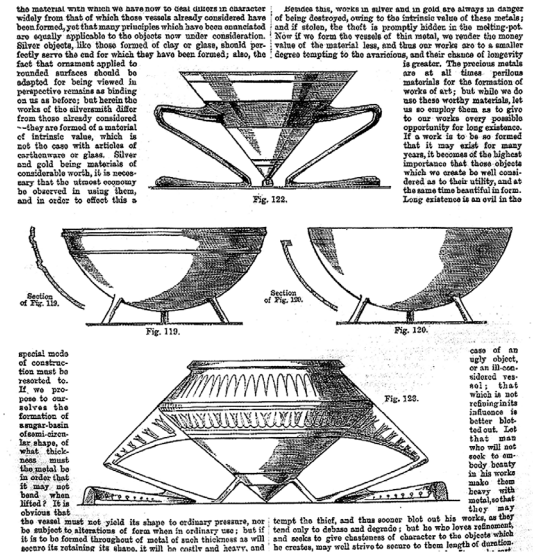
It is, in fact, at that time that some of the great works on this theme are published, coinciding with the discoveries made in Biology. In other words, project culture accompanies scientific development. Among the most important works to establish this bridge, as P. Steadman refers, is Owen Jones' Grammar 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."[59] 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: The Art of Decorative Design[60], from 1862, and, later, Principles of Decorative Design[61] (1873); *(See Figure 9)* the latter, C. Dresser encourages "young decorators to study the principles on which nature works"[62].

That last book, based on some articles that C. Dresser published on the relationship between natural forms and design, *(See Figure 10)* is followed, in 1874, by the article Studies in Design[63]. 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 degree 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, which will result in the publication, in 1882, of the book "Japan: Its Architecture, Art and Art Manufactures"[64]. Four years later, C. Dresser would also publish Modern Ornamentation[65], 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 influences of elements taken from the natural world to the project. Considered as the first independent industrial designer[66], 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 British industrial production"[67] *(See Figure 11 y 12)*.



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

Fig. 122.

Section of Fig. 119.

Fig. 119.

Section of Fig. 120.

Fig. 120.

Fig. 123.

Besides this, works in silver and in gold are always in danger 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 money value of the material less, and thus our works are to a smaller degree tempting to the avaricious, and their chance of longevity is greater. The precious metals are at all times perilous materials for the formation of works of art; but while we do use these worthy materials, let us so employ them as to give to our works every possible opportunity for long existence. If a work is to be so formed that it may exist for many years, it becomes of the highest importance that those objects which we create be well considered as to their utility, and at 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.

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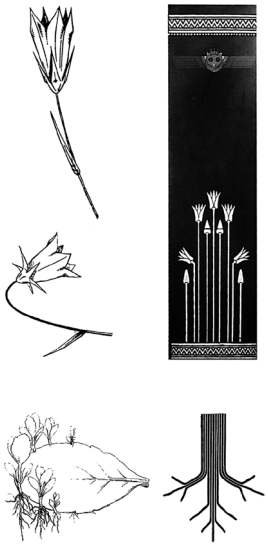

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Figure 9. Book page from Principles of Decorative Design (1873), by Christopher Dresser.
Figure 10. Analysis and synthesis drawings of natural elements (1859-1880), by Christopher Dresser.
Figure 11 y 12. Ceramic products (c. 1870) by C. Dresser showing the influence of pure geometries, Japanese art and observations of nature. **Figure 12.** Products designed by Christopher Dresser: Sugar bowl for Elkington (1864); Kettle for James Dixon (1879); Terrine for Elkington (1885).

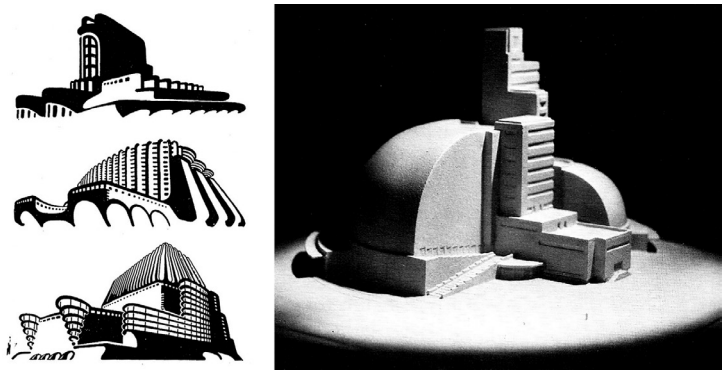
Through his flourishing studio, C. Dresser has designed hundreds of products for more than fifty client companies not only in England, but also in France, Japan and USA, in areas as diverse as furniture, tableware in ceramics, glass and metal, textiles or wallpaper, presenting a diversity and quality 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 the development 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.

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. These characteristics are not unaware of the fact that he had a scientific background, as well as the contact with Japanese culture, 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 stylized vegetal motifs. This application of *biomorphical methodologies* in Decorative Arts and Architecture had an enormous expression in the western world, but it would be the North American Streamlining 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 had a strong responsibility for the dissemination of streamlining, through his book Horizons[68], published in 1932 and with enormous success. This work served as an example for other *streamlining* designers, of which stands out the publications of: Design This Day[69] by W. Teague, 1940; Never Well Enough Alone[70] by R. Loewy, 1951; and Designing for People[71] by H. Dreyfuss, 1955.

Of great influence in N. Bel Geddes streamlining of the shapes, were the expressionist projects of industrial buildings by the Austrian architect Erich Mendelsohn carried out between 1914 and 1918[72]. This influence, assumed by N. Bel Geddes in the catalog introduction of E. Mendelsohn work, during Contemporary Exposition of Art and Industry exhibition in 1929[73] , in USA, which will be present in most of his projects *(See Figure 13)*.



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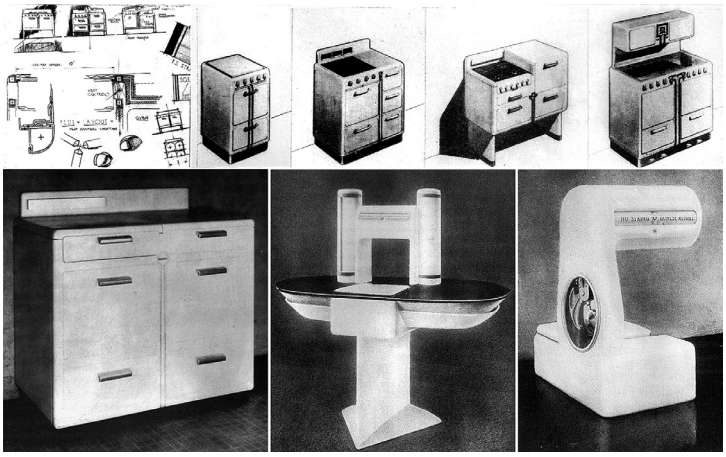

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Figure 13. Left: Industrial buildings drawings by Erich Mendelsohn (1914-18). Right: Repertory Theater model (1929) by Norman Bel Geddes.
Figure 14. Above: Norman Bel Geddes sketches for Standard stoves. Below, from left to right: Standard stove (1932) and Toledo scale (1929).

Early in N. Bel Geddes career, this influence is verified in theaters and theatrical scenarios projects that he had developed. 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[74]. 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 product design terms, with designs such as the Toledo Counter Scale, from 1929, and the Standard Gas Equipment Stove, from 1932 *(See Figure 14)*.

Regarding transportation design developed by him, should be referred 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; *(See Figure 15)* extraordinary examples of biomorphic languages application 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 pioneer in Industrial Design introduction in the U.S., having subsequently proved to be an internationally important influence. As he said: "As the artists of the 14th century are remembered for their cathedrals, those of the 20th century will be remembered for their factories and the products of those factories"[75].

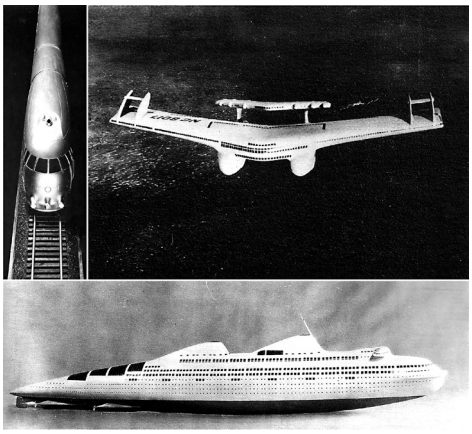
The meaning of this same comparison would be reaffirmed by R. Barthes, in 1957, in the text "The new Citroen" published in his book Mythologies: "I believe that the automobile is today the exact exact equivalent of the great Gothic cathedrals (…)"[76] *(See Figure 16)*.

In the continuity of N. Bel Geddes' organic and aerodynamic language, we find, as already mentioned, Biodesign[77] –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. 1928-2019), 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[78]; for Simca, in 1953, the first European car with a plastic body[79]; and in 1667, the body of the C-Form car, which will be the origin of all aerodynamic bodies with a ground effect[80] *(See Figure 17)*.

In the 70s and 80s, L. Colani proposes a wide variety of biomorphic language projects, developing transports in the form of birds, rays, or sharks. Of these, we highlight the 1977 Megalodon passenger plane, based on the shapes of a shark[81], the Super-High-Speed Monorail Car train, from 1978, based on the shapes a streak[82], or the Yacht boat inspired by the shapes of a whale, from 1981[83] *(See Figure 18)*. As the author 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!"[84].

But L. Colani did not only design transports. His work presents an impressive variety of proposals, ranging from sportswear, lingerie, shoes, glasses, jewelry, watches, pens, weapons, lighters, glass and ceramic tableware, toilets, tap lines, televisions, furniture, and even architectural proposals. In terms of transports, he designed bicycles, motorcycles, automobiles, racing vehicles, sailboats, transportation 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 aerodynamics, ergonomics and product engineering to megalomaniac projects of transport systems that present an organic-expressionist language, sometimes baroque.



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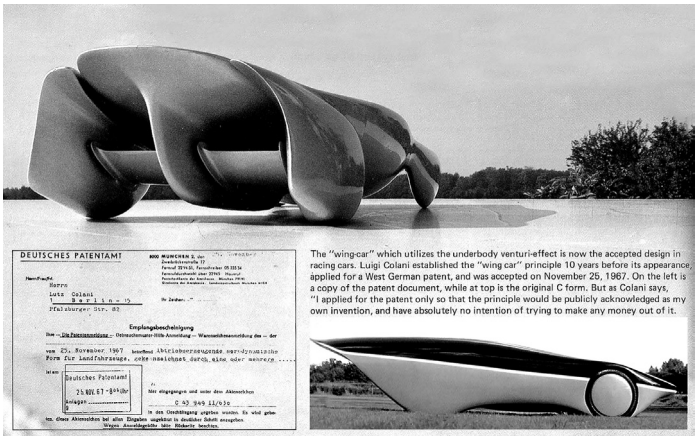

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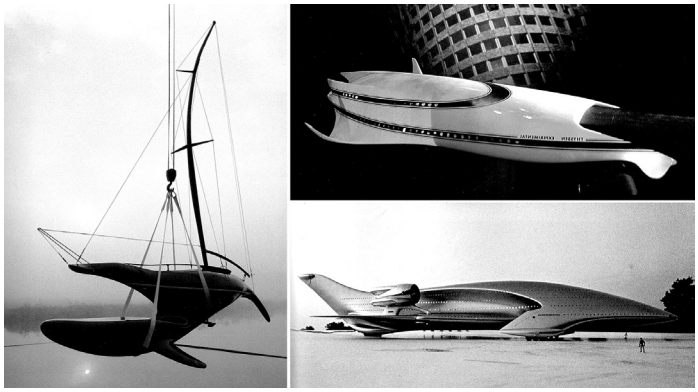

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Figure 15. Transportation projects by Norman Bel Geddes. Above: Locomotive Nº1 (1931), Air Liner # 4 (1929). Below: Streamliner Ocean Liner (1932).
Figure 16. Notre Dame Cathedral from Paris (1163) and Citroen DS19 (1957).
Figure 17. Luigi Colani projects. Top left: original C-Form aerodynamic body and patent (1967). Bottom right: Low consumption vehicle with high aerodynamic capacity, with Cx of 0.2 (1982).
Figure 18. Projects by Luigi Colani: on the left, Yacht (1981); top, Super-High-Speed Monorail Car (1978); bottom, Megalodon plane (1977).