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GROUP REF. : SC C3
PREF. SUBJECT : 1
QUESTION N° : 9

To explore the main current trends allowing multifunctionality in biomimetics three main axes will be further described: surface structuring, material composition/architecture and product design approach at the early stage of the process.

First, the surface structuring of systems mimicking plants or animals' epithelium allows the implementation of passive functions (self-cleaning, super-hydrophobic [1], drag-reduction [2], etc.) on an interface along with the regulation of the interface's exchange surface.

An operational example is the riblet4wind EU funded project led by the Fraunhofer society. This project investigated and proved that the structuring of wind turbine blade's surface with shark's skin inspired structures improves the energy collection performances (https://ec.europa.eu/inea/en/horizon-2020/projects/h2020-energy/wind/riblet4wind). Such technologies are already available and are predicted to be widely implemented in the next few years.

Second, materials' composition and organization are other key means to implement multifunctionality. Indeed, like butterflies' wings or pomelo's peel, the overall structuring of material, can generate functions such as light filtering and absorbance [3], thermoregulation [4] or elastic deformability and energy dissipation properties [5]. Along with these examples of simple architecture, the combination of specific architecture with active principles opens the door on smart materials. These systems are then able to react to specific stimuli, such as cracks, by putting into contact two reactive components to generate specific chemical reactions allowing the implementation of numerous additional functions such as antibacterial activity, UV protection, signal liberation or self-healing [6]. Such encoded responses mostly rely on both material architecture and composition.

An operational example of such multifunctional material is the self-healing concrete commercialized by the company Basilisk (https://basiliskconcrete.com/en/) and developed by Pr. Jonkers at TU Delft. The self-healing properties are based on the combination, within the concrete, of bacteria with various activating factors and nutrients. In case of cracks, the internal part of the material is exposed to atmospheric water and bacteria start to develop, turning nutrients into calcium carbonate (limestone) which fills and repair cracks. Such technologies are already available, have been successfully tested and can be used for all sort of infrastructure, from water dam to the foundation of electric pylons, to concrete in power plant.

Last, if the two previous axes give example on "how do living beings implement multifunctionality?", this last one explores "why are biological system multifunctional?" and doing so, give key elements to consider at the early stage of any biomimetic design process to successfully reach multifunctionality. The key concept is that living organisms have adapted to a lot of constraints at the same time, and doing so, they have optimized balanced multifunctional responses rather than maximized unifunctional ones. Thus, if photosynthesis yield is around 1%, it should not be forgotten that this apparent low efficiency is combined with foliage's numerous other properties such as flexibility, lightness, self-cleaning, self-healing, self-thermoregulation, semi-transparency, 3D light collection, biodegradability, manufactured with abundant material at ambient pressure and temperature, functional stability under partial tear or puncture, etc. Overall, living beings deal with trade-offs [7], and commonly rely "good enough" efficiency combined with large range of operation, robustness, and high resiliency [8].

A project presenting such idea of multifunctionality through trade-off consideration is the structuring of mega wind turbine inspired by palm trees. Palm tree's foliage collects sunlight to answer the plant's energy needs. As a result, it should maximize its surface of exposure to maximize the collected energy. However, palm trees are mainly located in tropical area where they face seasonal hurricanes. Thus, they must resist strong wind and so reduce surface area to limit mechanical load. To solve this trade-off, branches have evolved being thin and ramified to reduce wind load and allow then to bend under mechanical force. During hurricane, palm tree foliage is then able to bend following the wind flow, preventing the collapse of the overall structure. Such design then reduces its ability to collect sunlight as it reduces the surface and limits the size of the overall foliage, but it increases the system's robustness since it allows palm trees to resist extreme climactic conditions. "Drawing inspiration from palm trees, US researchers have found a way to significantly scale up offshore wind turbines — a development that could dramatically increase the amount of electricity generated from wind power." To do so they design wind turbines collecting downwind and having blades able to bend at their roots, depending on the wind speed and any other climatic conditions [9] https://www.freethink.com/environment/offshore-wind-turbines.

Overall, these projects are made possible thanks to massive research efforts. Investments are more than ever required to support the analysis of fundamental biological phenomenon for biomimetic development by research teams, the R&D key transfer step from basic knowledge to operational technologies by teams combining academic and industrial expertise and finally the development of methodological framework ensuring the impact reduction of such biomimetics solutions. This last pilar of biomimicry is often left aside since the technological challenge may be already solved early in the process, regardless of the environmental aspects. However, let us just keep in mind that the whole reason we are talking about biomimicry is to finally manage to innovate efficiently without modifying the environmental equilibrium of our planet. This step back isn't an option anymore, it is both the first and last thing that must be done on every project.

Multifunctionality then rely on multiple strategies at various scale, from the very beginning of the design process and the problem analysis to the innovative problem-solving approach, to the embodiment of ideas and the choice of material, biomimicry offers a unique possibility to combine and harmonize all these answers in a global and structured approach.

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