T.P., Marquis, J.; Wu, B.; Brett, D.J.L.; Coppens, M.-O. A Lung-Inspired Approach to Scalable and Robust Fuel Cell Design. *Energy & Env. Sci*. 2018, 11, 136-143.