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Biomimetic or Bioinspired?

I read a fascinating article the other day, “From Biomimesis to Bioinspiration: What’s the Benefit for Solar Energy Conversion Applications?” by Valentine Ivanov Vullev [*J. Phys. Chem. Lett.*, **2**, 503 (2011)]. While this article provides perspectives

within the relatively narrow and specialized context of harnessing solar energy, it got me thinking about the much broader implications of some of the ideas put forth by the author. A key point made by the author is the progression from biomimicry to biomimesis, and ultimately to bioinspiration. To quote from the author, “While biomimetics play a crucial role in exploratory research and in basic science, their technological implementations are somewhat limited. Going beyond what Nature provides usually entails a number of transitions, (1) from biomimicry, which involves solely superficial imitation of the biological systems, (2) to biomimetics, which attempts to copy and recreate the structure-function relations observed in living entities, and finally (3) to bioinspiration, through which structural properties and functionality are pushed to new levels, beyond what Nature offers.” For example, flying airplanes was an idea hatched by watching birds in flight; think of the movie “*Those Magnificent Men in Their Flying Machines*,” the 1965 British comedy film that is forever etched in my memory since childhood. Particularly hilarious in this movie were scenes of men test-piloting the many rudimentary machines and crashing them to the ground. These early aircraft versions were but a very crude (bio)mimicry of the amazing natural machinery inherent in the wings and muscles of birds. However even the most skeptic among us would have to agree that we have now surpassed Nature in designing powerful aircraft (and spacecraft) that can fly much longer, higher, and faster than birds. This example illustrates the “transitions” that Vullev is talking about in his article, although one can equally well argue that engineers short-circuited the progression by the invention of jet engines.

Photosynthesis provides another test bed for the above paradigms. Plants and algae have evolved over millennia in the intricate assembly of architectures and electron transfer pathways that enable them to convert CO₂ and water to biofuels that sustain them. Yet it is worth noting that these biological systems are not very efficient in converting solar photons to fuels. Unlike the aviation example above, however, scientists are only now beginning to understand how these intricate living systems work by constructing and studying artificial models (the biomimetic stage in the progression). In the next stage, hopefully, those of us engaged in energy conversion R&D will be around to witness a bioengineered photosynthetic system with performance superior to its natural counterpart.

Yet another example requiring some progress before we can surpass Nature concerns the design and study of robust bioelectrochemical systems for dioxygen reduction. Recall that this reaction has implications for fuel cells for converting chemical to electrical energy and constitutes the kinetic bottleneck in the overall energy conversion pathway. Specifically electrochemical scientists and engineers (including many within our Society) have carved out distinguished careers in developing efficient catalysts for driving the 4-electron reaction. Notwithstanding substantial progress in this field, the need for Pt and other noble metal catalysts remains a daunting technological barrier to commercialization of this type of fuel cells. On the other hand, Nature accomplishes this task with enzymes that have precisely tuned architectures and redox environments to facilitate the catalytic process without the need for Pt or noble metals!

This special issue focuses on materials that are close to my own research interests, namely, conducting polymers (CPs). As the guest editors of this issue point out in their preface, the sustained and dedicated efforts of generations of scientists in gaining fundamental understanding of how the polymer chemical architecture, morphology (specifically defects), and electrical conductivity are intertwined have now opened the door to practical applications. Some of the most intriguing of these applications lie in the biomedical arena. For example CPs are being considered for nerve regeneration, “smart” skin, and artificial muscle development. Are these endeavors biomimetic or bioinspired? Only time will tell. Stay tuned.

Raj K.

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Editor