Sustainability through biomimicry

Urban solutions inspired by nature

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Introduction: Sustainability through biomimicry

Biomimicry means the imitation of life. The term arises from the combination of the Greek roots *bios*, life, with *mimikos*, imitation [1]. Biomimicry is a new science and design discipline that studies nature's models and then emulates these forms, process, systems, and strategies to solve the problems of our time. The core idea is that nature is creative and sustainable by necessity and it can be used as an ecological standard to judge the sustainability of our innovations. After 3.8 billion years of evolution and bottom-up design brilliance, Nature has the key to solve many of the problems we are grappling with because it has learned what works and what lasts.

This research is about the scientific understanding of the concept of "life" in urban space and its main purpose is to explain the underlying order that is present in self-organized structures. Until now architecture has been especially interested in models of pure rationally; the patterns of organic urbanism were without any interest. Today this perspective is changing as we look more deeply into Nature.

We realize that more our built environment functions like the natural world, more sustainable it is. Therefore, this paper intends to speculate about the existence of patterns of self-organization in nature and in cities. The methodology adopted is the process of *abduction or hypothesis* [2], which is a kind of scientific inference not purely abstract or inductive. It is above all a process that involves an aesthetic and holistic vision of the world which allows applying a certain knowledge domain into another different domain. It is a mere suggestion of something that can be explained by the assumption that there are some general rules which govern the entire universe.

The city as a living organism

The city is more than a material artifact. It is also a living organism. But an organism of a higher order, a super-organism. According to Julian Huxley, human societies are biological individuals of third order, being the cells and the bodies, the first and second order, respectively [3]. Ecological perspective has included the environment in this super-organism and then replaces the term by ecosystem: "a

community of organisms and their physical environment interacting as an ecological unit" [4].
Cities are therefore organisms of a higher order: However, these organisms are very recent when compared with the first body created by nature 3.8 billion years ago: "In terms of age, we are dealing with a category of young biological individuals which is different from cells and bodies and consists of many of them. We are, therefore, entitled to consider them as biological individuals of a higher order than cells and organisms" [5].
It is good to remember that human culture and its artifacts are young and immature when compared with nature.Thus, there is a perspective that life has various stages. Life has evolved from inanimate matter. There is a prebiotic evolution. In other words, life is an emergent property of the matter; the most beautiful and fantastic one. The organic is born from the inorganic. There is no living matter different from physical-chemical matter [6]. What distinguishes life from non-life is the kind of organization, the relationships, the interconnections and the interdependencies. Studying these linkages is therefore to understand the geometry of life. And if life is a certain pattern of organization, we can learn about it in order to produce more sustainable environments because live always "creates conditions conductive to live"[7].
The new systemic and ecological understanding of life includes the perception of communities of individuals in symbiosis with their environment - the ecosystem. This systemic understanding is based on the assumption that life is endowed with a fundamental unity and that the various living systems exhibit similar patterns of organization: The network pattern is a specific geometric feature common to all living systems whether they are composed of organic or inorganic matter.
The application of systemic understanding of life in the field of urban studies is related with the application of our knowledge of standards and principles of life organization - and in particular the understanding of the organization of living networks - to the city (social reality). But while understanding the organization of biological networks can help us understand the city, does not mean to transfer to the city, our material understanding of biological networks.

Urban solutions inspired by nature

From the immense variety of forms created by Nature, only a few basic patterns emerge. Among the preferred forms of Nature, which appear in various contexts and scales, we found *spirals*, *meanders* and *explosions*, (Fig. 1). The reasons why this happens are due to limitations of three-dimensional space (curvature), the necessary relationship between the size and shape of things, the tendency towards simplicity and balance, and the prevalence of the law of minimum. This limitations, according to Peter Stevens, bring harmony and beauty to the natural world [8].
Natural forms are always the most adapted to local contexts. This is a fundamental principle of the theory of evolution outlined by Charles Darwin. The environment selects those varieties that are better adapted and the minimum advantage of one species over another is enough for selection [9]. Patterns in nature tend to the configuration that requires less energy. The form and structure which best fits the

external context. The most well adapted and consequently the one with more probability to exist – having in account all the other possibilities [10].

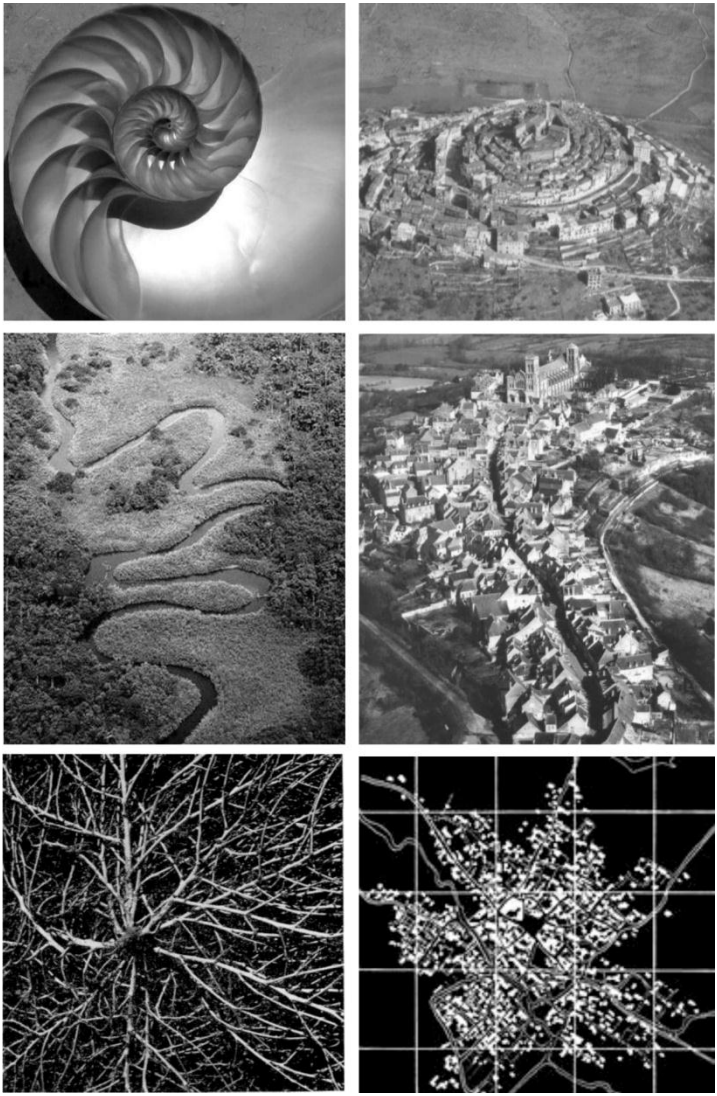

Figure 1: Urban solutions inspired by nature: Spirals, meanders and explosions

Being *spirals*, *meanders* and *explosions* so abundant, we can conclude that these patterns are better adapted to the characteristics of space. By other words, they are optimized structures in terms of expenditure of energy and material. Each of these patterns has some relative advantages depending on the context as well as the function.
Having this background in mind I start to look at spontaneous human settlements (organic cities) and I found that these patterns also exist in these structures (Fig. 1). The big surprise is to see that the reasons why this happens are the same: The city grows like a spiral because diagonal walking through the slope is the easy way to access the hill top. The center is the embryo, the point of energy where all the structure is developed from. The distribution in space is very uniform but access to the center is very indirect. However less energy is necessary to access it. Meanders also allow a good uniformity of space. Winding streets feat better the features of the terrain and they have many advantages over the straight streets. They are more compact structures and increase the surface contact between buildings and outside. They also invite people to stay in the streets because it slow down velocities. The explosion is less uniform but it has very direct access to the center. Thus, a city grows like an explosion pattern, because this is the most direct way to access the center. As it grows more and more it just branches out to get more uniform distribution in space.

Conclusion

However natural forms are never regular because they never repeat in the same way, some patterns in Nature like spirals, meanders and explosions have been identified as favorites. Even if these patterns appeared combined in multiple ways we cannot explain why there are just a few. We only know that they are optimized structures each time they emerge in nature or in any other forms of self-organization like organic cities. This explains the implicit order present in the universe where certain patterns tend to repeat at different scales and contexts. I believe this is a new way of viewing and valuing built environment based not on what we can extract from the natural world, but what we can learn from it.

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