

Modularity in the insect world as a strategy for bio-inspired and sustainable design

KEYWORDS: bio-inspired design; biomimicry; modularity; environmental sustainability; computational design

The morphological and functional diversity of insects provides a valuable source of inspiration for bio-inspired design of innovative and sustainable products and processes. The paper proposes to examine the principles and strategies that guide nature's evolutionary and adaptive activities, with a focus on the concept of "module" as a measure and standard for achieving resilience and sustainability in natural ecosystems. The concept of module, relevant in all living organisms, is particularly evident in insects: redundant and hierarchical geometries capable of generating high and unprecedented performances, such as, for example, the structural color observed in *Chrysina Gloriosa*, the superadhesion capacity observed in *Hydaticus Pacificus*, and the thermoregulation and structural strength of the Odonata dragonfly.

Modularity in insect structures manifests itself at different scales of observation, from nano to micro and macro scales, and at different levels, from morphology, structural organization, mechanisms of functioning, and behavioral processes. Emulating the principles and strategies of inherent modularity in insects in the design of processes and products can significantly contribute to increased sustainability, opening new perspectives in the field of Design for Environmental Sustainability in synergy with Bio-inspired Design.

Examples of insect morphological-functional diversity will be analyzed and related to case studies of bio-inspired designs and products, and the advantages gained in imitating some of their aspects and characteristics will be made explicit. In addition, it will be highlighted how computational design -that is, the application of algorithmic and systems thinking through the use of analysis tools, generative modeling and 3D printing- enables the replication of complex forms by imitating the modularity present in insects, which, in different aggregations, generates resilient, sustainable and performing structures.