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BIOMIMICRY AND CITY DESIGN.

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CHALLENGES AND SOLUTIONS...

What are the challenges facing cities in the 21st century? What balance should there be between the aesthetic, the functional and the natural in urban areas? What evolutionary level are human beings at as a civilization? What criteria should be taken into account and what should hold our attention? Facing the current and future challenges that urban design and development must respond to; understanding their complexity and tackling their magnitude must be the top priority. Therefore, a systemic approach and innovative strategies capable of bringing together different forms of urban planning may show us the way ahead.

Nature is a rich source of inspiration ideally suited to addressing challenges of this size. Historically, humans tried to understand the natural world through observation and endeavoured to apply what they have learned for the satisfaction of their needs. What we now know as Biomimicry is attracting increasing numbers of design teams in their quest for understanding and designing present and future cities.

THE CHALLENGES...

Cities emerge as a development of human settlements and appeared as a result of changes in lifestyle that had evolved as the species survived and thrived. During the last century and a half control of resources and mastery of different energy sources allowed humans, slowly at first and later more quickly, to become independent of the environment in which they lived. They have been able to cast aside natural cycles such as the weather and surrounding conditions, and have been able to create lifestyles, including urban developments, which have little or nothing to do with life in the natural habitat. Nevertheless, barring the sceptic who still refuses to see the impact that our development is having on the planet -and for us as a species- most people are aware of the issues every time a new page of the book of reality turned.

One aspect that we must clearly consider is that planning for the coming years will face frenetic population growth. Today we already number over 7 billion, but by 2050 population is estimated to have increased to over 9 billion, of which over 1 billion will be in Africa alone[1]. From that point, population growth will level off at around 11 billion due to the stabilization in the number of children together with the increase in life expectancy. This stabilization will only occur if the poorest get out of the poverty trap, children survive and the population has access to family planning[23]. This population increase is already having and will continue to have a great impact on cities, which are already home to very large populations. Some cities are experiencing such tremendous growth that increasing resources allocated to cover the needs of their inhabitants are no longer available.

Given that the control of population growth on the planet is based on improving standards of living, there will also be a corresponding increase in resource consumption. This means that in the future, with a stabilized world population, it will be necessary to meet these demands in a sustainable way to prevent a Malthusian catastrophe[4]. In the face of this evidence, inevitable population growth and increased consumption of resources will make it necessary to find viable, long term answers.

There is a model, in which a huge amount of variables engage, evolve, adapt, transform and consume resources in a sustainable way. It is nature. Mankind has always observed nature; in fact we have always been dependent on it for our survival. This is what is now known as Biomimicry. It can be defined as observation, discovery and learning from nature to inspire sustainable solutions to the challenges we face. For the 3.8 billion years, that there has been life on earth, it has been finding answers to the innumerable challenges and offering sustainable solutions that can be learned. We need to understand the utmost importance of preserving each and every living species, because every time that one becomes extinguished, we are losing forever the opportunity to learn something important for our own survival as a species. In addition, the system is inevitably altered. If one piece is lost then the whole system has to find a new balance which in turn affects all the other pieces with unpredictable consequences.

At this point, it is worth quoting E. O. Wilson who said in "The Creation"[5] that "If insects were to vanish, the terrestrial environment would collapse into chaos soon." This quotation is supported by the biologist Jonas Salk who reportedly said that "if all insects on Earth disappeared, within 50 years all life on Earth would end. If all human beings disappeared from the Earth, within 50 years all forms of life would flourish." From this perspective, it makes sense to think about what aspects are neglected in the construction of our cities, especially in relation to materials, design, recycling, lighting, size, dealing with catastrophes and determining which criteria will help us to evolve and develop in the future.

INSPIRING SOLUTIONS...

What can we learn from the way that ants forage? The existing relationships between fungi mycelium with the roots of the trees? The perfectly coordinated flight of a flock of starlings or a shoal of anchovies? Water management done in a rainforest, or developed water strategies that desert organisms use? Cell growth? The huge variety of materials and structures that life has developed with only a handful of the elements of the periodic table? How does a forest recover after a fire? In nature, processes are circular and the word trash is banished from the dictionary. The core principal of Nature is, in Janine M. Benyus' words, that Life creates conditions conducive to Life[6].

Incomappleux Inland Rainforest, BC, Canada (Flickr CC Jason Hollinger)

The number of people adopting biomimicry in different areas around the globe is constantly growing. Scientists, designers, engineers, architects, economists, sociologists, entrepreneurs, etc, are able to take advantage of what nature has to offer to find sustainable solutions and offer a future opportunity in the context of an 11 billion global population.

With this perspective in mind, how do we imagine cities will be in different regions of the world in 50 years with 2 billion people more? How in 100 years with another 2 billion on top of that? And how would we like them to be? The answers may be clear, but the solutions are not. We would envision cities in which the quality of all areas is good, where there are no marginal areas, where people live together conducting activities that provide real benefit and a positive impact for all, where the air is clean, where water is plentiful, where pollutants are not generated, where cities do not modify the climate of the area, where feeding inhabitants is not a problem but an opportunity…

Cities behave not like machines, but as organisms whose starting point is the nature of the people who inhabit them. So cities, in their territorial area, have broad parallels with natural systems, from organisms to ecosystems.

When urban planners, architects and engineers design a city, they should consider the long term. Understanding how what is designed affects the system, whether it is a building, a neighbourhood, a city, region, or nation, or even a continent. This is what may be defined as a systemic approach to urban development.

A concept in nature that underlies the importance of integrating is what we call "ecological succession"[7]. This refers to the replacement of elements in the ecosystem by others over the course of time. Thus, a given area is colonized by increasingly complex plants. At every stage and at every moment there appears a species better adapted to existing conditions, which would not have succeeded had it had not been for the existence of the first plants. Environmental conditions permitting, the appearance of moss and lichen is succeeded by grasses, then shrubs and finally trees. The stable state is reached after development has been completed, and this is called climax. In the process, changes occur between members of the same species. For example, new trees replace the old. Ecological succession starts when a natural or anthropogenic cause clears a space of the biological communities present, or is severely altered. It is therefore essential that every action carried out in the city be analyzed from this point of view. We need to ask ourselves whether this is the right time and not another, if what is going to settle makes sense, and what role will it have in the future. Taking what you have and creating opportunities for the future summarizes what determines this concept.

Another basic aspect in land management is the transport network, namely the connection of different foci of interest in an optimal way to maximize the use of resources. Here again, nature optimizes transport and communication networks. For example, the circulatory system in vertebrates transports nutrients and oxygen to all body cells and eliminates the residues produced therein. This represents a complex network which, however, is organized using a low amount of genetic information, has the maximum length and density of blood vessels and capillaries using the least amount of tissue and transports the maximum using the minimum effort[8]. Nature provides inspiration by showing the most accurate and balanced solution.

What can be said in relation to city management of vital resources like water? We can see how rain water quickly runs into the sewage system where different water qualities are mixed. This flow goes straight to the treatment system, where it is all treated together. After being used in industrial processes, water quality is reduced to its lowest levels. In nature, water management is impeccable. If we look at the dynamics of water in a rainforest in Brazil, Indonesia or the Congo, much of the vast amount of water that falls goes back to the atmosphere as result of evapotranspiration. This helps to preserve weather and biological cycles. Another significant portion is retained in the soil, preventing surface erosion by water flow. This system also cleans and purifies water when it passes through the ground frame, which works as a large scale water-filter. This scheme should serve as a guide for us to design cities that retain water, boost its utilization and favour evapotranspiration in order to preserve the original climate in the region.

Our cities produce large amounts of waste, toxic emissions and greenhouse gases as result of their activity. In nature there is also a flurry of activity, however waste produced by an organism at one stage becomes the starting point for generating closed cycles, rendering the term “residue” superfluous in nature. Why can activities in the city not be organized in such a way that what the few don’t need others will be able to use? We can think of cities as a huge opportunity to remove carbon dioxide and other gases from the atmosphere by getting our construction materials from these gases just as coral reefs obtain carbon from the atmosphere and fix it. A systemic vision of the city is needed to take advantage of the opportunities to integrate operational strategies, thereby closing the circle.

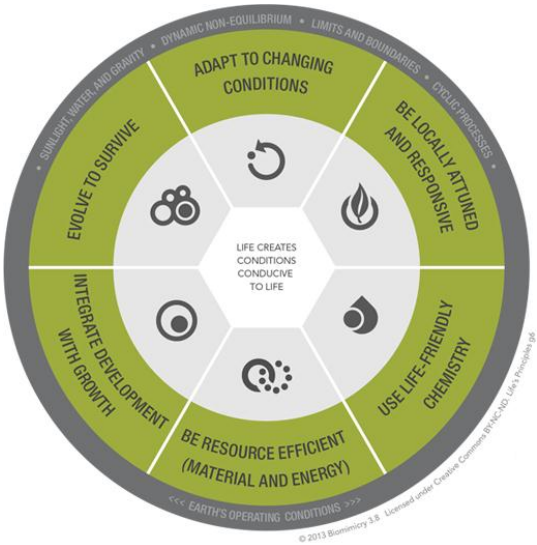
A last but crucial aspect of the analysis of the city is that it must begin in the location where it is found, in particular with reference to the features that shaped it. In this way it can be better understood, since in nature everything is perfectly adapted to where it is, there are no general solutions, only those within the system.

Where should we therefore concentrate our new vision? On long-term solutions, management of the basics, like any organism, on consumption and recycling, and on needs assessments geared to the system.

THE PATH...

Understanding the interrelationships, boundaries, growth, resource management, processing and transportation, etc. which are permanently sustainable in nature, is increasingly bringing biologists in multidisciplinary teams of designers. The symbiosis that it creates is generating powerful and rich sustainable proposals adapted to the singularity of each place.

The methodology consists of deep understanding of Nature Life's Principles that have been shown to be a perfect combination towards balance and sustainability. These principles are: evolve to survive, adapt to changing conditions, be locally attuned and responsive, integrate development with growth, be resource efficient (material and energy), use life-friendly chemistry[9]. The more these principles are integrated in design the closer to nature sustainability the design will be. So during design phases it is important to evaluate them against Life's Principles.



Life's Principles

…WORK IN PROGRESS

What might seem utopian is starting to become real, defining new planning paradigms. Here are some interesting examples:

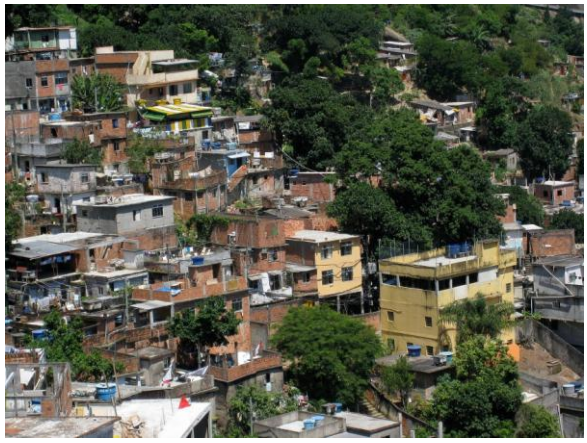
Khed Sez and Lavasa

Nature-inspired city design bases the alliance between HOK, one of the largest architectural firms in the world with Biomimicry 3.8, a consultant who put biologists and designers together to implement biomimicry in city planning. In India, they have planned the cities of Khed Sez and Lavasa[10], where the specifics of the local ecology have been integrated in the design, and lasting interventions made to minimize the impact on the environment and the site where these cities are planned. In Lavasa, for example, an area affected by monsoon rains, where rainfall is concentrated in a few months while the rest of the year the site is arid, the planning involved creating designs that approach water management in the manner of the moist deciduous forest that once existed but which agricultural practices drove to deforestation. The forest effectively managed the water, maintaining soil quality and storing water during the dry season by preventing evaporation after the rainy season.

Rocinha favela

The concept of "ecological succession" is integrated in the project conducted by Jan Kudlicka to regenerate the Rocinha favela in Rio de Janeiro[11]. As a result of his deep understanding of the "favela ecosystem", this project seeks strategies to create spaces that contribute to social and economic development of the community. The project plans two stages of intervention. The first looks to

consolidate existing buildings instead of removing the urban frame, improving urban structural safety and regenerating façades to improve indoor hydrothermal quality. In the second stage, buildings will be organized vertically, stratifying certain functions that are carried out in the neighbourhood, e.g. commercial and service areas at ground level, including medical centres, schools, markets, pharmacies, etc. The upper floors will be used for residences and, finally, roofs will become public space for people to move through, for children to play on in playgrounds, as well as outdoor cinemas, and cultivation areas to produce food that can then be sold on the ground. Regeneration provides a future for slum areas, offering an opportunity to biomimicry inspired solutions based on the system and answers from playing with elements within its own system



Rocinha favela, Rio de Janeiro, Brasil. (Flickr CC Alicia Nijdam)

Kalundborg

The city of Kalundborg in Denmark has developed an industrial ecosystem.[12] Since the 1960's, public and private enterprises buy and sell waste products from industrial production in a closed cycle. A residual product of one enterprise becomes the raw material of another, and key resources such as gas, steam, cooling water and gypsum are shared among different industries, thus benefiting the economy and the environment alike. Excess heat is used in activities such as fish farms, greenhouses and homes and many other by-products that become usable by other industries or are sold to companies nearby. The aim is to reduce resource consumption and achieve a significant reduction in environmental impact. Several educational institutions have developed curricula and classes about Kalundborg and the model is being exported to different industrial areas all over the world.[13]

Kalundborg, Denmark. (Flickr CC Life in Bonn Green)

Road planning with slime mould

Several experiments, using physarum polycephalum, a slime mould, have found that during its foraging, it creates optimized networks for the transfer of nutrients. In the experiments, geographical locations of most populated urban areas are represented by oat flakes to study what would be an optimal layout of transport links between these urban areas from the "mould's point of view". Results of these experiments show that the mould forms a network in the experimental space, isomorphic to a network of major motorways[14] in the different countries studied. This could be a seed for future science of biomimetic urban and road planning.

Physarum Polycephalum. (Flickr CC i- saint)

DREAMING OF THE FUTURE

The enormous challenges that will face us as a species in the coming decades will find a powerful ally in nature, which has, until now, largely been on the receiving end of our development but which has already solved it once before.

ENDNOTES

[1] United Nations Population Division, *World Urbanization Prospects: The 2011 Revision* (NY: UN, 2012)

[2] Hans Rosling, *Don't Panic – The Facts About Population* (Wingspan Productions, broadcasted on BBC November 7, 2013).

[3] Danny Dorling, *Population 10 Billion*, (Constable & Robinson Ltd., 2013)

[4] Thomas Robert Malthus, *An Essay on the Principle of Population,* (1798)

[5] Eduard Osborne Wilson, *The Creation, An Appeal to Save Life on Earth*, (NY: W.W. Norton and Company, 2006)

[6] Janine M. Benyus, *Biomimicry: Innovation Inspired by Nature*, (Harper Collins, 2002)

[7] "Ecological succession", The Virtual Nature Trail at Penn State New Kensington. accessed January 10, 2014. http://www.psu.edu/dept/nkbiology/naturetrail/succession.htm.

[8] Charles Little, Vladimir Mironov and Helen Sage, *Vascular Morphogenesis: in Vivo, in Vitro, in Sapio* (Springer, 1998)

[9] Biomimicry 3.8, *The Biomimicry Resource Handbook: A Seed Bank of Best Practices*, (2013)

[10] John Gendall, "Architecture that imitates life," *Harvard Magazine Sept-Oct* (2009): 9-10

[11] "Regeneration of the Favela de Rocinha Slum / Jan Kudlicka," ArchDaily, accessed January 12, 2014. http://www.archdaily.com/?p=146314.

[12] "Kalundborg Industrial Symbiosis. Wastes used as resources," Asknature, accessed January 12, 2014. http://www.asknature.org/product/b08979c20b2d379a8af64fa83826db34.

[13] "Kalundborg Symbiosis," accessed January 12, 2014. http://www.symbiosis.dk/en.

[14] Andrew Adamatzky and Jeff Jones, "Road planning with slime mould: if physarum built motorways it would route M6/M74 through Newcastle*," International Journal of Bifurcation and Chaos* (2010): 3065-3084