ISSN 2386-5414
e-ISSN: 2340-8391

Paulo Parra

Perspective | Perspectiva

https://doi.org/10.25267/P56-IDJ.2023.i3.06

Director of the Department of Equipment Design at the Faculty of Fine Arts of the University of Lisbon. Responsible for the teams that developed Strategic Design and Industrial Product Design for companies such as Vista Alegre, Silampos, Spal, Icel, Herdmar, Iduna, Zenite, TemaHome, MVP, TVS, Shamir, A Produtora, Solzaima, Alualfa, Delta, NEXX, Rusticasa, and Leitão & Irmão.

The author has been recognized by national and international companies and institutions such as Vista Alegre, Oliva, and Sonae (Portugal), Sony and Japan Design Foundation (Japan), Arflex (Italy), LG Electronics (South Korea), Design for Europe (Belgium), and Best of IF - Industrie Forum Hannover (Germany).

His work has been featured in international exhibitions.

Symbotic design and natural systems.

Biotechnical methodologies and Biomorphic methodologies

Introduction

How are operational knowledge extracted from biological systems and applied rigorously in project practice? Can we speak of biological methodologies, that is, of projectual methodologies of nature? And can these methods be applied in technical methodologies? Is there a technological evolutionism, just as there is a biological evolutionism (Figure 1)?

Nature has always been, in multiple ways, a source of inspiration for man. However, according to the author, there are two fundamental approaches to these uses that should be distinguished here. They are, on the one hand, a more structural and functional approach, such as Bionics and Structural Morphology, for which the name Biotechnical Methodologies is proposed and, on the other hand, a more formal approach, as are cases Streamlining and Biodesign, for which the name Biomorphic Methodologies is proposed.

These two methodologies are fundamental in the definition of “Symbiotic Design”, which aims to identify the symbiotic processes applied by biological systems and to propose them as important elements in the integrated design of technological systems. In this view, the relationship between human beings and objects is proposed as a symbiotic system, in which Design assumes itself as a hinge element. This Cosimbiosis, allowing intimate cooperation, reduces the distance between biological systems and technological systems and provides a new project unit for the 21st century.

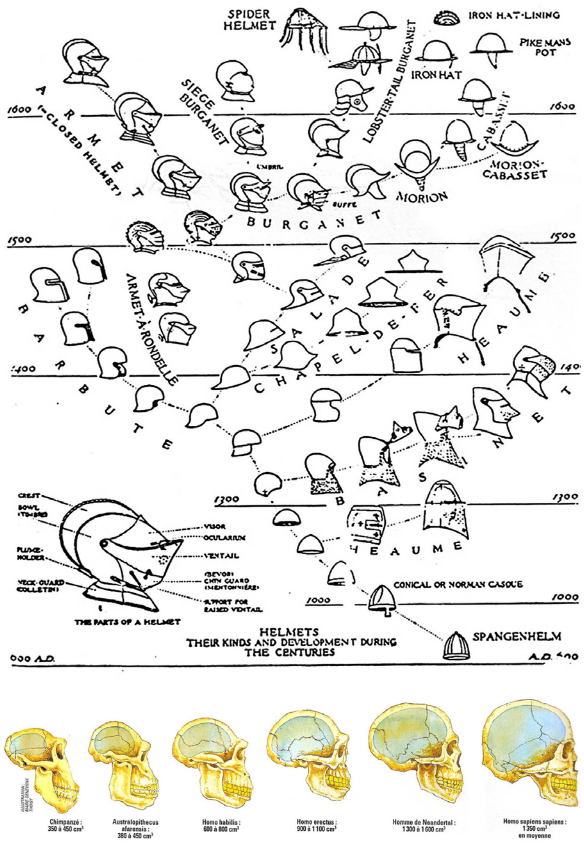


Figure 1. Above: Evolution of the helmet by Bashford Dean (1915). Below: Comparative evolution of brain volume from Chimpanzee to Modern Man.

1 - Biotechnical and Biomorphic Methodologies

Indeed, it is a given that nature and the systems used by it have been a reference for human beings throughout its history. Initially, this attitude was essentially mimetic, that is, what is commonly called Biomimicry and Biomorphism - imitation or formal inspiration of nature - and which, more recently, gave rise to proposals applied to design such as Art Nouveau, Streamlining or Biodesign. For these latter methodologies, as mentioned, the author proposes the designation of Biomorphic Methodologies - in the sense of grouping all methodological proposals that propose to analyze natural systems, living or non-living, which in a direct or indirect way, contribute to the aesthetic and formal evolution of objects and systems of man-made objects.

But also, progressively and above all following the technological evolution, another form of inspiration appeared in nature, no longer at the level of simply the forms, but at the level of a deeper understanding of natural systems, that is, at the structural and functional level. These methodologies base their projectual praxis in Technical Biology, analysis of technical systems developed by natural systems. These proposals were based on the concept of biotechnology proposed in the 1920s by authors (Raoul Francé et al. 1920, Friedrich Kiesler 1939 and Patrick Gueddes 1915) who argued that, if nature had experienced structural, mechanical, chemical and electrical solutions over thousands of years - an “engineering of nature” -, it could, after carefully studied, be adapted and used in the design of technological systems.

In this sense, and as we will see, the first systematic demonstration of the application of Biotechnical Methodologies, according to the author, was developed by Leonardo da Vinci whose methodological process is analyzed in the chapter “From Technical Methodologies to Biotechnics”, in proposals ranging from the study and dissection of animals until the study of complex phenomena of hydrodynamics and aerodynamics. Many other proposals for using these methodologies have since been developed. However, it was not until the end of the 19th century and the beginning of the 20th century that they acquired a greater systematization, with a perfectly defined and structured theoretical body, especially by Raoul Francé et al. 1920, Friedrich Kiesler 1939 and Patrick Gueddes 1915.

More recently, for project studies in this area, new disciplines have been developed and applied, such as Structural Morphology, in the faculties of architecture and engineering, and like Bionics, in the faculties of Design. For this structuralist and functionalist vision, also with several methodological proposals, such as Organic Functionalism, Biotechnics or Bionics, the author proposes to use the term Biotechnical Methodologies - in the sense of grouping all methodological proposals that in a more rigorous and scientific way , they propose to analyze the natural technical systems, living or non-living, transporting them to the projectual culture in the perspective of producing technical or technological systems of greater or lesser complexity.

1.1 - Biotechnical Methodologies: Organic Functionalism and Bionics

The idea that the beauty of an object depends on its usefulness and efficiency is responsible for initiating a new philosophical view on material culture. Among the first functionalists, there is the German architect and urban planner Friedrich Weinbrenner (1766-1826), who writes in his work Architektonisches Lehrbuch, published between 1810 and 1819: “Beauty is in the total agreement between form and function”. Made up of a group of three books, this work is published in Germany and especially aimed at students of Art and Architecture - “Geometretrische Zeichnungslehre” from 1810, “Perspektivische Zeichnungslehre” from 1817 and “Uber die hohere Baukunst” from 1919. The contents of Architektonisches Lehrbuch would later be complemented by two additional essays: “Uber architektonish Verzierungen” from 1820 and “Uber die Saulenordnungen, den Gebrauch der Saulen, die Eintheilung, Anordnug and Ausfuhrung der Gebaude” from 1825. One of the aspects that stands out in these writings is the fact that they examine the problems of the relationship between “form and function” in architecture based on the examples of objects in current use. It is also likely that the statement by F. Weinbrenner, previously quoted, inspired the maxim “Form follows function”, passed on too many generations of designers and architects, and that this, in turn, was inspired by the work of JB Lamarck.

Friedrich Weinbrenner, Professor and architect, was born in Lehrjahren in 1766. He was “construction director” of the Grand Duchy of Baden, between 1801-1826, the main architect and urban planner in the city of Karlsruhe, and the first German architect of the 19th century to be internationally recognized. His planning for the city of Karlsruhe - including the design of buildings, such as palaces, churches, synagogues, government buildings, city gates, shops, fountains, theaters, arms depots, cemeteries and farms - is a remarkable achievement. Its disciplinary intersection in fields as diverse as mythology, aesthetics, the history of culture and society, the history of art, geometric design and perspective, structures and materials, architectural composition, management of construction and building costs and above all, the domain of scientific theories of the time are based on the new rationalist models that were extremely influenced by the scientific movement of the 19th century.

The example of this is confirmed when F. Weinbrenner assumes the direction of Baugnade or “construction direction” of the Grand Duchy, in order to bring about social improvements through the reform of aesthetic paradigms. He announces that whoever builds according to municipal parameters, considering factors such as location, height, number of facilities, among other things, will receive a fixed economic fee. In 1815, he presented the final version of the standard construction document, in which three type houses were designed according to their location and economic class of destination. Also, with regard to the issue of urban planning, namely due to the consideration of the safety factor, F. Weinbrenner imposes specific construction rules: the buildings should have at most a height equivalent to the width of the streets; the doors should open into the houses and not out; the woods used in the interior should be at least about ninety centimeters away from any flame producer. This German architect is one of the precursors of functionalism. His ideas about beauty accentuate her agreement with the function. As the author refers, on page 6 of the third volume of Lehrbuch, “Uber die hohere Baukunst”, the author refers to beauty as übereinstimmung der form mit dem zweck, that is, in the total agreement between form and function, giving examples of functional objects of everyday life. But his concept of beauty is not limited to the simple satisfaction of purposes, since it also includes adequacy and usefulness, transforming Friedrich Wienbrenner into one of the first great references of functionalism.

Another renowned functionalist author was Horatio Greenough (1805-1852), an American sculptor who lived in Italy between 1829 and 1851, the date on which he returned to the U.S., where he would pass away the following year. Considered, along with Friedrich Wienbrenner, one of the first functionalists, he published his ideas about the evolution of the arts, architecture and design in the work entitled The Travels, Observations, and Experience of a Yankee Stonecutter. His theories about functionalism were adopted at the end of the century. 19th and early 20th centuries by architects and designers, such as Louis Sullivan and Ludwig Mies van der Rohe. The comparison made by H. Greenough between the evolution of design and biological evolution was a precursor and would influence numerous later authors.

His observations about the functioning and suitability of natural systems, with their respective transposition to artificial systems are notable: "(...) observe the skeletons and skins of animals, through the variations that go from the beast to the bird, from the fish to the insect, are we not impressed by its variety and beauty? There is no arbitrary law of proportion and no rigid model of form". Defending that: "The law of adaptation is the fundamental law of nature in all structures", years before the publication of the Origin of Species, he criticized the domain of arbitrary rules of taste, installed in everyday objects. As he said: "Many works are more beautiful without ornament". And he adds: "When I define Beauty as the promise of Function; Action as the presence of the Function; As a function record, I arbitrarily separate what is essentially one".

Defender of the function, he found in shipbuilding the exemplification of his theoretical proposals. "Watch a boat in the sea! Notice the majestic shape of its hull as it advances through the waters, observe the graceful curvature of its body, the gentle transition from the curved to the flat, the firmness of its keel, the launch of its bowsprit, the symmetry and rich outline of its masts and risers, and those big wind muscles, the sails!". The analysis of the characteristics of shipbuilding will then be proposed as an example to be followed in civil construction Figure 2: "We could transfer to civil architecture the responsibilities that weigh in shipbuilding and we would have long buildings superior to the Parthenon for the purposes for which they were intended (...)". Anticipating all pedagogical theories of design, he says: "I wish to see normal schools of structure and ornament working, organized in a simple but effective way, and constantly busy in designing for manufacturers, and for all mechanics who need guidance aesthetics in your operations".

But H. Greenough goes even further in defending a notion of progress associated with the role: "If you go through the various stages of development of the boat, from the canoe dug in the trunk of the tree and the old galley, to the latest types of corvettes, we will note that any progress in performance has been a progress in composition, beauty or grandeur, in accordance with the function of the vessel".

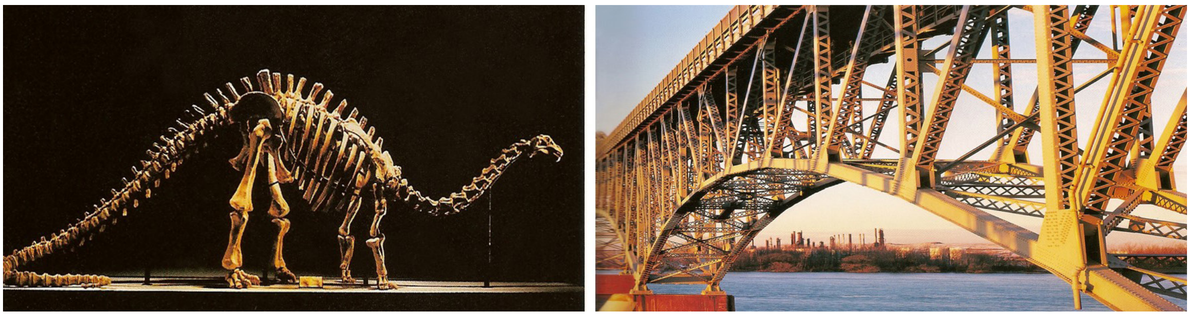


Figure 2. Brontosaurus skeleton and bridge structure on South Grand Island, New York. Analogy established by Alan Powers, in Nature in Design (1999).

In this statement, the author advocates a technological evolution because, as already noted, the term progress was used to refer to the evolution in technical systems. As R. Lewontin and R. Lewis refer in the introduction to their article on Evolution: "Although the concept of evolution has been firmly identified with organic evolution, the history of living organisms on Earth, the theory of the evolution of life is just a special case of a more general view of the world, which can be defined as evolutionism".

That is, before being a scientific theory, evolution was an ideology, that is, it proposed a global view of the changing world. In the 18th century, August Diderot, author of the Encyclopédie, stated: "Everything changes, everything passes, there is nothing but everything that remains". A natural static ideology typical of the feudal system in which owners and servants were attached to the land, was gradually being replaced by a theory that considered change as natural, that is, by an evolutionary vision, better suited to the rise of the classes of traders, financial and later industrial. But between the agricultural revolution (associated with land) and the industrial revolution (associated with production) another revolution had to exist, the commercial and financial revolution (associated with exchanges) in which movement was a crucial factor. As Friedrich Engels says in the 19th century: "Movement, in the most general sense, understood as the mode of existence of matter as its inherent attribute, comprises all the changes and processes that occur in the universe, from the mere change of place to thought".

But change is not enough, as Alfred North Whitehead says: "There can be meaningless change and no progress". The term progress would therefore be more appropriate, and James Ferguson, an English writer and scholar, in his book An History Inquiry into the True Principles of Beauty in Art, published in 1849, dedicated a chapter to the theme with the name "Progress of Art ", in which, in this thematic perspective, refers to the evolution of ships as follows:" We have a constant progress (of ships) over eight centuries, and it will be difficult to calculate how many millions of people, not only in each port of the Europe, but also in America, were necessary to produce this great result "Ship design is often referred to as an example in rationalist literature as it is strongly illustrative of progress in terms of technical systems, in the same way that variations in the Gothic cathedral are a reference in studies that focus on progress in architecture. Technological progress manifests itself in all areas: in terms of engineering, in the construction of bridges, in agriculture, in the mechanization of processes, etc.

As P. Steadman points out, more than a great leap resulting from a brilliant inventor, the great progress was due, for millions of years, mainly to the work of anonymous artisans and mechanics who with their combined efforts were responsible for small and sequenced progress. These notions of progress and evolution of objects appear perfectly visible in the illustrations by A-H. Pitt-Rivers on the evolution of the boomerang, of 1906 - whose precursor work was previously referred to in the article "Orthogénesis of the Tools" - in Bashford Dean's on the evolution of the helmet, of 1915 (cf Figure 1) and, more

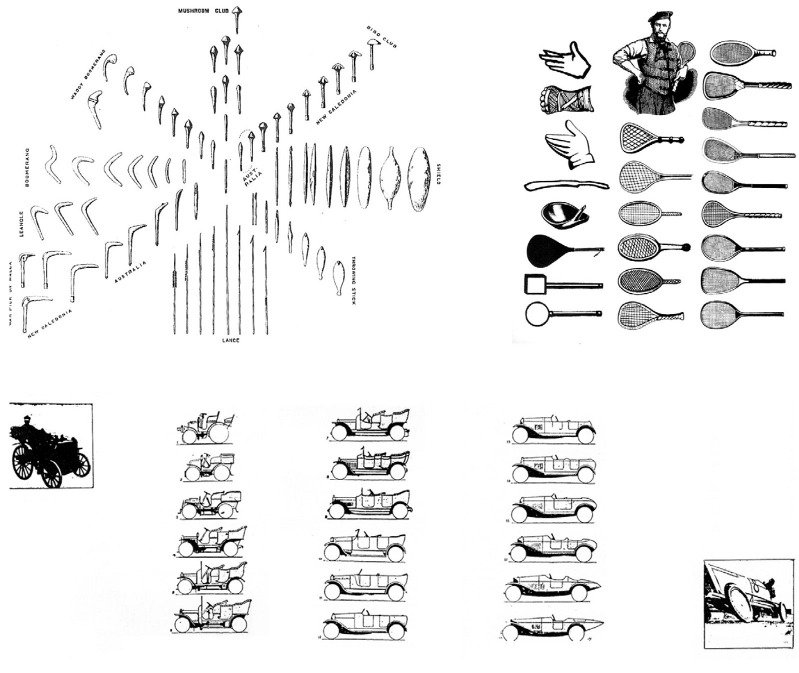


Figure 3. Evolution of some types of objects: "boomerang" by Pitt-Rivers (1906), tennis racket (author and year of unknown design) and automobile by Le Corbusier (1921).

recently, in Le Corbusier's 1921 evolution of the automobile. Figure 3

The study of social systems also presupposes evolutionary theories, as we have already seen. As R. C. Lewontin and R. Lewis refer: "The evolutionary theories of social systems, namely Marxism and some of its variants, are explicitly progressive and perfectionist". And then they add: "And the stories of religion, philosophy, science, fine arts, industrial techniques, show the existence of a succession of states." That is, in modern theories of evolution, C. Darwin was a culmination and not its origin. C. Darwin himself, in fact, in the third edition of Origin of Species of 1861, makes a historical outline of the writings that preceded his, on organic evolution.

Basically, the evolutionary analogies of H. Greenough or J. Ferguson, among others, predate the publication of the Origin of Species, thus demonstrating the existence of the genesis of an evolutionary theory of technology and a notion of progress related to systems or technological organisms, even though, in this case, the reference to "evolution", as defended by P. Steadman, refers more strictly to the sense of "progress" or "development". As H. Spencer - the greatest defender of evolutionary progress in the 19th century - says in Progress: Its Law and Cause, 1857: "From the first traces of cosmic changes to the last results of civilization, we find that the transformation of the homogeneous into heterogeneous is what progress essentially consists".

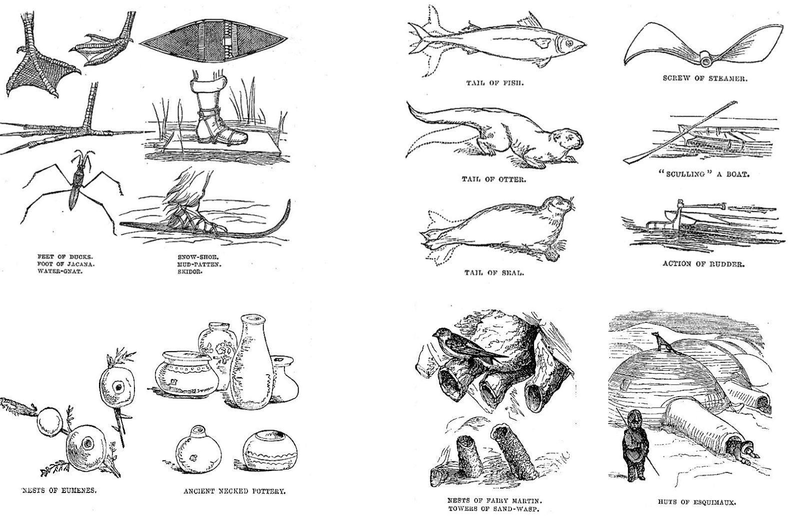


Figure 4. Comparative studies between natural and technical systems illustrated by Reverend Wood.

The functionalist vision of H. Greenough marked proto-modernism by proposing "beauty as a function commitment." In the book Form and Function - Remarcks on Art by Horatio Greenough, the editor says on the back cover: "It was Greenough, not Walt Whitman, who first protested the lack of meaning in ornamentation. It was Greenough, not John Ruskin, who first expressed the idea that a people's buildings and art express their morality. It was Greenough, not Le Corbusier, who first said that buildings primarily for use "could be called machines". It was Greenough, not Louis Sullivan, who first spelled out the principle that, in architecture, form must follow function." But as we noted earlier, it was not H. Greenough but F. Weinbrenner who first said that the form must follow the function. This important German author owes the maxim of functionalism. But perhaps even more important and less publicized in the work of H. Greenough, are his proposals for the analysis of natural structures intended for later application in artificial systems, anticipating future biotechnological methodologies. Later, this will be a great step in the methodological and scientific consolidation of the referred processes of analysis of the natural structures.

The Origin of Species would be crucial for the understanding of biological evolutionism and for the consequent creation of a support base for the development of technological evolutionism, this one previously explored based on Lamarkian theories, closer to the adequacy to technological systems. However, it is very important to keep in mind that this work by C. Darwin was published seven years after the death of H. Greenough, which is to say, seven years after the edition of his book The Travels, Observations, and Experience of a Yankee Stonecutter. H. Greenough's work remains in history as a reference of functionalism, extremely important in the evolution of project culture and biotechnological methodologies.

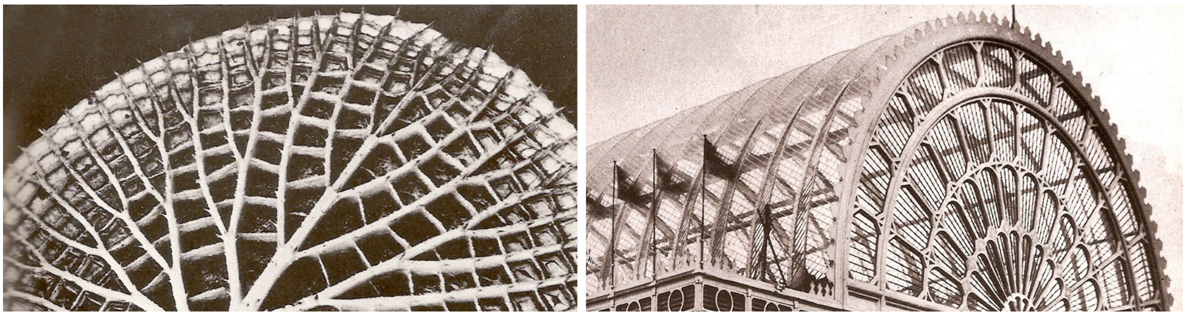


Figure 5. Lower structure of the water lily Vitoria Regia and gallery structure of the Palácio de Cristal (1851), by Joseph Paxton.

Also a forerunner in the analogies established between nature and art is the work of Reverend John George Wood, published in Boston in 1875, with the suggestive title Nature's Teaching's: Human Invention Anticipated by Nature Figure 4, where the author, using different areas of human knowledge ordered by chapters such as "nautical", "hunting and war", "architecture", "utensils", "optics", "utilitarian arts" and "acoustics", seeks to demonstrate that prototypes that can help in concretize human productions. This manual is probably the first comprehensive survey of comparisons between biological and technical systems, with about 750 illustrations that help to understand the analogies advocated by J. Wood.

One of the most famous examples he mentions in architecture is that of the Crystal Palace designed by Joseph Paxton and inaugurated for the Great Exhibition of 1851. Inspired by the leaf ribs of the giant water lily Victoria Regia, it is a good example of Structural Morphology. Figure 5 But hundreds of other examples appear in his work, establishing analogies between examples taken from Biology and human production.

Another reference work and perhaps the first to use the term "Biotechnics" is the book by the German Raoul Francé, Die Planze als Erfinder (Plants as Inventors), published in Stuttgart in 1920. According to him, all forms of nature are a product of natural selection and a consequence of functions developed by organisms in their adaptation, that is, their forms are the solution to solve problems that biological systems encounter. In this sense, R. Francé proposes that anyone looking for a technical solution, should study "biotechnology", and thus seek a solution to the same problem in biology and imitate it. Lazlo Moholy-Nagy, artist and emblematic professor at Bauhaus, defended and disseminated R. Francé's ideas at the famous school, citing him even in his book The New Vision, referring to R. Francé as follows: is an intense study of the analogy between biology and technology, and draws on its research method and its biotechnical results ". But L. Moholy-Nagy allowed an opening in the mimetic process in that, according to his view, the important

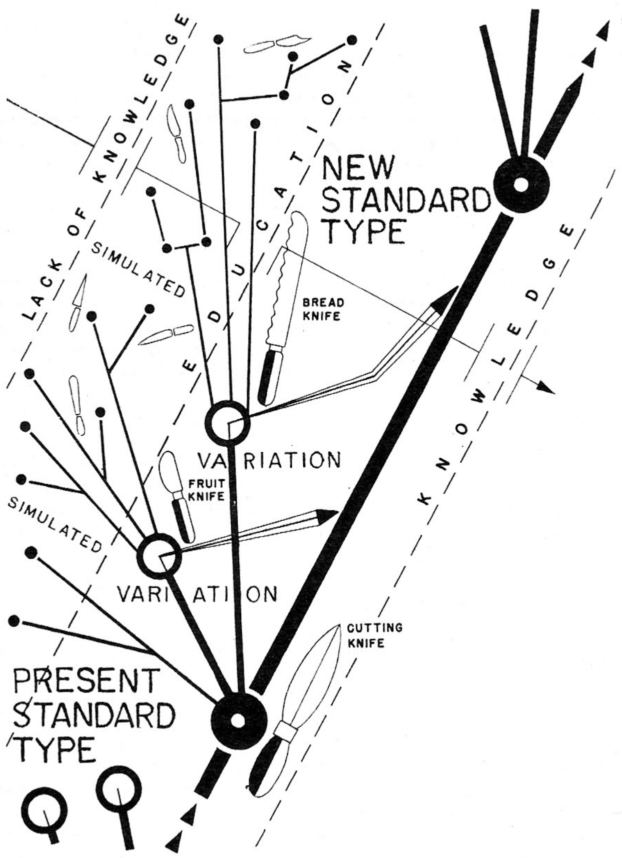


Figure 6. Diagram by F. J. Kiesler that shows the evolutionary process of the "standard type" of the knife (1939).

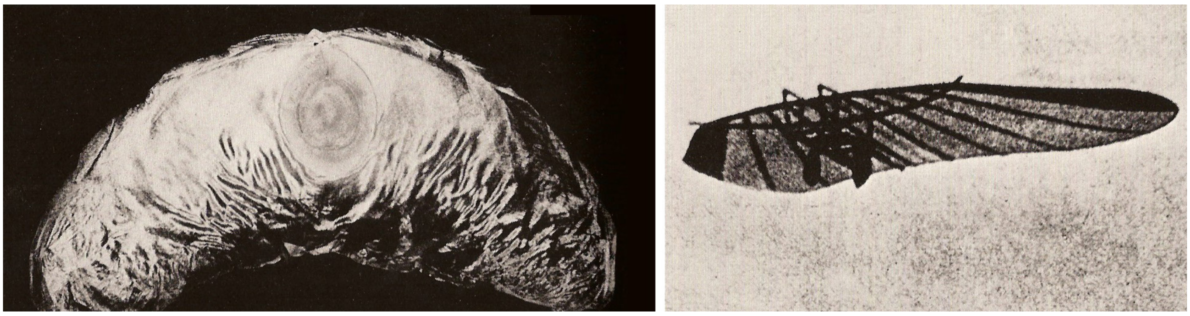


Figure 7. Glider seed of the Zanonia macrocarpa and Zanonia glider (1904) of the aviation pioneers Etrich and Wels.

thing was to follow the general principles of the methods of nature, that is, for him it was possible to conceive works "that functioned organically".

Another important reference in this area is the article On Correalism and Biotechnique by the architect Friedrich Kiesler, published in the Architectural Record of 1939. According to the author, correalism means the study of the relations between man and his natural and technological environment. F. Kiesler argues that "instruments and architecture are created to serve as mediators between man and the natural environment and therefore form a second and interposed, "technological environment". For this author, all utensils go through an evolution process with several states that correspond to "variations" from the "standard-type", as shown in the knife's evolution scheme. Figure 6

But, unlike what happened with the previous authors, for F. Kiesler, biotechnology is not a simple copy of natural prototypes, but a method capable of polarizing natural forces in the direction of man's intentions. In this sense, he distinguishes between biotechnology and biotechnology, attributing the latter to Patrick Gueddes and defining it as "a method of building nature ... and not man". Also, of anticipatory reference is, in the book Cities in Evolution by P. Gueddes, biologist and pioneer of urbanism, published in 1915, the introduction of the terms "biotechnology" and probably the term "biotechnical". In the same work, he also proposed the terms "paleotechnical" and "neotechnical", referring to the first rudimentary and disastrous phase of the Industrial Revolution and the second to an emerging industrial order that tended towards prosperity, beauty and harmony with the environment Natural.

Thus, studies in the field of biotechnology began to be formulated, which would be widely disseminated and developed in the post-war period, with the introduction of notions such as Technical Biology and Bionics. If, in the first, the objective is the study of formal and structural systems produced in biological systems, in the second, in addition to the analysis of natural systems, the respective synthesis is produced that allows the future application of knowledge in technical and technological systems produced by human beings. This is not a purely theoretical process, but a rigorous and scientific method of transforming organic structural and functional systems into technological systems, thus allowing their subsequent application in the project culture Figure 7. The study and investigation of these biological and biochemical systems allows the construction of prototypes later used in the design of synthetic systems. Although naturally more developed, these post-war proposals are, however, nothing more than the "biotechnical" proposals presented, in the 1920s and 1930s, by P. Gueddes, R. Francé and F. Kiesler and which were defended as a methodology by L. Moholy-Nagy.

The proposal for the name Bionics is attributed to the major of the US Air Force, Jack E. Steele in 1958, and according to J. Steele, it means "systems science whose function is based on living systems, or which have characteristics of living systems, or that resemble them ", having been, however, later defined with more precision by David Offner as:" The study of living systems or assimilable by the living, tending to discover new principles, techniques and processes of application to technology. Bionics analyzes biological systems, their principles and fundamental characteristics from a qualitative point of view, in order to draw inspiration for the development of new orientations in the design of technical systems that have similar characteristics ". Although Bionics was considered by J. Steele as a new science and was officially presented in May 1960 at the Annual Aeronautical Electronics Conference, that name is given by J. Steele with no knowledge that this new science already existed under the name of Biotechnics (in English Biotechnics) according to a proposal by P. Gueddes, from 1915, or by R. Francé, from 1920.

One of the best known systems for the application of methodologies and processes of biotechnological methodologies in a widespread product is the fixation system invented in 1941 by the Swiss engineer Georges de Mestral, which is usually known by the name of Velcro. The name, according to its inventor, derives from the combination of the French words "velours", which means velvet and "crochet" which means hook.

This fixation system is based on a process developed by some plants, of which Burdock seeds stand out, which, when coated with small tentacles with hooks at the end, allow their attachment to the animals' fur, thus allowing their transport to other locations and, consequently, the spread of the plant. Sometimes these seeds, in their natural fixation process, also adhere to clothing. This was what happened to G. de Mestral when, while walking in the mountains of the Swiss Alps, he observed that these seeds were fixed on his clothes and on the coat of his dog. Developed by G. de Mestral, the quick fixing system works by producing two nylon tapes, one of which is coated, on one side, by tiny hooks that in contact with the other tape, covered by tiny rings, allows the anchoring the hooks in an extremely resistant way and with a number of almost infinite possibilities of

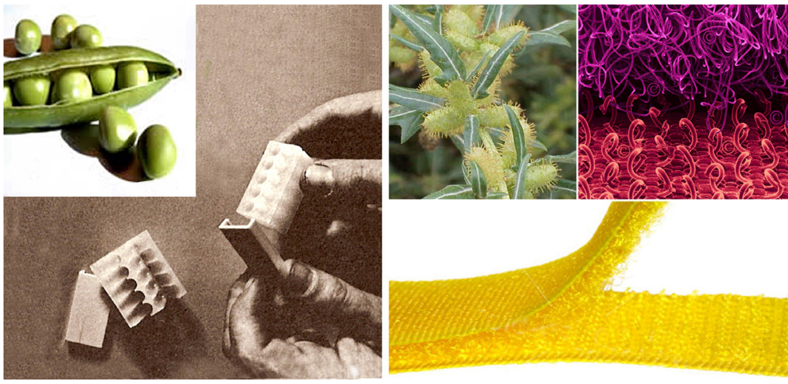


Figure 8. Left: Suppository packaging based on the pea pod (1960s), by Victor Papanek. Right: Burdock, plant that served as inspiration for the development of Velcro, expansion of Velcro structure, Velcro system.

use Figure 8. Patented in 1951 by its inventor, today, the Velcro brand has more than 300 registrations in about 160 countries.

One author who systematically defended the use of Bionics in design processes was Victor Papanek (1935-1998). Born in Austria, he graduated in architecture and industrial design in the USA, subsequently becoming interested in subjects such as Ethnology and Biology and, thus, creating the basis for the development of what would come to be called "Design for Needs" (Design for Need); representing a reaction to the consumer society, the author defended a design designed for real human needs. Already previously, another author, Richard Buckminster Fuller, had made proposals in this regard, which culminated in his research project World Resources Inventory, developed at Southern Illinois University, which proposed a review of the distribution of global resources so that they could be used in a more efficiently. Also, Richard Neutra, in 1954, published his book Survival through Design that defends a worldwide strategy for non-commercial design. But it would be V. Papanek with the publication of his book Design for the Real World, in 1971, who would assert himself as responsible for the great dissemination of the notion Design for Need, as well as the concept of Bionics. Indeed, this book has been translated into 23 languages, making it the most widely read design work in the world. With the subtitle "Human Ecology and Social Change", in this book V. Papanek's views on the ethical, social and environmental issues of design are approached in an unprecedented systematic way. In that same work, the author also dedicates a chapter to Bionics, entitled “The Tree of Knowledge: Biological Prototypes in Design” in which it provides a simple definition of the term: “use of biological prototypes for the design of man-made systems. “

Other more contemporary proposals, mainly developed after the energy crises of 1971, 1973 and 1974, seek to create positive interfaces between technical systems and environmental systems. Among the main ones are Green Design (Ecological Design), Ecodesign (Ecological Design), Design for Environment (Environmental Design) and Sustainable Product Design. Alastair Fuad-Luke’s book, the eco-design handbook is, in this sense, a very complete manual of products in which these concerns are thoroughly analyzed. The methodologies of the proposals in question are not necessarily based on Technical Biology, as they seek, fundamentally - with more or less efficiency, and through different processes and methodologies - to make the products and the product systems compatible considering, respectively, variables such as their production, distribution, use, destruction, recycling, reuse, that is, the factors that can be readjusted in order to reduce the environmental impact of everything that human beings produce. In this sense, these methodologies usually resort to processes such as: Life Cycle Analysis, Environmental Management, Eco-audits, or Energy Flow Management. Focusing mainly on the inside of the technical system, they will be able, through the use of Biotechnical Methodologies and Design, to have access to a new vision, external to the human technical system, which may bring unexpected and innovative information flows. It will certainly be part of contemporary Biotechnical Methodologies to use, in its design process, information provided by these environmental methodologies.

Biotechnical methodologies have, in fact, been an indispensable resource in the evolution of technological systems, acquiring an increasing importance in the current context of debate on environmental crises. The latter, in turn, have led to the priority search for approximation solutions and greater compatibility between technological systems and biological systems. However, the potential of biotechnological methodologies - applied in project areas such as Design, Architecture or Engineering - has, however, been underused; although the projectual knowledge is in a process of maturation in which Nature tends to be, increasingly, an example to follow in the century. XXI.

1.2 - Biomorphic Methodologies: Streamlining and Biodesign

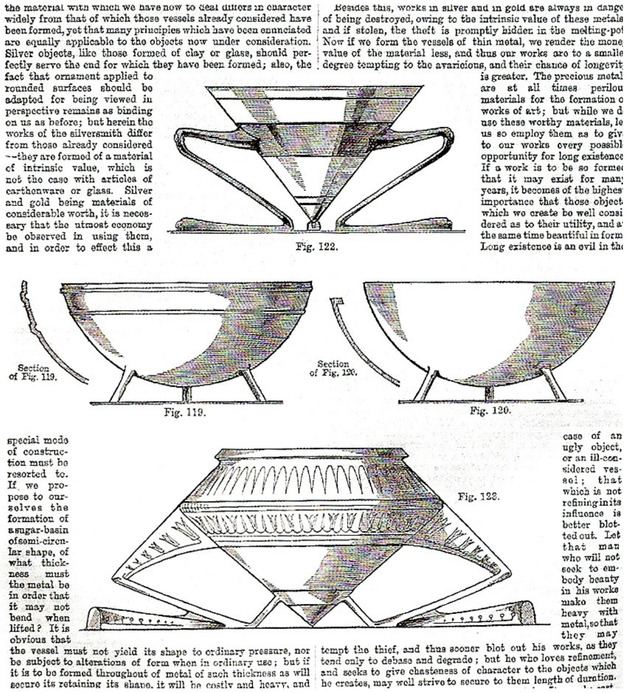
Other methodologies that use natural systems as a reference are those that the author called as: biomorphic methodologies. This denomination intends to group all the methodological proposals that propose to analyze the natural systems, living or non-living that, in a direct or indirect way, contribute to the aesthetic and formal evolution of objects and systems of objects produced by man. More linked to the morphological transposition of natural elements to artefacts, these have been present in material production since its inception. As P. Steadman says: “The use of plant and animal figures in decoration is practically universal throughout the history of architecture and applied arts; in the last half of the 19th century, however, there was a special interest (...) ”.

It is, in fact, at that time that some of the great works on this theme are published, coinciding with the discoveries made in Biology. In other words, project culture accompanies scientific development. Among the most important works to establish this bridge, as P. Steadman refers, is Owen Jones’ Grammar of Ornament, published in 1856, defended by its author as a practical guide of documentation based on natural elements, intended for designers.

But we can affirm that the great diffuser of the application of this methodology in industrial products, in a systematic way and with scientific foundations, was Christopher Dresser (1834-1904); considered by some historians - and defended by the author of the present work -, as the first, modern product designer. As Stuart Durant says, “He revealed himself in the machine’s triumph and understood his demands more clearly than any of his rivals.” In fact, in addition to being a designer, C. Dresser was also the author of theoretical studies on this subject, highlighting in this context two important works of his: The Art of Decorative Design, from 1862, and, later, Principles of Decorative Design (1873); Figure 9 in the latter, C. Dresser encourages “young decorators to study the principles on which nature works”.

That last book, based on some articles that C. Dresser published on the relationship between natural forms and design, Figure 10 is followed, in 1874, by the article Studies in Design. Any of the works will have been influenced by the investigations produced for his doctorate in botany, defended in 1860.

C. Dresser studied design at the Government School of Design in 1847, where he proved to be the most talented student. He was invited to teach botany classes at the school in 1854. In 1860, at the age of 26, he received his doctorate from the University of Jena, Europe’s most advanced scientific center in botany, located in Germany. He opens his design studio and, in 1876, asserts himself as the first western designer to visit Japan. This trip, on behalf of the British government, lasts four months and allows him to get in touch with artistic production, arts decorations and architecture of that country, the result of which will be the publication, in 1882, of the book “Japan: Its Architecture, Art and Art Manufactures”. Four years later, C. Dresser would also publish Modern Ornamentation, a book that includes works produced by his design studio. The contribution of C. Dresser in design processes, illustrated in these books and in the dozens of articles published by him within the same themes, is decisive for the way he systematically applies the



the material with which we have now to deal differs in character widely from that of which those vessels already considered have been formed, yet that many principles which have been enunciated are equally applicable to the objects now under consideration. Silver objects, like those formed of clay or glass, should perfectly serve the end for which they have been formed; also, the fact that ornament applied to rounded surfaces should be adapted for being viewed in perspective remains as binding on us as before; but herein the works of the silversmith differ from those already considered --they are formed of a material of intrinsic value, which is not the case with articles of earthenware or glass. Silver and gold being materials of considerable worth, it is necessary that the utmost economy be observed in using them, and in order to effect this a special mode of construction must be resorted to. If we propose to ourselves the formation of a sugar-basin of semi-circular shape, of what thickness must the metal be in order that it may not bend when lifted? It is obvious that the vessel must not yield its shape to ordinary pressure, nor be subject to alterations of form when in ordinary use; but if it is to be formed throughout of metal of such thickness as will secure its retaining its shape, it will be costly and heavy, and

Besides this, works in silver and in gold are always in dange of being destroyed, owing to the intrinsic value of these metals and if stolen, the theft is promptly hidden in the melting-pot Now if we form the vessels of thin metal, we render the mone value of the material less, and thus our works are to a smalle degree tempting to the avaricious, and their chance of longevit is greater. The precious metal are at all times perilou materials for the formation o works of art; but while we d use these worthy materials, le us so employ them as to giv to our works every possibl opportunity for long existence If a work is to be so forme that it may exist for man years, it becomes of the highes importance that those object which we create be well consi dered as to their utility, and a the same time beautiful in form Long existence is an evil in the case of an ugly object, or an ill-considered vessel; that which is not refining in its influence is better blotted out. Let that man who will not seek to embody beauty in his works make them heavy with metal, so that they may tempt the thief, and thus sooner blot out his works, as they tend only to debase and degrade; but he who loves refinement, and seeks to give chasteness of character to the objects which he creates, may well strive to secure to them length of duration.

Fig. 122.

Section of Fig. 119.

Fig. 119.

Section of Fig. 120.

Fig. 120.

Fig. 123.

Figure 9. Page from the book Principles of Decorative Design (1873), by Christopher Dresser.

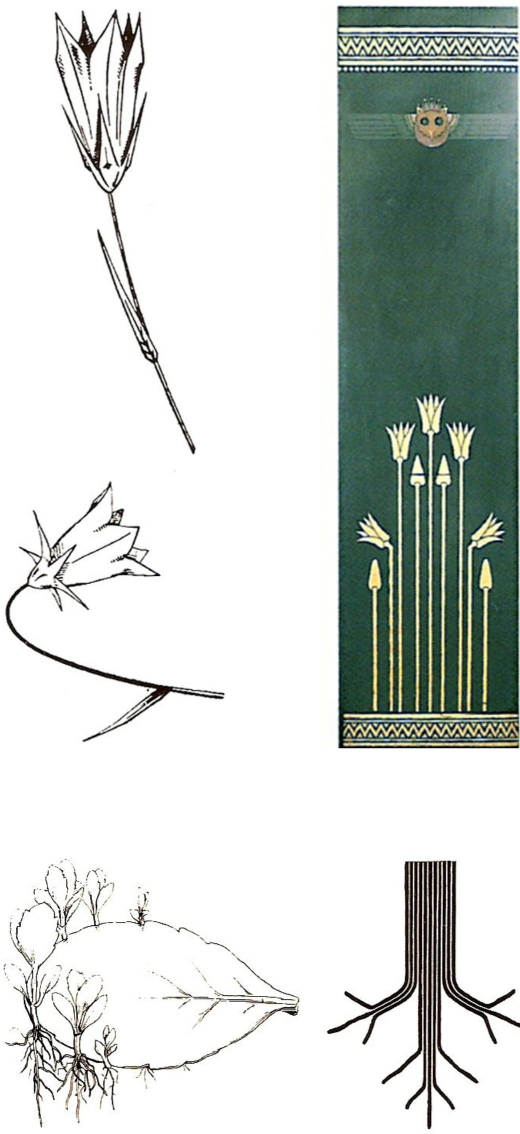


Figure 10 Drawings of analysis and synthesis of natural elements (1859-1880), by Christopher Dresser.

influences of elements taken from the world to the project. Natural. Considered as the first independent industrial designer, in a tribute dedicated to him by the English magazine Studio, in 1899, its importance is highlighted as follows: “possibly the most important of commercial designers, he imposed his fantasy and invention above ordinary industrial production British”. Figure 11

Through his flourishing studio, C. Dresser has designed hundreds of products for more than fifty client companies not only in England, but also in France, Japan and the USA, in areas as diverse as furniture, tableware in ceramics, glass and metal, textiles or wallpaper, presenting a diversity and quality of radical designs in relation to the current Victorian style. His designs were so innovative that some of them are still in production today, highlighting, in this sense, the undertaking undertaken by the Italian company Alessi, which recently marketed some replicas of products designed by C. Dresser. In fact, his inspirations had as main reference elements taken from the observation of nature, as well as elements of Japanese art and pure geometries, in an aesthetic path in which the formal simplification and its innovative capacity has been progressively solidified.

Figure 11. Ceramic products (c. 1870) by C. Dresser showing the influence of pure geometries, Japanese art and observations of nature.

C. Dresser believed and defended the supremacy of form over ornament. In the way he assumes the materials and the extremely refined language, C. Dresser can be considered as one of the first modernists. which influenced him a lot. His optimistic view of the future industrialization and the importance of machine production would be references that, only in the 20th century, would be taken up again, namely in the work carried out at Bauhaus, in the metal workshop directed by L. Moholy-Nagy, of which the pieces by Marianne Brandt are a good example of the continuity of C. Dresser's work.

Still in the late 19th and early 20th centuries, Art Nouveau - whose name derives from a Parisian store, Maison de L'Art Nouveau -, with its formal inspiration drawn from plant elements, stands as a widely known example from the application, to the project, of ornamental and structural vegetal motifs, stylized. This application of biomophical methodologies in Decorative Arts and Architecture had an enormous expression in the Western world, but it would be the North American Streamlinig that, in the thirties, would revolutionize the application of biomorphic methodologies through the exploration of inspirations taken from nature, namely aerodynamic and hydrodynamic, whose formal application to the project required technologically very complex solutions.

This current - which includes Norman Bel Geddes (1893-1958), Raymond Loewy (1893-1986), Walter Dorwin Teague (1883-1960) and Henry Dreyfuss (1904-1972), all of them working in industrial design at the end of the 1920s - it was strongly marked by the influence of aerodynamic and hydrodynamic forms and can be considered the first application of the notions involved in both areas to highly consumed industrial products. N. Bel Geddes has a strong responsibility for the dissemination of streamlining, through his book Horizons, published in 1932 and with enormous success. This work served as an example for the other designers of the streamlining, of which the publications of: Design This Day by W. Teague, 1940 stand out; Never Well Enough Alone by R. Loewy, 1951; and Designing for People by H. Dreyfuss, 1955.

Figure 12. Products designed by Christopher Dresser: Sugar bowl for Elkington (1864); Kettle for James Dixon (1879); Terrine for Elkington (1885).

Of great influence in the streamlining of the shapes of N. Bel Geddes, were the expressionist projects of industrial buildings by the Austrian architect Erich Mendelsohn carried out between 1914 and 1918. This influence, assumed by N. Bel Geddes in the introduction to the catalog of the work of E. Mendelsohn, during the exhibition in the USA of the Contemporary Exposition of Art and Industry of 1929, will be present in most of his projects. Figure 13

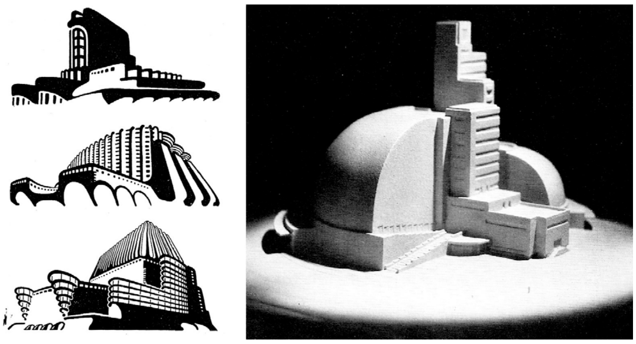


Figure 13. Left: Drawings of industrial buildings by Erich Mendelsohn (1914-18). Right: Model of Repertory Theater (1929) by Norman Bel Geddes.

Early in the career of N. Bel Geddes, this influence is verified in the projects of theaters and theatrical scenarios that he develops. In 1927, the American designer decided to dedicate himself to industrial design and, in this context, in addition to developing projects for his clients, he also developed visionary aerodynamic projects such as boats, airplanes, cars and trains, houses, airports, new motorway systems and traffic models, whose ideas would come to fruition at the Futurama exhibition, integrated in the General Motors stand at the New York World's Fair in 1939, which was visited by twenty-five million people. As the name Futurama indicates, this exhibition presented a city of the future, interpreted according to the avant-garde visions of its author.

N. Bel Geddes also stands out, in terms of product design, the designs of the Toledo Counter Scale, from 1929, and the Standard Gas Equimpent Stove, from 1932. Figure 14

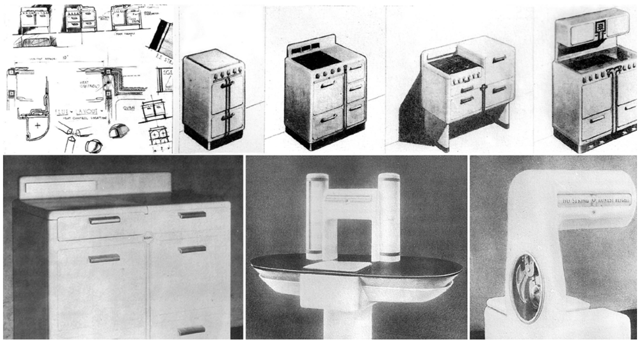


Figure 14. Above: Norman Bel Geddes sketches for Standard stoves. Below, from left to right: Standard stove (1932) and Toledo scale (1929).

With regard to the transport design developed by you, refer to the projects of the Air Liner # 4 airplane, from 1929, the Locomotive No. 1 train, from 1931, and the Streamliner Ocean Liner boat, from 1932; Figure 15 extraordinary examples of the application of biomorphic languages that have had a great influence on some later proposals such as those by Luigi Colani and Biodesign.

The work of N. Bel Geddes was a pioneer in the introduction of Industrial Design in the U.S., having subsequently also proved to be an internationally important influence. As he himself said: "As the artists of the fourteenth century are remembered for their

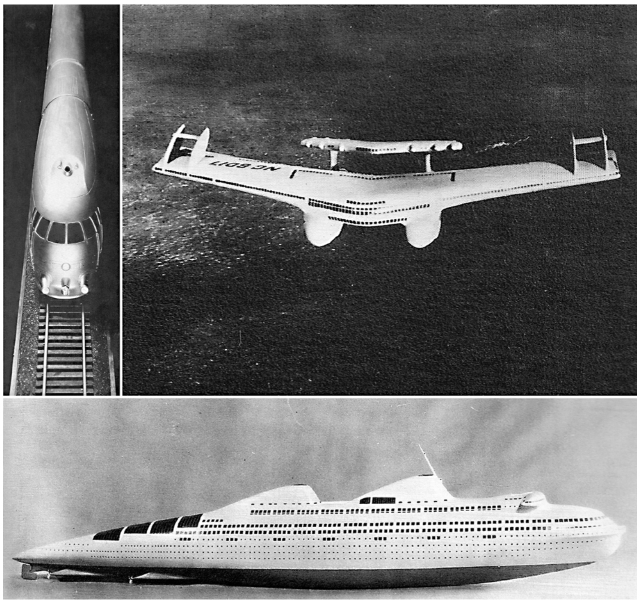


Figure 15. Transport projects by Norman Bel Geddes. Above: Locomotive Nº1 (1931), Air Liner # 4 (1929). Below: Streamliner Ocean Liner (1932).

cathedrals, those of the twentieth century will be remembered for their factories and the products of those factories".

The meaning of this same comparison would be reaffirmed by R. Barthes, in 1957, in the text "The new Citroen" published in his book Mythologies: "I believe that the automobile is today the exact exact equivalent of the great Gothic cathedrals (...)". Figure 16

In the continuity of N. Bel Geddes' organic and aerodynamic language, we find, as already mentioned, Biodesign - a name attributed to the biomorphic language explored by the German designer Luigi Colani.

Born in Berlin and registered under the name of Lutz Colani (b. 1928), he studies sculpture in this city, moving, in 1948, to Paris where, at Sourbonne, he develops studies on "aerodynamics". In 1952, he moved to California to study aeronautics at Mc Donnel Douglas' New Materials division; again in the United States he would later work for NASA and Boeing (1974). Back in Europe, he presented, in the 50s and 60s, a series of aerodynamic proposals in the automotive sector, of which the projects, in 1952, of a turbine-propelled motorcycle stand out; for Simca, in 1953, the first European car with a plastic body; and in

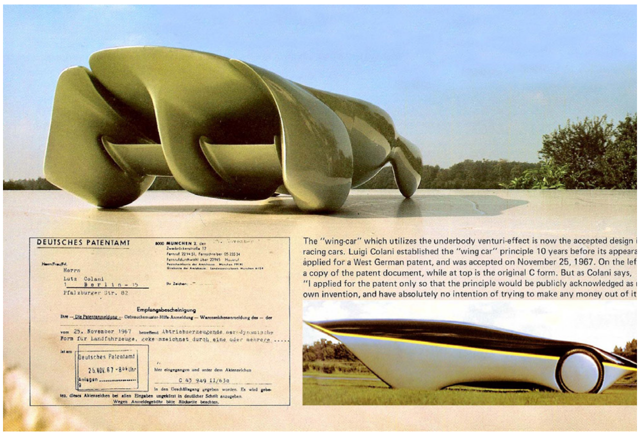


Figure 17. Projects by Luigi Colani. Top and left: original C-Form aerodynamic body and patent (1967). Bottom right: Low consumption vehicle with high aerodynamic capacity, with Cx of 0.2 (1982).

1667, the body of the C-Form car, which will be the origin of all aerodynamic bodies with a ground effect.

In the 70s and 80s, L. Colani proposes a wide variety of biomorphic language projects, developing transport in the form of birds, rays or sharks. Of these, we highlight the 1977 Megalodon passenger plane, based on the shapes of the shark, the Super-High-Speed Monorail Car train, from 1978, based on the shapes of the streak, or the Yacht boat inspired by the shapes of the whale, from 1981. Figure 18 As the author

Figure 16. Notre Dame de Paris Cathedral (1163) and Citroen DS19 (1957).

says: "The shape of a shark is a perfection … This animal has modified and perfected the effectiveness of its shape for millions of years, we cannot dream of a better one!".

But L. Colani does not design only transports. His work presents an impressive variety of proposals, ranging from sportswear, lingerie, shoes, glasses, jewelery, watches, pens, weapons, lighters, glass and ceramic tableware, toilets, tap lines, televisions, furniture and even architectural proposals. In terms of transport, he designed bicycles, motorcycles, automobiles, racing vehicles, sailboats, transport boats, oil tankers, helicopters, cargo and passenger planes and even spaceships. It applies organic, hydrodynamic and aerodynamic forms (an area in which L. Colani is a specialist and precursor), sometimes exaggerated, to his mega-projects, adopting an extremely diversified path in his curvilinear language, ranging from more rigorous proposals influenced by

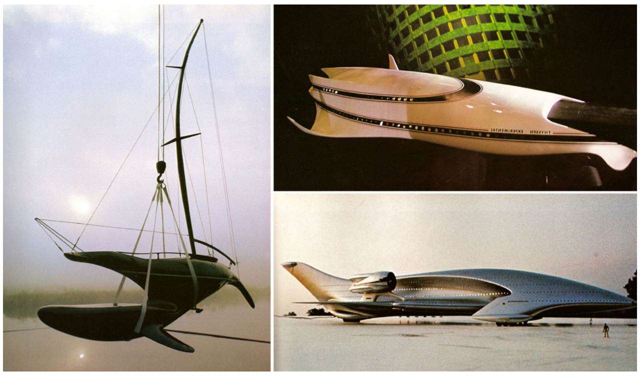


Figure 18. Projects by Luigi Colani: on the left, Yacht (1981); top, Super-High-Speed Monorail Car (1978); bottom: Megalodon plane (1977).

aerodynamics, ergonomics and product engineering, to the megalomaniac projects of transport systems that present an organic-expressionist language, sometimes baroque.

L. Colani, reveals on the small scales a revolutionary attention to ergonomic and anthropometric details. As he himself says: "Engineer's design products in order to facilitate production: their products are often angular and aggressive. I strive to devise lines that reveal the mark of the human body on the object. And in the case of photography, the relationship between the device and the hand is paramount". In the industrial product area, which he designed, the following stand out: in 1981, the ballpoint pen for Pelikan; in 1984, headsets for Sony; in 1991, binoculars for Bresser; in 1993, the "mouse" and the "joystick" for Highscreen, Figure 19 and, above all, the cameras he designed for Canon, of which the T90 stands out, one of the most popular products by L. Colani.

In fact, L. Colani started a collaboration, in 1974, with the Japanese company Canon, which will strongly influence the future industrial products of the brand. This collaboration gave rise to a series of

Figure 20. Camera Models (1982) designed by Luigi Colani. Above, from left to right: Model CB10 and Model Hy Pro. Below, from left to right: Model Frog and Model Homic.

Figure 19. Products designed by Luigi Colani: Ballpoint pens for Pelikan (1981); mouse for Highscreen (1993); binoculars for Bresser (1991).

experimental models of photographic devices in organic forms such as the more conventional CB 10 and Hy Pro and the Frog and Homic designed for underwater photography. Figure 20

He applied the formal principles of Biodesign to these projects, “considering that these are objects that we hold in our hands and touch our faces”. These models later gave rise to the Canon T90, the most complex of the T series, the result of L. Colani’s collaboration with the company’s design office, announcing the influences of its boldest models. Launched in 1986 in Japan, it quickly became an icon of industrial design, influencing the design of thousands of products worldwide. This experience demonstrated in practice, in a very evident way, how a designer with new conceptions sometimes considered utopian can collaborate with the project office of a large company and achieve an innovative result. The T90, with its organic forms that were clearly demarcated from the small black box style parallelepiped box, has historically revolutionized not only the Canon range but also those of the competition. Figure 21 This formal trend naturally expanded later on to most products consumer electronics, first to portable objects such as transistorized

Figure 21. Canon photo cameras, series T. Above, from left to right: T50 (1983), T70 (1985). Below: T80 (1985) and T90 (1986).

radios, walkman’s, diskman’s, etc. and subsequently to other more complex products. This helped that this type of product became more ergonomic and even more sensual.

ºBut this fact also forced the development of more perfected CAD (Computer Aid Design) systems, capable of representing and manipulating all these complex forms, allowing to create a skin that involves all the internal organs of these products. Enabling the use of more organic and ergonomic forms, there was a formal and structural approach to the human body, acting almost as extensions of it. As Raymond Guidot says about the projects developed by L. Colani for Canon: “Colani found shapes that somehow prolong those of the human body”.

Conclusion

In this perspective, biological systems present an inexhaustible diversity of solutions tried for thousands of years, ranging from morphological evolutions, the development of structural or dynamic systems, the modes of information transmission and interfaces, but it is mainly from a wide knowledge of the system in which the object is inserted, that it will be possible to project it so that its adaptation is complete. In this sense, the contribution of areas such as Biology and Chemistry, as well as that of social and economic sciences, Physics and Mathematics will be essential for the enrichment of project culture and for the creation of a future universe of fusion between natural and artificial. This proposal, which we will talk about later, passes, as is defended by the author, by the definition of symbiosis methodologies for a fusion design or Symbiotic Design that, considering biotechnical and biomorphic methodologies such as Bionics or Biodesign, goes further to the propose a new methodology of symbiosis between natural and artificial systems, with sharing of energy, communication and usage systems.

Symbiotic Design is an attempt to understand and apply the methodologies and processes of the great Symbiotic Project that nature has been developing. Applying these methodologies and processes does not guarantee “success”, because even nature learns through experimentation, but it places us within the process, that is, with a greater probability of evolving more integrated and, therefore, with greater success. The 21st century, could be that turning point in this direction. We hope that this is the future, the construction of a "universe of symbiosis" and the preservation of the "Living Laboratory called Terra". And on that day, we can say that we are an integral part of the Symbiotic Planet!

Figure 22. Planet Earth, about 4.5 billion years experimenting with symbiotic methodologies.

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