Chapter 6
Nature:
The Design Mentor

ABSTRACT

This chapter discusses the historical origins of the concept of borrowing from nature and coining the science of bio-mimetics. The material also surveys examples of tribological systems in nature. Generation of design in natural systems (geometry, pattern, form, and texture) is shown to be holistic in essence. It synchronizes simple interaction of design constituents and efficient performance. Such an approach yields deterministic design outputs that while conceptually simple are of minimized energy footprint. Natural engineering, it is shown, seeks trans-disciplinary technically viable alternatives to our technological practices. These alternatives, given functional constraints, require minimum effort to construct and economize effort while functioning.

INTRODUCTION

Bio-mimetics, Bio-inspiration, Natural engineering, Bionics, etc., stand for widely spreading trends in the technological world. A tool common among these trends is scouring technical solutions available in the natural world then; transfer them to the human engineering domain. Although the previous terms are of recent origin, the underlying concept is deeply rooted in antiquity. Indeed, inspiration by nature dates back to primitive man. Human fascination with nature is rooted in the harmonic expression of form, function, and

DOI: 10.4018/978-1-7998-1647-8.ch006

proportion often observed in our surroundings. Throughout history, humans sought to identify a perceived "heavenly order" manifested as beauty, order, or optimality of function.

There are many examples in nature that reflect optimized "smart" function. One intriguing example is that of bees (Hales, 2001). Humans have recognized the brilliance of constructing beehives since at least two millennia, especially when the relation between the hexagonal shape of the unit cell and the economy of material (wax in this case) is considered. The earliest claim of such knowledge appeared as early as 36 B.C., in the writings of Marcus Terentius Varro within his book on agriculture. He supported the claim that the hexagonal structure was explained by the isoperimetric property of the hexagonal honeycomb:[1]

"Does not the chamber in the comb have six angles. The geometricians prove that this hexagon inscribed in a circular figure encloses the greatest amount of space."

Toth (Tóth, 1964) alluded to the same property and explained that the three-dimensional problem of shaping the ends of the hexagonal cells to interlock with the ends of the cells on the other side is quite complex. Interestingly, according to his calculations, he concluded that the material in the bees' idealized three-dimensional structure can be reduced by a fraction of one percent. In 1999 Hales (2001) proved that a honeycomb of regular hexagons is the most efficient way to partition the plane into unit areas (using the least amount of average amount of material). In the world of the beehives, this statement confirms that bees have practically solved a recondite problem, and have made their cells of the proper shape to hold the greatest possible amount of honey, with the least possible consumption of precious wax in their construction.

Branch compliance presents a major problem for arboreal animals that travel and feed in the forest canopy. Branches taper towards their ends, but the narrowest gaps between trees are situated between the thin terminal branches of adjacent tree crowns. Efficient travel through the rainforest canopy requires animals to minimize the deviations from their travel path, unless such deviations are more energetically efficient than direct travel (although non-energetic factors such as the risk of falls may also influence gap-crossing decisions). In theory, compliant terminal branches may act