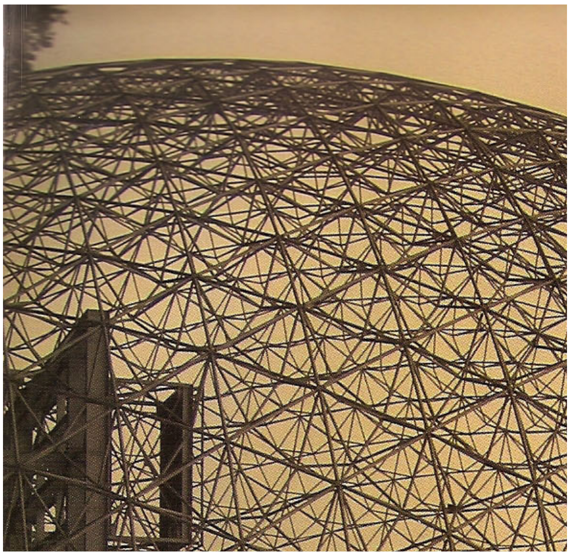


montreal expo 67 dome, Buckminster Fuller

munich olympic stadium Frei Otto

study for a mechanical wing imitating the wing of a bird

Introduction

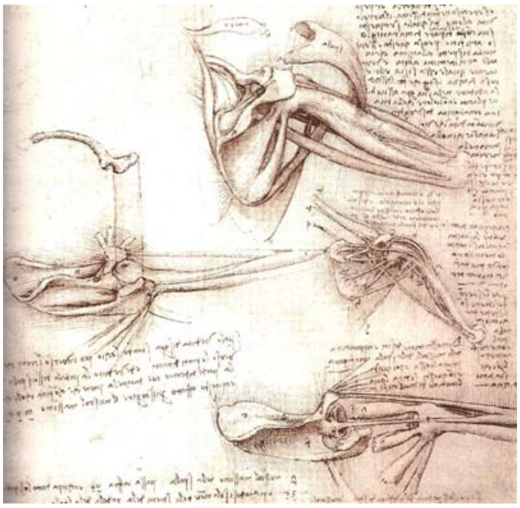
The purpose of this essay is the understanding and manipulation of the genotype and phenotype in nature and architecture. The requisite research is being enriched with the search in history and the manner in which human has handled nature's functions. Along with an introduction on the new materials created and used based on biology and emergence.

In history there has been a chain of revolutions beginning with the proletarian one, followed by the industrial, which was followed by the revolution of communications, and the most recent, the revolution of genetics. Genomes of living things; how genes create the genomes according to compensatory and balancing laws. We acknowledge the possibility of creating projects with genes, being able to give structures, organisms or contexts the possibility of transforming themselves through proposed action. A great potential advantage of creating systems by evolution is that, if the evolution goes on long enough, they can be very complex, as in nature. The characteristic of evolutionary engineering has been referred to as 'complexity independence'. The idea is not to compose, but to generate; not to organize, but to provide guidelines; not to sort, but to develop.

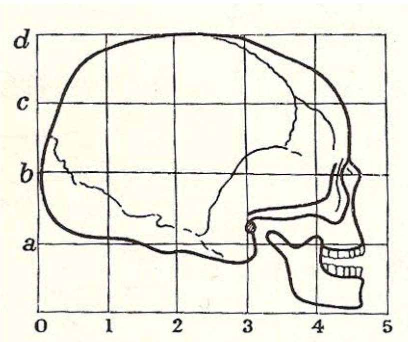
During the 20th-century there has been a chasm between nature's systems and man-made systems, no interconnection between the living and the nonliving. The model of architecture was the motorised machine, whether that was aeronautical, nautical or road vehicle. Le Corbusier was one of the supporters of these movements. Today, in the 21st century, we are intending to create developments that combine living and non-living systems. We provoke future civilizations to become profoundly complex and ecological. We are planning on green homes, green cities, and grand virtual-reality worlds. Our new knowledge of nature's genomes and the creation of phenotypes make possible further development also in medicine and farming. Computer technology has started to produce 'artificial life'.

History of biomorphism in art and architecture

"From old times, architecture has served as a means to adjust ourselves to the natural environment. The contemporary architecture needs to function, in addition, as a means to adjust ourselves to the information environment. It must function as the extended form of skin in

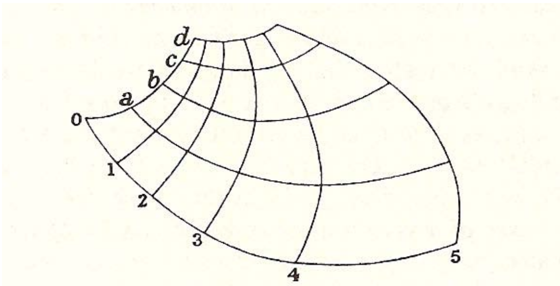


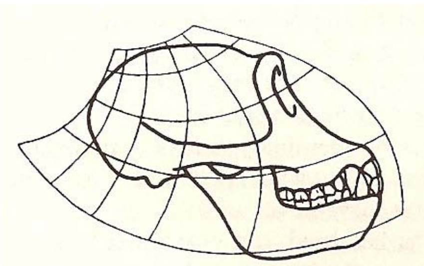
deep structures of shoulder , anatomical Studies, 1509



human skull

co-ordinates of chimpanze's skull, as a projestion of the Cartesian co-ordinates of the human skull





skull of chimpanzee

relation both to nature and information at once. Architecture today must be a media suite". [1]

Scientists, as well as artists have been inspired by natural Systems.In contemporary architecture Frei Otto and Buckminster Fuller[2] both explored the relation between nature and architecture. The pioneer of all was Leonardo Da Vinci, during Renaissance, whose art and inventions have been based upon his studies on anatomy and the botanical.

His science is very relevant to our modern era. He combined research of architecture and human anatomy, the flow of human hair with growth pattern of grasses. His systematic studies of living and non-living forms amounted to a science of quality and wholeness, a persistent exploration of patterns and interconnection of phenomena. His approach is known today as the complexity theory. Today mathematics is being formulated within the framework of complexity theory, which involves complex nonlinear equations and computer modelling, in which curved shapes are analysed and classified with the help of topology, geometry of forms and movement. Leonardo Da Vinci had already been experimenting with a simple form of topology in his mathematical studies of 'continuous quantities' and 'transmutations´.[3]

Understanding a phenomenon for him meant connecting it with other phenomena through a similarity of patterns. When he studied the proportions of the human body, he compared them to the proportions of buildings in Renaissance architecture. He also interlinked animal physiology and engineering. Leonardo Da Vinci was the precursor of an entire lineage of scientists and philosophers whose central focus was the nature of organic form. He always thought that nature's ingenuity was vastly superior to human design. He felt that we would be wise to respect nature and learn from it. Such a concept has emerged today very strongly in the practice of genetic architecture.

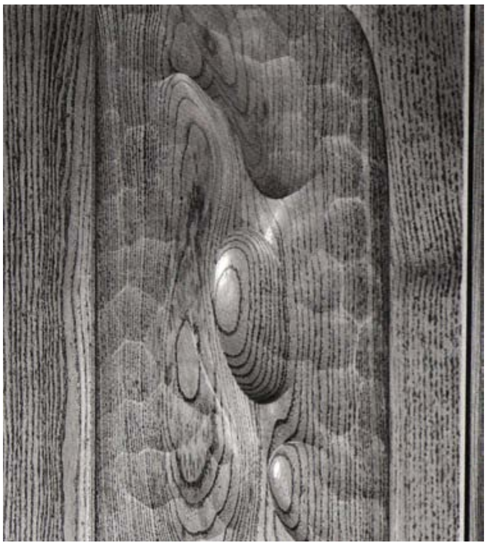
The recent development of complexity theory has generated a new mathematical language in which the dynamics of complex systems, including the turbulent flows and growth patterns of plants studied by Leonardo Da Vinci, are represented by geometrical shapes. Similarly to the computer-generated attractors or fractals, which are analysed in terms of topological concepts. The mathematics of complexity has led to a new appreciation of geometry. Like Leonardo Da Vinci five hundred years ago, modern mathematicians today are showing us the understanding of patterns, relationships, and transformations. It is crucial to understand the living world around us, and that all questions of pattern, order, and coherent are ultimately mathematical.

Much of the world around us can be explained in terms of command systems and hierarchies. Some of the great minds of the last centuries, such as Charles Darwin

1 ITO Toyo, image of architecture in electronic age, online interview, www.designboom.com, 5/11/ 2008.

2 POHL, Ethel Baraona, Watercube_The Book, dpr editorial, Barcelona, 2008, p. 70.

3 See, CARPA, Fritjof, The science of Leonardo_inside the mind of the great Genius of the renaissance, Doubleday, New York, 2007, p. 157-209.



arboreal anomalies

the flaws on the wood have been transformed into volumetric ornaments

Casa Calvet door pulls

interior of the Temple, 2008, columns structure

and Alan Turing[4], contributed to the research of the science of self-organisation.

D'Arcy Thompson[5], a zoologist and mathematician, regarded the material forms of living things as a diagram of the forces that have acted upon them. He, like Leonardo Da Vinci observed the homologies between skulls, pelvises and the body plans of different species suggesting a new mode of analysis, applying mathematics to biology.

In the following centuries a model architect in biomorphic architecture was Antoni Gaudi, whose love of wood led him to the study of the tree itself, and the development of its live fibres. He immersed himself into the examination of the shapes that these fibres adopt in accordance with the static equilibrium of the entire branch system. His further studies related human bone structure with that of buildings, as he shared Leonardo Da Vinci's opinion that nature reasons well. By studying the plant world and more specifically trees, Antoni Gaudí concentrated his interest in the appliance of straight line development as he believed to have found in it nature's surprising reactions to the laws of statics. For the structure of the Sagrada Familia and its complex mathematical modulation, he claimed that the inspiration and leader of the project was the tree of eucalyptus with its straight line geometry.[6]

At some point of his career he was extremely enchanted by the arboreal anomalies, which translated in geometric terms are the parabolids and hyperbolids, and the botanical corroboration that inspired his architectural theories. Botany's self-organization processes such as, the helicoidal development of leaves and stems into systems defined by fractions, helped Antoni Gaudí to discover the possibilities of applying geometry and mathematics to nature in order to translate the law of physics. Even for the creation of metal fittings, he combined anthropomorphism, ergonomy and the negative of human fingerprints, resulting these extremely functional sculpture-like handy objects.

What is fascinating in the architecture of Antoni Gaudí is the way he successfully managed to combine conceptual symbolisms of life and theology with biomorphism. In Casa Batlló as in Casa Milá he has covered the façades with a layer of a 'still noticeable lavra'[7]. His architecture had a terrible, sinister facet, because he was very conscious on the sin and death, and represented it with decomposition of the material. Manuel Sayrach was an architect who follwed Antoni gaudí's biomorphic dreadfull figures, details. In one of his buildings everything seems to decompose like dead flesh, suddenly revealing strange hard bones and hard spirals that look like ribs. This concept was also shared by Miró Dali although

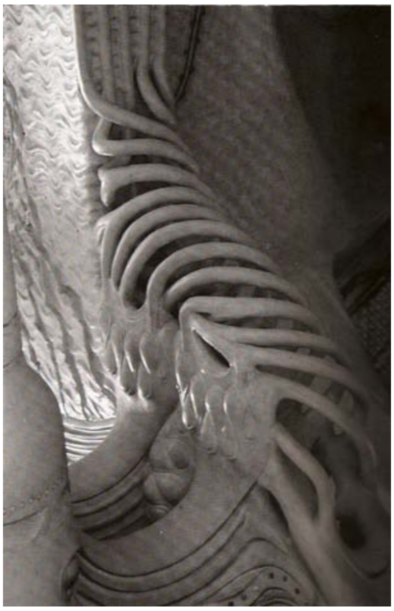
4 A Turing machine is a theoretical device that can be adapted to simulate the logic of any computer algorithm, an "a(utomatic)-machine"). Turing machines are not intended as a practical computing technology, but rather as a thought experiment representing a computing machine. They help computer scientists understand the limits of mechanical computation.

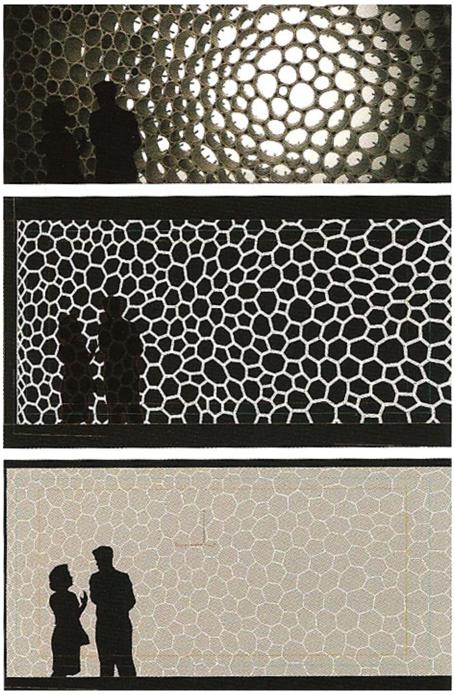
5 THOMPSON, D'Arcy, On Growth and Form, Cambridge University Press, Cambridge, 1961, p. 319.

6 See, LAHUERTA, Juan José, Antoni Gaudí_1852 1926, Electaarchitecture, Milano, 1992, p. 254-294.

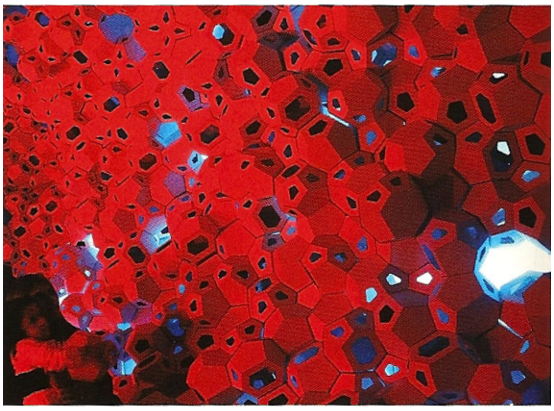
7 See, LAHUERTA, Juan José, Antoni Gaudí_1852 1926, Electaarchitecture, Milano, 1992, p. 322.

Casa Sayrach, Manuel Sayrach





parametric honeycomb, Davide del Giudice



oregami exhibition, chris Bosse

he was often referred to the bourgeois pomposity and the political matter of Surrealism[8].

"Art goes further, imitating that rational and most excellent work of nature"[9]

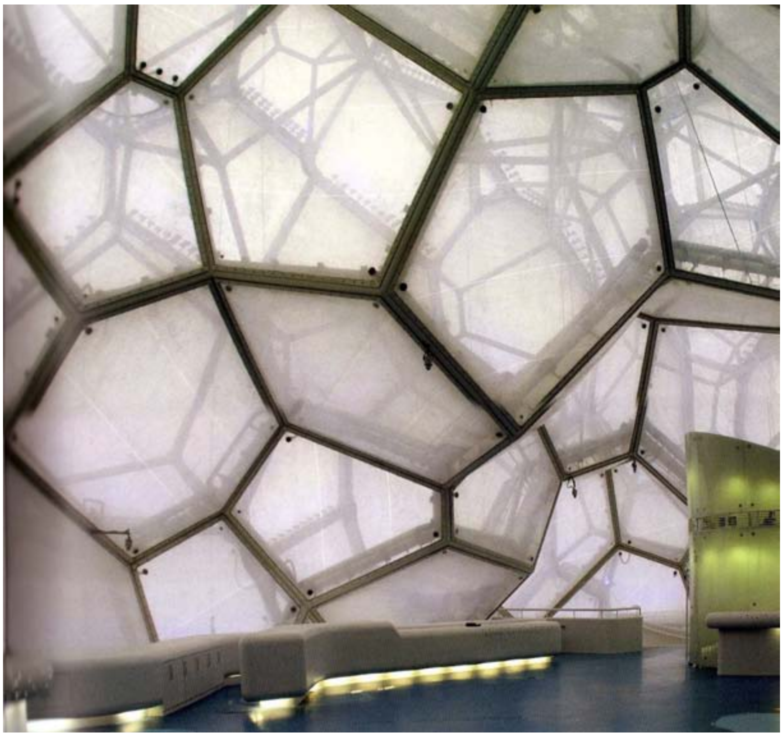
Self-organization and material constructions

The self-organization of biological material systems is a process that occurs over time, a dynamic that produces the capacity for changes to the order and structure of a system. It is an evolutionary response. For example, the importance of the microstructure is that larger cells make a weaker material. Cellular materials are common at many scales in the natural world. The structure of cells consists of voids or spaces filled with air or fluids. In foam, cells are polyhedral and are differentially organized in space in a 3-D pattern. Honeycombs on the other hand form irregular shapes and may vary in distribution. They are the most famous of all hexagonal conformations and have attracted the attention and excited the admiration of mathematicians. Pappus the Alexandrine has recognised that certain geometrical forethought in the construction of bees in the History of Greek Mathematicians: "τὴν γεωμετρίαν της σοφωτάτης μελὶσσης"[10]. The designer Davide del Giudice experimented on the 'parametric' Honeycomb by using the porosity, the thickness and location of the cells as generative parameters. Chris Bosse exhibited the beauty of the art of Origami by using parametric modelling, digital fabrication and material science.

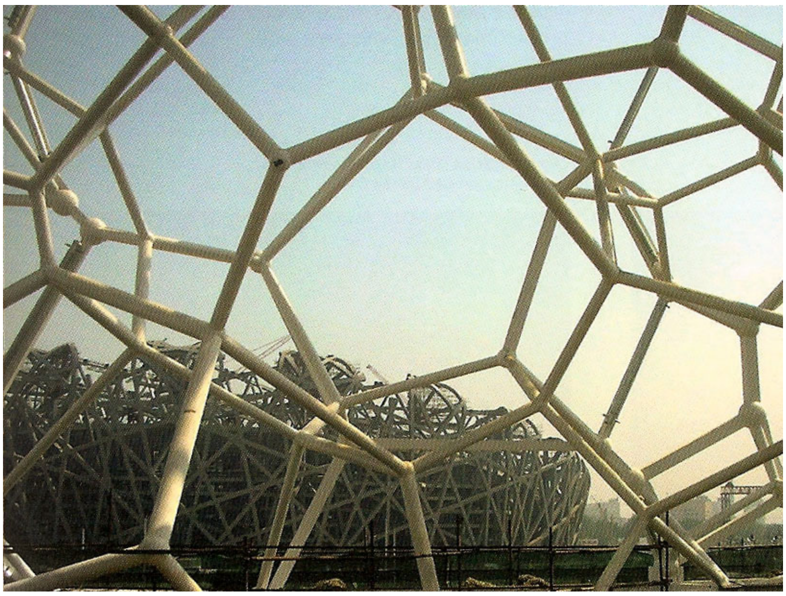
Observing for instance the construction of foamed cellular materials, it is evident that they take advantage of the unique combination of properties offered by cellular solids. These are analogous properties to those of biological materials, but they are structured and manufactured in ways that are derived from biological materials, although they are made from inorganic matter. They are known for the simultaneous optimization of stiffness and permeability, strength and low overall weight. This is the logic of biomimesis, abstracting principles from the way in which biological processes develop a natural material system, and applying adequate methods in an industrial context to manufacture a stronger material that has no natural analogue.

The ability of some materials to self-organize into stable arrangements under the stress has been the founding principle of structural form finding in the physical experiments of Gaudí. Today many manufacturing techniques based on biological models are being tested for producing synthetic materials that have increasingly complex internal structures. Some examples of such designed materials are polymers and foamed metals, which are already being used in many aerospace, maritime and medical applications. They are lightweight, very

8 See, ESARQ, Universitat International de Catalunya, Arquitecturas Geneticas II, ESARQ/SITES Books, Barcelona, 2005, p. 55-78.
9 See, LLOYD, Seth, Programming the future, a quantum computer scientist takes over the cosmos, Vintage Books, New York, 2006, p.168.
10 See, THOMPSON, D'Arcy, On Growth and Form, Cambridge University Press, Cambridge, 1961, p. 108.



Watercube, interior and structure.



flexible and mechanically strong. Their electrical and optical properties make them highly suited to military applications, providing structural stability and flexibility. Simple polymers, such as the ubiquitous plastics like DuPont's Corian, are homogenous materials, similar in density and strength in all directions. Complex polymers[11] don't need to be homogenous, and can be produced with surfaces that have different properties from the polymer interior. By mimicking and adapting the self-organizing behaviour and complex functions of natural polymers, very strong transparent or translucent films can be produced with a water-relent and self-cleaning surface for façade systems. This is called 'free living radical polymerization'.

Self-organized structures have been intricate cellular biological materials to produce modularity, redundancy and differentiation. An attractive development model in material science for new structural systems in architecture and engineering would be the foam geometries of cellular materials. They form ductile structural systems that are strong and permeable. New techniques for making materials even for large constructions have emerged based on biological models of the processes by which natural material forms are produced. Form, structure and material acting upon each other create biological organisms.

The building for the National Aquatics centre for the 2008 Olympic Games in Beijing, is a genuine example. The 'Watercube' is a digital structural model, the mathematics of foam geometries are used to produce the structural array ensuring a rational optimized and buildable structural geometry. The structure of water gives the sophisticated 'micro' details to the monolithic totality. The bubble has a restless random structure, a moral tale, not overlooked by poets and philosophers. As the bubble changes its shape in sudden topological re-arrangements and it grows or shrinks, in time, it might even shrink to the point of vanishing entirely.

Emergence: the process of appearing

Emergence is the scientific mode in which natural systems can be explored and explained in a contemporary context. It began more than 80 years ago and has made changes to the technological world, changes that have altered the perception of architecture and the it is produced. It is the basis of sophisticated reflexive attributes, which exceed any mechanistic or static notion of architectural form. It defines new levels of interaction and integration within natural ecosystems. It can be called a comprehensive intellectual program for architectural design. Its impact on architecture is of significant potentiality.

As mentioned earlier, nature's complex forms and systems arise from evolutionary processes. Taking as an example growth, is a complex process, because it bedevils conditions of the

[11] See, HENSEL, Michael – MENGES, Achim – WEINSTOCK, Michael, Techniques and Technologies in morphogenetic design, AD_Architectural Design, Vol.76, No.2, March/April, 2006, Wiley-Academy.

genotype with the accordingly conditions of environment, therefore creating a phenotypic dependency. In nature the genotype comprises the genetic constitution of an organism, while the phenotype is the product of the interactions between the genotype and the environment. The genome of natural forms creates generative processes, which produce the emergent properties. The genome is compact data that is transformed into biomass of increasing structural complexity. The amount of information required to describe a system's regularities is its effective complexity. This is a simple way to measure complexity.

Conclusion

The arrival of genetic architecture appears to be an ecological environmental design; A new design project that incorporates real live elements, above all vegetal, to the construction of buildings creating literally genetic and metaphorically genetic architecture. This gives us the opportunity to design as strategic planners, with open and self-generating processes, increasing our capacity for new discoveries. We can design by saving energy, when we rediscover within fixed parameters a conjoint of new and changing possibilities. Information technologies require a new approach to the conception of architecture and cities.

"The mere presence of an emergent meshwork does not itself mean that we have given a segment of society a less oppressive structure. The nature of the result will depend on the character of the heterogeneous elements meshed together, as we observed of communities on the Internet: They are undoubtedly more de-stratified than those subjected to massification by one-to-many media, but since everyone of all political stripes-even fascists-can benefit from this de-stratification, the mere existence of a computer meshwork is no guarantee that a better world will develop there."[12]

Faced with the new situation, architects need to accept a new active condition in the planning processes and the application of the new techniques and materials that they are called to use. It would be an interaction between the natural, the artificial and the digital that draws up new rules in the biodigital architecture. For as long as complex organisms have been alive, they have lived under the laws of self-organization, and now the philosophers of emergence are struggling to interpret the world.

[12] DE LANDA Manuel, A thousand years of Nonlinear History, Swerve Editions, New York, 1997, p. 202.