



Analyzing the Architecture of Antonio Gaudí with Reference to Art Nouveau Style: An Inspiration from Nature

Osama Nasir¹, Waqas Akhtar¹, Mohd. Faiz Iqbal², Mohammad Arif Kamal^{*}

¹ Faculty of Engineering and Technology, Aligarh Muslim University, Aligarh, India

² Faculty of Architecture and Ekistics, Jamia Milia Islamia, New Delhi, India

DOI: 10.32629/aes.v3i4.1100

Abstract: Art Nouveau was a global movement that began in the early 1890s and combined two of the most powerful elements in the world: art and nature. Although these two have been associated from the beginning of time, Art Nouveau's significance and impact are far above any earlier attempts. Worldwide, artwork, sculpture, architecture, pottery, and furniture all exhibited this new style. Although there were many supporters and benefactors of Art Nouveau, only a select handful achieved the recognition and distinction of Antoni Gaudí. Sustainability and bio-education have been the hottest topics in the globe today. Hence, providing everyone with a search box for a solution. Let's take a look at the natural world around us, which is a never-ending source of lessons in effectiveness and a never-ending source of architectural inspiration. Moreover, what we actually need is learning, not just inspiration, which comes in second. As a result, and particularly for us as architects, it is within our power and duty to address sustainability in this plot — the architecture — with which we have been entrusted. The paper explores Antonio Gaudí's philosophies and works, the effectiveness, the bio-learning, the self-sufficiency of nature, and other specific lessons that can be extracted from nature in order to be applied to architecture and to human life itself in order to help understand these inspirations from nature. The masterpieces by Gaudí reveal what made him special: his faultless exploitation of nature, extremely religiously inspired design, and unheard-of modernism. This combination not only helped Gaudí become famous around the world, but it also helped Art Nouveau become one of the most significant trends in art and architectural history.

Keywords: Antonio Gaudí, Art Nouveau, architecture, nature, inspiration

1. Introduction

Art and nature are two of the most potent and enduring effects on our planet. Since the Paleolithic paintings at Lascaux and Pech Merle, these two forces have been at work, eventually leading to the creation of one of the most well-known art movements: Art Nouveau. Beginning in the early 1890s, Art Nouveau challenged conventional notions of what constitutes art (Paul, 2000). Victor Horta and Henry van de Velde were instrumental in the rapid expansion of the international Art Nouveau movement, which began in Europe and North America and swiftly spanned all of Europe by the end of the nineteenth century. According to Michèle (2012), it was known as Glasgow style in Scotland, Stile Liberty in Italy, and Sezessionstil in Austria. Each of these countries has a well-known artist who served as the ambassador of Art Nouveau's cultural adaptation there. Antoni Gaudí, the founder of the Art Nouveau style, garnered the attention and acclaim that few others did because he incorporated elements of nature and religion into all of his works.

Each of us has come to understand the significance of living in a sustainable environment as a result of the rising global concerns and events that have had an impact on our planet over the past 50 years. Sustainability has become a crucial global concern affecting all people (Ching, et al., 2014). Nature, which is both invisible and obvious, has the solution to this crucial and urgent issue (Estévez, 2002 A). We learn from "Nature," which is another aspect of this. It is feasible to see invasions and plagues as a result of the same natural process known as "bio-plasticity of nature" (Estévez, 2010). To completely understand the history of the art movement, one needs to look at the historical occurrences of the period, especially the shift in industrial power. Great Britain, the prevailing country at the time, was losing influence over the production and distribution of industrial goods (Paul, 2000). These countries were forced to search for new trading partners and territories to increase their dominance. John Ruskin's statement that this technology was "nothing but ugliness and despair" shows that the majority of people opposed it despite the fact that it was novel (Laurence, 1982). Out of a need for what was real, the majority of people in the world drew back to nature, the basis of our world.

The foundations of Art Nouveau architecture are generally regarded as being the rejection of traditional architectural styles and, in particular, the use of new industrial materials (steel, reinforced concrete, and dating to the Art Nouveau period for potential information on the materials' recipes and placement technologies). This enables the formation of repair recom-

mentations for the preservation of Art Nouveau architectural history on a European scale, as well as the development of an in-depth understanding of the construction materials employed throughout the modernist era, as a foundation (Sandrolini and Franzoni, 2006). Because of the migration from rural and underdeveloped areas to big cities, nature was more scarce than ever. Nature had become an observational science and was no longer a part of life. By 1860, there was a genuinely diverse and exotic selection of plant imagery, as Paul Greenhalgh noted. Books about famous botanists' journeys, like those of Alfred Wallace in the Malay Archipelago and J.D. Hooker in the Himalayas, allowed aficionados to learn about the plant life of the majority of world religions without leaving a library or bookshop (Paul, 2000).

With their "magnificent portrayals of cellular life," these publications "presented organic life to a wide public for the first time" (Wallace, 1905). The general public and scientists were also able to appreciate and explore the natural world with the aid of direct observation. This inevitable solitude led to nature becoming a "primary source of urban enjoyment" and a "important source of artistic inspiration" all around the world (Paul, 2000). Nature and modernity both have a big impact on Art Nouveau's originality. Rejecting the old, "dominant, and change-resistant art formulations" was the intention behind this concept (Paul, 2000). They thought that "art and life were intertwined," contemporary artists attempted to incorporate their unconventional aesthetic into daily life. Although combining the fine and applied arts was not one of Art Nouveau's primary objectives, it was something that very few other movements had done before (National Geographic, 2010). By merging the ideas of modernism and nature, Antoni Gaud evolved the Art Nouveau movement into the Barcelona style of Modernism. Spain will always remember Gaud as the "priest of beauty" of Barcelona (Gijs, 2001). This creative genius, who had a major influence on the Art Nouveau movement, revolutionized by using nature exclusively in all of his creations.

2. The Art Nouveau Moment

The turn of the 19th and the start of the 20th centuries saw the emergence of a new style in the history of European and American art. It first appeared in the 1880s of the nineteenth century in an effort to depart from the established stylistics and produce something fresh and original. Its peak period is regarded as being from 1890 and 1910 (Kubalska, 2005). During the same period, this tendency emerged in other nations under various names. Art Nouveau, also known as The New Style, The Wavy Line, or The Neo-Floral Style, was a common word in England. Similar to the United States, Art Nouveau, or "Modern style," was the name given to the new artistic movement in France. All of the names highlighted the variety of the recently developed art and encapsulated its key characteristics (Wallis, 1984). The art movement known as Art Nouveau was born in response to the Industrial Revolution. It was incorporated into art in accordance with the technological developments of the time, such as the decorative processing of iron. Asymmetry characterizes this kind of art, which also uses geometric shapes, animals, flora, fauna, and plants. Art Nouveau was inspired by nature, mathematics, city art, Islamic art, and Japanese art. Two of its representatives were Henry Vande Velde and Antonio Gaudí (Tietz, 2000).

Art Nouveau was characterized by its ornamental elements, linear design, and flowing, wavy, and naturally curved lines that drew inspiration from nature. Gentle pastel tones have taken the place of the previous years' vivid, saturated colors (Estreicher, 1986) (Pekala, 1995). The new aesthetic shifts from decorative and painted art to architectural and landscape art (Wallis, 1984). Antonio Gaudí made a significant contribution to the popularisation of the new style with his structures namely Casa Batllo, Casa Mila, and Sagrada Familia in Barcelona, whose organic facade shapes and ornamental features made them the most recognizable secession symbols in the world (Zerbst, 2004). Designers like Józef Mehoffer and Stanislaw Wyspianski were well-liked in Poland.

2.1 Evolution and Origin of the Art Nouveau Moment

The emergence of Art Nouveau was impacted by numerous elements. The industrial revolution's advancements in metal technology encouraged this rigidity of fashion by making it possible to produce items in large quantities using machines (Kubalska, 2005). The glass vases, bowls, and other items created by the French artist and designer Emile Gallé are still highly appreciated for their sinuous curves and subdued colors (Figure 1). His fascination with botany and evolution, however, is less well recognized. One of the pioneers of the important art and design movement known as art nouveau was Gallé. But when archaeology grew in popularity in the middle of the 19th century, it started to become fashionable to wear jewelry inspired by ancient Greek, Roman, and Etruscan artifacts. This historicism sparked a romantic resurgence in which artists turned away and looked solely to nature for inspiration. A comparable resurgence of interest in the design aspects of Gothic and Celtic art was observed in the British Isles, and this phenomenon paralleled the gradual resurrection of interest in the intricate curving forms of rococo in France.



Figure 1. Emile Gallé vase with an etched dragonfly

The restoration of trade with Japan in 1854, however, was arguably the single most significant factor in the development of Art Nouveau design. Many western painters and designers were enthralled by the Japanese art that was on display in Europe at the end of the nineteenth century. The Parisian art community was further introduced to Japanese design principles when Siegfried Bing (1838-1905) started a Japanese import store there in 1871 (Weisberg, 1986). Chrysanthemums, a significant symbol in Japan and a decorative motif used by Gallé, piqued the curiosity of both the French artist and the Japanese botanist Hokka Takashina.

The 19th century saw the introduction of exotic plant species to Europe for the first time, including the tiger lily, bleeding heart, and orchid. His meticulous observations led to the creation of plant, insect, and animal themes that also included deeper significance. According to Jennifer Hawkins Opie in *Art Nouveau* (Jennifer, 2000), "Beetles denoted industriousness; the thistle symbolized Nancy, Lorraine, and separation from Germany; the rose symbolized France and the lover." Art Nouveau transformed the numerous influences into a distinctive type of art that found expression in jewelry, fabrics, furniture, wall coverings, and perhaps most pervasively architecture. It became a metaphor for the metamorphosis of the times.

2.2 Elements of Art Nouveau Style

Art Nouveau style is known for its undulating, asymmetrical lines, which frequently resemble flower stalks and buds, vine tendrils, insect wings, and other delicate, sinuous natural elements. These lines can be graceful and elegant or have a strong, rhythmic, whiplike force. The main elements of the Art Nouveau moment are namely:

2.2.1 The Organic Motifs

The most well-known motif among the many repeating pictures of the Art Nouveau style is that of a naked or partially clothed lady surrounded by her loose, flowing hair. She is frequently pictured swimming or flying, symbolically showing her freedom (Figure 2). The sinuous interpretation of nature in the Art Nouveau line, which emphasized movement, desire, life, and the youthful vigor of new ideas, is evident in this erotica (Encyclopaedia Britannica, 2002). It is referred to as the "whiplash line," in almost all Art Nouveau designs. *Palingstil*, which means "eel style," is one of the descriptive terms for Art Nouveau.



Figure 2. Partially clad female figures, two pendants and a brooch designed by Spanish jeweler Luis Masriera



Figure 3. Dragonfly brooch with a woman's face in Art Nouveau jewelry

Numerous types of avian creatures were also prevalent in Art Nouveau jewelry. Swans, swallows, roosters, owls, bats, and the peacock in particular are commonly sighted together with other animals. Insects like the dragonfly and butterfly were especially beloved because enamellists could expertly and convincingly depict the gauzy transparency of wings (Figure 3). Scarabs, which have a mystical significance in Egyptian mythology, as well as grasshoppers, bees, and wasps were other popular topics. Fish, seahorses, and other aquatic animals were also shown, along with the chameleon and lizard. Mythical beings and creatures like Medusas, griffons, dragons, and chimeras were a manifestation of a "fascination with the shocking and frightening, with things which are not what they seem to be" (Becker, 1985).

Realistic depictions of the cycles and elements of nature show the Japanese influence. In miniature landscapes, the changing of the seasons was shown while buds or seedpods, full blooms, and withered, drooping flowers expressed birth, death, and rebirth. The Art Nouveau-style use of subdued hue was made possible by these life cycles: Verdant greens, delicate pinks, mauves, and lavenders were used to depict spring and summer; deep reds and oranges combined with soft earth tones represented autumn, and chilly shades of blue and silver were used to depict the chill of winter.

2.2.2 The Plant Motifs

Numerous decorative plants served as a significant inspiration and fully portrayed the fundamental elements of the new aesthetic movement. The most prevalent motifs included trees, perennials, bulbs, and the as-yet underappreciated herbaceous plants, their stems, leaves, inflorescences, and fruit (Okoń, 2001). In most works of art, plants, animals, and people all have symbolic meanings that were interpreted uniquely in addition to their literal, ornamental value.

Aesculus hippocastanum was widely planted in gardens at the turn of the century and utilized as a decorative motif due to the distinctive structure of its leaves, which comprises 7 obovate leaflets (Encyclopaedia Britannica, 2002). Facades, metalwork (such as the stair balustrade), murals, paintings, and applied arts all included it. Many Art Nouveau structures had decorative elements in the form of different tree species, e.g. *Quercus robur* [the building facade at 17 Narutowicza Street or 9 Szopena Street in Lublin (Figure 4)].



Figure 4. The Oak leaf motif at 17 Narutowicza Street in Lublin, Poland

Tropaeolum majus, with its procumbent, flexible stem, distinctive oval leaves, and delicate blooms, was also well-liked. Despite having grown in gardens since the 17th century, it rose to prominence as a result of these qualities. It can be seen on building facades, and paintings, and as a companion to iris, lily, and helianthus. *Papaver rhoeas* were frequently utilized in decorating. *Papaver rhoeas* (similar to *Tropaeolum* in its slenderness and softness) was also frequently used as a decorative element (Figure 5).

Due to their decorative characteristics and different symbolic meanings, *Rosa* and *Lilium* have gained enormous popularity. These themes can be seen in applied arts (a section of the fencing in Schopp Villa in Vienna, Austria), painting, and drawing (armfuls of flowers consisting of *Rosa*, *Lilium*, *Papaver*, *Iris*, *Dianthus*, and *Campanula* are present in posters and a series of large-format canvases by Alfons Mucha), and architectural style (*Helianthus*, *Lilium*, *Rosa*, *Tulipa*, and *Papaver* decorate the Art Nouveau buildings).



Figure 5. The balustrade of a balcony with the poppy motif in an Art Nouveau building at 3 Maja Street, Katowice, Poland

Many structures and commonplace items are decorated with its erected stems, leaves, and original flowers. They are shown in drawings and paintings. The Franciscan church in Kraków's chancel and transept are decorated with iris-themed Art Nouveau polychromies and stained glass windows (Okoń, 2001). What makes Lublin stand out is the abundance of structures with sunflower decorations, which Iris used to symbolize the verticality of inside doorways.

2.2.3 Interplay of Materials: Concrete, Iron Work, Ceramics and Stained Glass

A vast range of materials, including iron, glass, concrete, wood, and ceramic, were available to Art Nouveau architects during the Industrial Revolution, allowing them to build free-form and nature-inspired designs. Many Art Nouveau exteriors have concrete and ironwork sculptures (DK Studio Architecture, 2022). Traditional designs for intricate iron gates, railings, and balconies include asymmetrical balusters and vine-like motifs. Antonio Gaud and other architects created extremely sculptural facades that occasionally had no flat surfaces at all. The color scheme that nature already provides serves as the source of inspiration for Art Nouveau. Historically, architects and designers used greens and browns as the foundation of their designs, highlighting them with deep jewel tones like yellow, indigo, dark red, and violet. Stained glass or ornamental window panes can be found in many Art Nouveau structures (DK Studio Architecture, 2022). These windows frequently featured abstract motifs inspired by the shapes of flowers and climbing plants or sceneries from nature.

3. Materialism: Building Materials and Technology

Regarding architectural design, construction methods, and building materials, the Art Nouveau movement has been interpreted in a wide variety of ways. In Italy, modern materials, such as cement-based mortar and concrete, were mostly used to create embellishments that were intended to resemble genuine stone. "Artificial stones" were created using a cement binder. The agglomerated cement-bound stones that were thus formed may be made in a wide range of hues and textures.

However, a large amount of workmanship was used in the series-production of façade decorative elements (columns, ledges, moldings, and floral stylistic features). The molds were frequently filled twice, with the first layer of fine mortar providing the appropriate surface effect and the second layer of rough concrete, sometimes reinforced, filling the internal space after adequate compaction and some hardening (Figure 6). The technology for making molds was also highly sophisticated, especially when decorations (usually flowers) required a strong undercut. In these situations, detachable molds or even jelly molds were utilised.



Figure 6. a) Precast concrete columns on a weak sandstone base in the Sacro Cuore Church in Bologna, Italy; b) detail of a column where the external cement-based mortar layer is detached from the concrete core

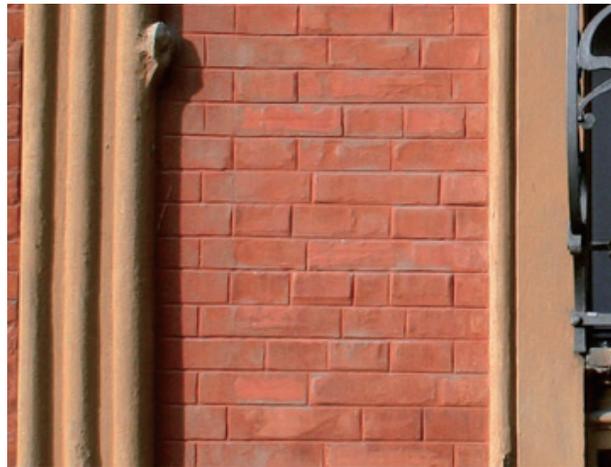


Figure 7. The scratched cement-based plaster imitating sagramatura in the Girasoli House in Bologna, Italy

In the Girasoli House in Bologna, the common brick walls were covered with a cement-based plaster that was carefully scratched at the fresh state to imitate the brick-to-brick joints and then red painted (Figure 7), to hide the texture of possibly irregular bricks and to reproduce sagramatura (Marinelli and Scarpellini, 1992). It is noteworthy that modern materials were used side by side with traditional ones, such as natural stones, lime mortars with ground brick, etc. In order to create a very thin protective layer comprised of a fine mixture of scraped brick powder and joints lime mortar, a recently constructed masonry wall was repeatedly rubbed by a masonry brick fragment using the traditional Sagramatura surface finishing process in Italy (Marci, 1565). This demonstrates how, throughout the Art Nouveau era, antiquated placement methods and modern materials occasionally coexisted.

Another illustration is the employment of the graffito method, which was also adapted from an extremely old Italian tradition, to embellish plasters with classic Art Nouveau female figures in some of the structures under examination. The façade decorations of Italian buildings were made of ceramic tiles or steel, but these materials were supplied by outside artists or businesses working in the fields of applied arts and industrial design, like William Morris' "Arts and Crafts" or Italy's "Aemilia Ars" (Cremona, 1984).

The situation was very different in Portugal, where traditional materials like hand-carved stone, lime plaster mortars, and gypsum plaster were mostly used to create Art Nouveau ornamentation. Even the ceramic tiles, which feature classic Art Nouveau figures, were created using the antiquated azulejos process (Veiga and Galhano, 2003), with the design patterns just being adjusted to the new style. The major load-bearing structural walls were constructed using adobe bricks, but in certain spots, burned clay bricks or wood were also used (traditional tabique, a wood structural wall coated by thick plaster layers).

The following summarises the fundamental definition of Casa Major Pessoa's structure:

- Adobe bearing-load walls (perpendicular to the façades);
- Hefty, painstakingly carved limestone blocks in the façade;
- Thin stone columns supporting certain points;

- Timber trusses in the roof; and
- Timber beams in the floor bearing directly on the adobe walls

Gates and railings for the stairs and windows were made of steel. In Poland, natural stone was primarily employed for statues adorning the exterior walls and only infrequently for façade decorations constructed of cement-based mortars or concrete. While cast-in-place ornamental details were occasionally found, the majority of the mortar/concrete decorations were made and cured (by tiny in-series manufacturing) outside of the construction site.

In order to create a visual contrast between the decorations and the background, the cement-based embellishments were either added to plastered façades or unplastered brick walls. The ornaments were frequently colored, indicating that they served a purpose more than merely imitating stone, as is frequently seen in Italy. In contrast to Portugal, where steel was mostly employed in rails for façades, decorative ceramic tiles were used exclusively for interiors.

4. Nature: The Inspiring Context

Let's take a look around now. We don't have to travel far. In our own cells, bones, and physiological systems, it is readily apparent to us. Even though we can't see it, it exists in all the huge and small plants and creatures that are all around us (Estévez et al., 2020 B). Here is where to locate the best sustainability model: Nature is all there is. "Nature" is defined by humans as an abstract concept, a human figuration of the collection of constituent parts that make up our world. Life has been evolving in nature's "laboratory" for millions of years with the primary goal of just "surviving." From the simplest to the most complicated, it has evolved. Our objectives—those of nature and humanity—converge. However, when it comes to its "science" and applications, nature has a significant advantage over us. Therefore, we must concentrate on using bio-learning to learn from it (Estévez, 2014). Every area of human knowledge must establish a unique bio-learning path. In our example, we'll aim to apply bio-learning to the discipline of architecture. This is when Antoni Gaudí, a famous pioneer and champion, enters the picture. He was the first to go beyond the instant inspiration that nature provides and apply it to architecture beyond its simple formal application, which is something that architects occasionally accomplish.

4.1 Nature: Our Origin

In order to move forward in today's greatest and most critical problem for humanity, paradoxically, we must look "backwards" towards the beginning of everything. The best possible understanding of sustainability that we can put into practice must be learned from Nature and all that it has to offer. That is where the problem began and is still the best place to look for solutions to ensure the sustainability of the entire world. With life, nature finds a solution to planetary sustainability. The same path must be taken by humans. The progress of architecture from its beginning to the present, leading to ideas like Genetic Architecture (Estévez, 2003), Biodigital Architecture (Estévez, 2015), and Metabolic Architecture (Dollens, 2017), has been yelled out loud for many years.

In some cases, we are able to apply living plant elements—which are sustainable, renewable, and recyclable—to architecture. For example, façades that block the direct incidence of the sun by casting a shadow on the walls can prevent heating in the summer, emit oxygen, and absorb carbon dioxide and dust. Today, any effort to breathe life into architecture should not only be welcomed, but also be required. When history is written, we will look foolish if we don't pay heed to the *Zeitgeist* and the signs of the times because today, in addition to the tremendous advancements in biological science, we also have the enormous support of digital technology. We must have brains and the willingness to take on the challenge of our time in addition to the power of the media that we currently possess. Sensibly, for modifying the goals, the methods, and the applications of the findings.

4.2 Nature: Efficiency

The maximum level of compression building was achieved during the Art Nouveau period, revolutionising architectural history. Furthermore, we should acknowledge that the sinuous shapes that result are those of Nature. Through natural evolution, the best structural geometries have been chosen. This geometry, which consists of conoids, ellipsoids, hyperboloids, paraboloids, and helical development patterns, is what gives living things their trunks, branches, stems, and other structural components (Estévez, 2002).

As we can observe in nature, the growth of trees is governed by paraboloids, hyperboloids, and helical growth patterns. And Gaudí constructed the entire interior of the Sagrada Família Church using paraboloids, hyperboloids, ellipses, and helioids, for example, where the pillars of the Basilica stretch out like tree branches and follow the natural lines of thrust from the structure above (Figure 8).



Figure 8. The Paraboloids and hyperboloids of a tree and the paraboloids and hyperboloids of the Sagrada Familia Basilica columns

We can learn from nature's lessons at any time; all we need are open minds and sensitive, receptive souls. For instance, plant leaves achieve the best balance by covering the maximum area feasible, absorbing the most light, and allowing water to pass, preventing overloads in the event of rain. Similar to this, bones in nature balance most well when they adopt hyperbolic shapes. When made of the same amount of material as traditional architectural columns, they are more durable than cylindrical shapes.

Gaudí's whole body of work as an architect was only possible with the help of Nature and her guiding principles. Additionally, he was able to synthesize a fundamental aspect of nature, which led to the configuration of continuity as a value, an intelligence value, and a quality indication. One crucial aspect of Nature is the continuity of forms, which allows for the resolution of each part's purpose while maintaining the integrity of the whole. This is the perfect fusion of form and function that we have learned from nature.

4.3 Nature: The Self-Sufficiency

In fact, in order to maintain the sustainability of the earth, and as Nature teaches us, every living thing, in every region, in every country, as well as every structure, city, and region must strive towards self-sufficiency (Estévez, 2020 C). Everything must thus be created with that trend in mind. Nature is incredibly precise and efficient in how it allocates resources for the skeletal system, respiratory system, digestive system, and other systems that makeup living things. One may point to the idea for a telecommunications tower in Santiago de Chile as an illustration of self-sufficiency and taking part in the production of an abundance of resources (Figure 9). The entire structure of this project evolves through fractal development using digital design, capturing the values of complexity, unity, harmony, organicity, and continuity—the values of beauty that every living thing has in Nature. Additionally, parabolic and linear antennas are planned. Along with spherical luminaries that, at night, evoke the image of "the crown of the city," in keeping with Bruno Taut's concept of the "Stadtkrone" (Taut, 1919). The brightness of the spheres creates the same appearance throughout the day. Instead of one of those telecom towers that dot the mountains and city skylines, it appears as a crown.

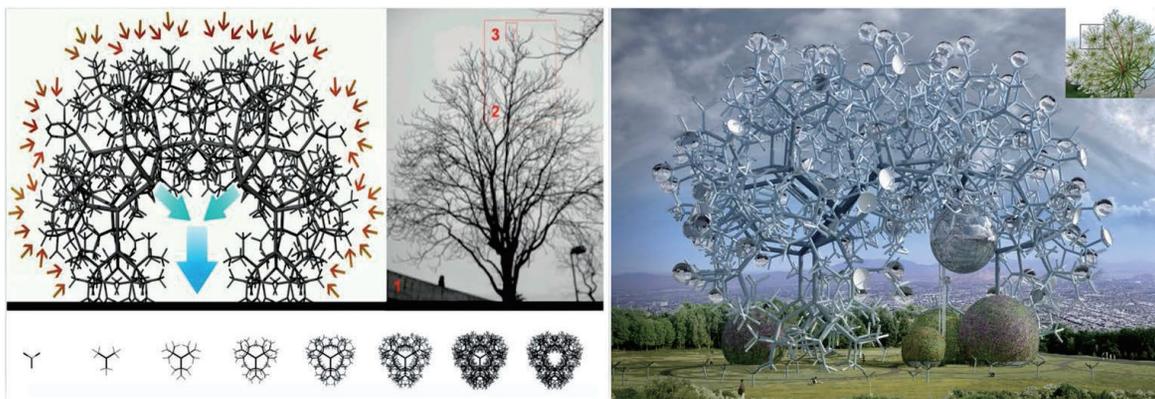


Figure 9. The Telecommunications building at Santiago de Chile

The ability of Nature's beings to regenerate and heal themselves on their own accord is another sign of its self-sufficiency. In order to achieve reinforcement (El Gazzar et al., 2021) or as a sort of "self-healing" of potential cracks that may develop in the various construction materials, for instance, of "living tissues" that would grow on their own in the places damaged by some pathology. In conclusion, all new construction needs to be self-sufficient. Any technical defense against

this is now obsolete.

4.4 Nature: The Inspiration

It may be stated that "Nature," as it is colloquially and generally understood around the world, has always served as people's primary source of creative inspiration. Based on the idea that the earliest ornamental items were created by nature herself. Shells, conches, flowers in the hair, bones around the neck, etc. Nature creates everything in harmony, down to the very last detail. Being set up in accordance with the traditional idea of beauty.

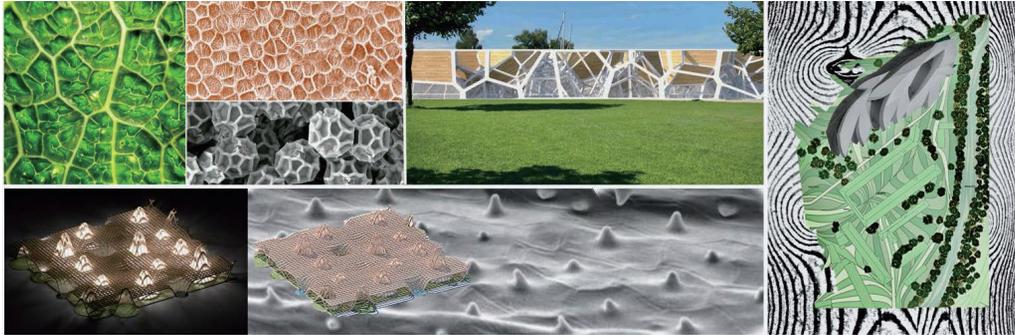


Figure 10. Examples of generative design, a biological system applied digitally to architecture

The ideals of classical Rome and Greece have served as the primary sources of inspiration for architects for many years. They started looking for what that new modern architecture would look like, therefore rejecting all the styles of the past and searching for the style of the new modern period. The extent to which nature may serve as an inspiration for building was then found. Although, as has been noted, only Gaudí had been able to see past the elaborate exterior, searching for answers to the rules of nature and proclaiming that Nature was his teacher by profoundly demonstrating not just the existence of skins but also of souls, systems, and structures. So, using a design that takes its cues from nature would be a simple way to start explaining this idea. However, the real goal is to transcend simple inspiration. It's all about taking cues from nature. And it's not just a surface-level inspiration from nature, like when someone creates a fleeting cloud of smoke. But in reality, it is education rather than just inspiration (Estévez, 2021).

Therefore, the similarity between the biological and the digital is confirmed in this learning. A comprehension that would combine biotechnology and digital technology to the farthest extent possible. It should be perceived as actual learning, not only as inspiration. A comprehension of designing architecture using open systems rather than concrete, particular, closed forms or using generative design. Then comes an understanding of their systems, relational functionality, and long-term effectiveness. Yes, the first stage in the creation of such a structure would be inspiration, paying attention to human people's innate attraction to and interest in living things. Understanding the digital tool will also ensure its harmony both overall and in each of its components (Figure 10 and Figure 11).



Figure 11. Examples of generative design, learning of biological systems applied digitally to architecture

Such a design has elements that go above and beyond mere inspiration. It is education. It also goes beyond simple imitation. Not literally strong, but philosophically "strong." All of this contributes to the development of a true architectural design approach, one that creates specimens with unique DNA rather than focusing on designing a single building but rather an entire species of buildings. Given that their "digital DNA" can be combined to create new "building beings," it is possible to refer to them as "species of buildings," "breeds of buildings," or "races of buildings" (Estévez, 2021)."

To put it simply, if we want to learn from Nature, we must constantly be curious about the nature of its creatures and how they coexist with other species. Living things do not harm their own essential environment, hence yes, they are sustainable (Estévez, 2021). They are perfectly integrated with the climatic environment and live there. They don't require resources

from the other side of the earth because they are self-sufficient. They work together and coexist as symbiotic organisms. Additionally, they never steal more than they can get away with. These sustainability lessons not only apply to architecture but to every aspect of our lives. To our traditions and social understanding, with wisdom, rationalism, and profundity. And it is at this point that the wisdom of the decent legislators who write the laws should be put to use so that we can understand the problems that call for personal responsibility and education.

5. Antonio Gaudí: A Pioneering Architect

Gaudí, who was born in 1852 into a family of artisans, grew up admiring the work of his metalsmith father. It was clear from a young age that Antoni possessed a remarkable aptitude for creating "three-dimensional volumes and structures" in his mind (Maria, 2003). His introspective tendencies, which influenced his love of nature, added to this aptitude. Along with his love of the natural world, Gaudí's education also had an impact on his legacy as a designer. When Gaudí was a child, the Catholic Church controlled the bulk of the schools. His education, which placed a strong emphasis on liturgy, petitions to the Virgin Mary, and the Bible, undoubtedly had an impact on his spirituality and relationship with God, which is reflected in many of his works.

The Sagrada Familia, also known as the Templo Expiatorio de la Sagrada Familia, was Gaudí's crowning achievement and a prime example of both his religiosity and love of nature (Jordi, 2012). The Asociación de Devotos de San José initially commissioned the Sagrada Familia in 1866 for St. Joseph and the holy royal family. While not the project's initiator, Gaudí aimed to turn the neo-Gothic foundation into a "soaring visual story of Christ's life" (Jeremy, 2010). Gaudí was aware that a work of this stature could not be completed during his lifetime. Gaudí committed his entire life to realize his dream despite knowing this. Gaudí drew inspiration from the natural world, which he considered to be the direct creation of God, to realize this ambition.

5.1 Art Nouveau and Antonio Gaudi: The Way of Nature

Antonio Gaudi is well-known for his original works. Only a select few people are aware of the true and profound bio-learning of Nature that lies beneath the shapes of his construction. Gaudí said, "This is my instructor!" while pointing to a tree close to his studio when someone inquired about where he had learned architecture (Bergós, 1974). Because of his precarious health as a child, he spent a lot of time in the country, where the mountains, stones, trees, flowers, birds, and insects helped him get stronger by overcoming his weaknesses. Little Gaudí amassed the cleanest and most beautiful representations of Nature, whom he referred to as "my teacher," and even in his advanced years, he enjoyed recalling them (Bergós, 1974). At the same time, he "created a personal architecture based on applying what he acquired from Nature to his work" (Bonet, 2000) since he was "gifted with a tremendous gift of observation" (Bonet, 2000). Additionally, each of us should learn this lesson from Gaudí. To gain knowledge from nature while viewing it through the lens of our profession, in Gaudí's case, architecture (or "with spectacles on").

It is simple to be in awe of Nature's forms when viewed from the outside, yet that is insufficient. As soon as we focus more intently, its operational aspects fascinate us. For instance, sunflowers turn their heads throughout the day to follow the sun's path across the sky. At the start of his professional career, Gaudí paid homage to sunflowers by including them in the designs of his first two ceramic works. When Gaudí began building Casa Vicens, his first home, he felt bad for the tiny yellow flowers on the job site that were destined to vanish. Therefore, he made the decision to permanently conserve them in the colorful ceramic tiles that covered the entire structure. Before anyone talked about ecology, Antoni Gaudí was a wonderful example of someone who respected the environment (Estévez, 2002 A).



Figure 12. Left: catenary (free-hanging chain) and parabolic-catenary arches. Right: a string model, hanging from the ceiling with bags of sand to calculate the weight proportional to that of the real construction

In that regard, the fact that he ventured beyond the simple external forms of Nature, till, as he claimed, he was learning the hidden laws of the cosmos as his contemporaries did in the architecture of the late nineteenth and early twentieth centuries, Gaudí did not embrace the various arches characterizing each architectural style. He would have a catenary arch of his own. That is his unique constructive system, which is unrelated to any earlier historical aesthetic. If you look at a free-hanging chain, you can understand how the catenary arch works (catenary). In order to determine the weight proportionate to the weight of the actual construction, he made string models, hung them from the ceiling, and tied sacks of sand to them. The designed building's structure was revealed in the most structurally effective manner by flipping the model's photograph upside down (Figure 12).

Gaudí went above those engineering infrastructures and was the first to elevate architecture to a completely new level through the use of his creative reasoning. He was aware of its structural effectiveness on a scientific level. This fact demonstrates that Nature was his primary source of knowledge and inspiration. In addition to its "meat," which was formal and visible, he also found inspiration in its "bones," which were its structures and functions. In nature, bones achieve the best equilibrium by utilizing the least amount of material, increasing their resistance, and adopting hyperbolic shapes. When made of the same amount of material as traditional architectural columns, they are more durable than cylindrical shapes. Knowing this, Gaudí used hyperboloids to construct the vertical parts in Casa Batlló and the Sagrada Família Church, adhering to the same efficiency principle (Figure 13).



Figure 13. Hyperboloids in an image of bones (left), balustrade (Gaudí, Casa Batlló, Barcelona), and pillars of a gallery (Sagrada Família Church, Barcelona)

The helix was a motif that appeared frequently in Gaudí's works (Figure 14). This cylindrical spiral, which may be found in nature in the form of snail shells, was decorated in a number of different ways. The natural line of thrust of the loading is followed by the catenary arches, their resemblance to a parabola, their corresponding vaults of ruled geometry, and the resulting inclined pillars. As in nature, they produce the ideal structural work in the buildings using the least amount of material and the least amount of energy.



Figure 14. Sagrada Família's Interior Stairwell inspired by a helix, in the form of a snail shell

Never clothed haphazardly, Gaudí's creations adhere to the same tectonic functional standards as those found in nature.

5.2 Case Studies

Although the Sagrada Família may be Gaudí's most famous creation, he also created a number of other structures using the same basic concepts. The following two case studies discuss and illustrate how Antonio Gaudí incorporates various natural concepts architecturally.

5.2.1 La Sagrada Família at Barcelona, Spain

The interior structural support is one of Sagrada Família's most noticeable organic designs (Figure 15). Gaudí employed

a vertical framework that resembled the support and appearance of trees (National Geographic, 2010) in place of conventional columns. Gaudí's architecture imitates the safety and tranquility of nature and may enhance one's spiritual connection to God. Naturally, the weight of the leaves was supported by these tree branches, but in Gaudí's cathedral, they also supported the weight of the ceiling's "canopy" of artwork (Figure 16).



Figure 15. The Sagrada Família, Facade, Barcelona

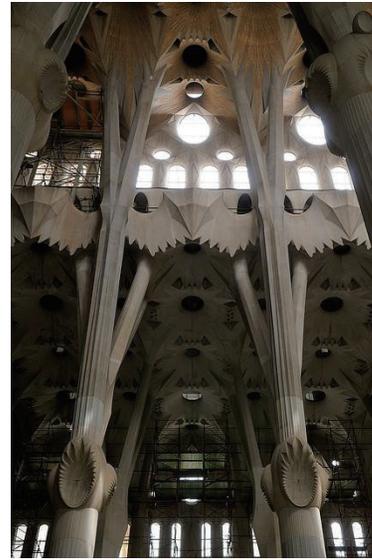


Figure 16. The Sagrada Família, Interior support column, and arches, Barcelona

The doors, like the tree-like columns that support the church's interior, were also strongly influenced by nature. Gaudí affixed lead sacks to a rope in a symmetrical arrangement to determine the shape that would appear to be the most "natural" (National Geographic, 2010). The rope was then hung against the wall and its ends were secured to the wall. Gaudí chose to shape the gateways in the Sagrada Família and several of his other works in the ensuing hyperbolic shape.

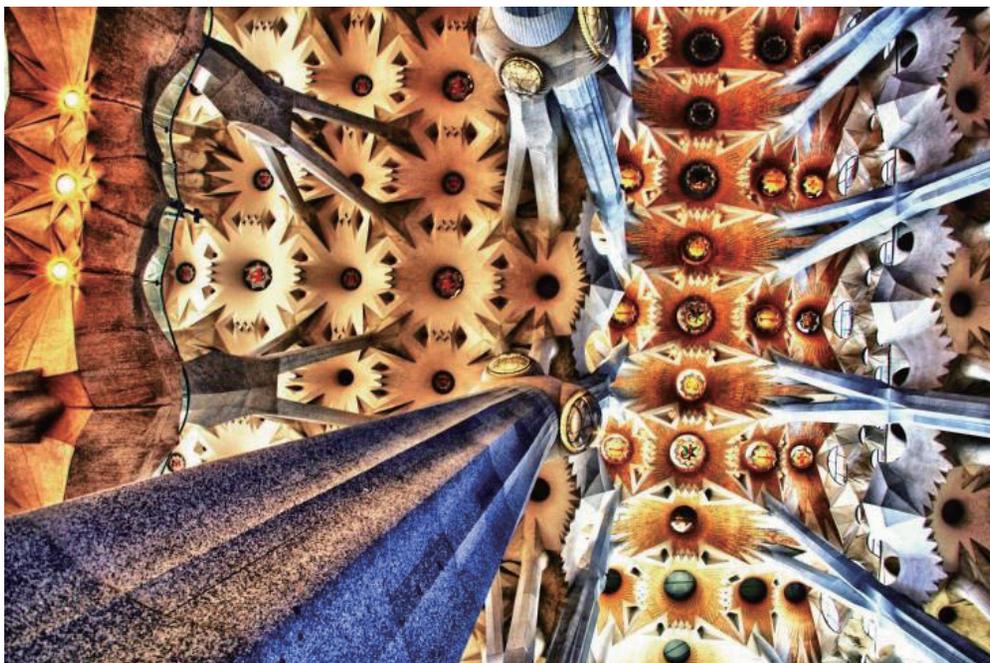


Figure 17. The ceiling of Sagrada Família

Gaudí aimed to use nature as an inspiration for the embellishment of the cathedral in addition to the structural support of the structure. The ceiling was designed to imitate a forest canopy, as noted above. To achieve this, the ceiling was covered in ceramic blooms coated in green and gold mosaics, flowers were set above each vault, palm leaves covered the entire ceiling, and these elaborate ceilings were illuminated with natural, radiating light using colored-glass filters of Temple Expiatori in

Sagrada Família (Figure 17).

The Sagrada Família's stairway design was inspired by the shape of a snail's shell. Gaudí chose to model the staircase after the motion of the dropping maple-seed pods, which he regularly watched (National Geographic, 2010). In addition to illustrating the beauty of God's intricate work, Gaudí may have also wanted to demonstrate the complexity of religion via God's creations. In addition to the helix, Gaudí regularly referred to Barcelona-specific natural features (National Geographic, 2010). These features were mostly used in the famously tall towers of this enormous cathedral, even though they weren't the cathedral's main focal point. A sculpture of a flowering lavender stem is perched atop the apse. Pyrite stones that have been carved into the same shape rest atop the apostles' and evangelists' towers (Figure 18). Gaudí demonstrated his love for Barcelona by utilizing these local natural forms, but more significantly, he utilized God's creations in a piece that was devoted to Him.



Figure 18. The Roof Pinnacles of Sagrada Família

5.2.2 The Casa Batlló at Barcelona, Spain

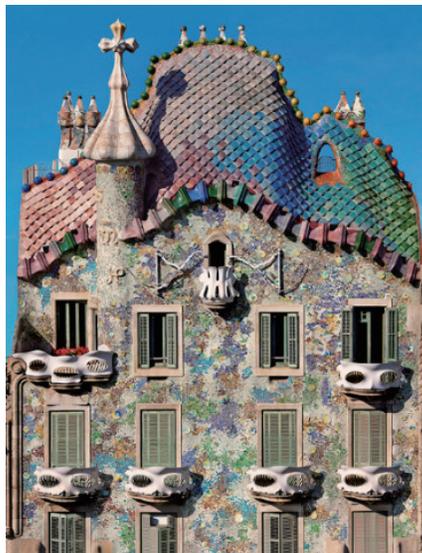


Figure 19. The Facade of Casa Batlló by Antonio Gaudí at Barcelona

The Casa Batlló, described as "the most symbolic masterpiece" of Barcelona and its adored inventive genius, appears as though it were taken from a fairy tale (Casa Batlló History) (Figure 19). Gaudí had complete creative freedom and was not constrained by his client (Encyclopaedia Britannica). Never before had an architect displayed such audacity in his design choices for the building's framework, color scheme, media, and overall aesthetic, all of which were influenced by Gaudí's awe of nature and religious convictions.

The bright, undulating facade of Casa Batlló is one of its most outstanding aspects. Due to its abstract color and design, this multi-colored mosaic has been compared to Monet's famous Water Lilies. More significantly, the building's facade is home to what many people have referred to as a dragon that is perched atop it. There's a good chance that the dragon is a nod to St. George. The Bible claims that St. George saved the daughter of a Libyan king from a dragon in exchange for the king's subjects all receiving baptism (Encyclopaedia Britannica (Saint George)). Gaudí might have incorporated this idea into the building's design to demonstrate his commitment to both his city and his religion. The colorful tiles that depict scales and are perched upon the cornice are used to create the dragon.



Figure 20. The façade detail of Casa Batlló

Gaudí's use of bones was one of the most interesting elements that highlighted his conception of Art Nouveau (Figure 20). Long cream columns that resemble bones span the lower part of the facade and are placed on either side of the windows. Casa Batlló's unusual structural elements earned it the moniker Casa dels Ossos or House of the Bones. Contrary to what one might assume, the playful architecture doesn't have a dark undertone as a result of these forms. It is immediately apparent upon entering Casa Batlló that Gaudí was incredibly devoted to both his craft and the reverence of nature. The inner courtyard serves as the best physical example of how the coast and marine life have influenced the home. This area creates the sensation of being submerged in the sea since it is decorated from top to bottom in various shades of blue in the Inner Courtyard of The Casa Batlló (Figure 21).



Figure 21. The Inner Courtyard of Casa Batlló

Gaudí used a distinctive architectural feature, the ceiling, to allude to the ever-changing sea throughout the rooms on the Noble Floor (Figure 22). These orbs echo raindrops splashing on the water's surface, continuing the marine theme. Skylights that resemble tortoise shells were created by Gaudí to emphasize the marine theme even more. These windows, along with the ceilings and the interior courtyard, add to the overall maritime design that Gaudí painstakingly created in accordance with God's natural order.



Figure 22. The Noble Floor Ceiling of Case Batlo

6. Analysis and Discussions

Art Nouveau is remembered as a period of greater interest in nature despite its brief existence. Many species at the time rose in popularity and served as inspiration for works of art in the fields of architecture, applied arts, painting, and graphic design. A particular interest was shown in plants with adaptable corrugated shapes, straight stems, or unique blossoms. Creepers covering balconies, terraces, and buildings were associated with Art Nouveau. The Art Nouveau era did not influence the subsequent generations to follow any particular composition, but it did leave behind many intriguing instances where the influence of nature is evident.

6.1 Comparative Analysis

Organic themes, or ornamental components, were a feature of Art Nouveau art (plants, animals, or anthropomorphic elements; Table 1). The decorations based on slick plant patterns were employed the most. The animal kingdom was equally fascinating as the flowers. Birds, small amphibians or reptiles, insects, and insects were given special consideration. The primary sources of colors and decorations were butterflies, dragonflies, grasshoppers, swans, and flamingos.

Table 1. The floral and animal motifs in the Art Nouveau period and their meanings

S. No.	Elements, animals, and plants motif	Symbol
Elements		
1.	Line (twinning, straight)	fluency, changeability, movement in nature
2.	Asymmetry	longevity, persistence
3.	Tree	symbol of space, life, youth, immortality, worship of Mother Earth and abundance
Plant Motifs		
1.	Lilium	purity, innocence, virginity, resurrection, and God's providence
2.	Calla	femininity
3.	Dianthus	symbol of marriage, promise of love
4.	Helianthus	affection, symbol of the sun
5.	Iris	symbol of the virgin birth, attribute of Virgin Mary, the sabre-shaped leaf means suffering, grief
6.	Papaver	symbol of night, sleep, dreams, it means death but also sacrifices, vanishing
7.	Rosa	love, memory
Insect Motifs		
1.	Butterfly	resurrection, salvation, symbol of soul, happiness, change
2.	Dragonfly	infinity, regeneration, activity, richness of colors – permanent change
3.	Swan	perfection, beauty, purity, nobility, dignity but also sadness
4.	Peacock	immortality, glory, but also the incarnation of the sun and illumination

Although Gaudí may not have intended for resource consumption to be reduced, his constructions are inherently "light-weight," with the roof's natural curves imparting a strength that required less material and columns patterned after trees that can support larger weights with smaller diameters. The intricate ornamentation's surface mimicry is clearly seen in Gaudí's work. The nature-inspired elements used by Gaudí are listed in Table 2.

Table 2. Basic elements of the building, inspired by nature as used by Gaudí

S. No.	Element of Building	Inspiration from nature	Examples
1.	Structural	Catenary arches, spiral stairways, conoid-shaped roofs, and a novel sort of tree-inspired column or bone-shaped columns using hyperbolic paraboloids as its basis are a few examples of architectural features that draw inspiration from nature.	La Sagrada Familia, Casa Batlló, Gaudí's Crypt, Güell Palace, Gaudí House Museum
2.	Ornamentation	Among the natural aesthetic features are honeycomb gates, a frieze modeled after vines, windows shaped like diatoms, gargoyles showing creatures driven from their homes by the church's construction, and pinnacles in the shape of grasses and pyrite crystals.	La Sagrada Familia, Gaudí House Museum, Casa Batlló, Casa Milà
3.	Facade	Marine-inspired façade were commonly representing waves on a calm day, modernist patterns in a variety of atypical shapes were inspired by various plants and animals, and inspiration from enormous rocky mountains.	Casa Batlló, Casa Milà, Park Güell
4.	Roofs/chimneys	Fire, air, and land are represented by the somewhat varying shapes of the ventilation slots on the roof, roof's design symbolizes a sword embedded in the dragon	La Sagrada Familia, Casa Batlló, Casa Milà

6.2 How Art Nouveau Inspires and Encourages Bio-Learning?

Bio-learning is a practice that still has to be developed. Antonio Gaudí, a bio-mimetics and bioinspired architect, has shown us chances for additional research as well as areas of opportunity. There is the potential for mixing not just at the start of a project but from the beginning of the research into qualities and principles if scientists and artists/architects collaborate on future research. We could see that scientific study may progress not just the discussion of art and architecture, but also the development of its own field.

Additionally, we have witnessed the development of creative and architectural practise, with the addition of bio-inspired components advancing the field. Too abstract, and the design falls short of the biolearning ideal and thus falls short of utilising the opportunity offered by natural concepts. The case examples demonstrate the need to strike a balance between ornament/aesthetics and principle adaption as well as between form and function. Through his prior work, Antonio Gaudí has discovered a way to achieve this equilibrium; in terms of architecture, a balance is created between "ducks and adorned sheds." This equilibrium offers architects the chance to include bioinspired design at all scales and at the core of the creative process, resulting in bioarchitecture.

If we take a look at the lotus leaf, we may use its shape for both aesthetic and practical reasons because it is perfect for collecting rainwater. Similarly, Gaudí was inspired by bones, and other natural biotic components People can be transported through a building effectively by using the same concepts that govern plant circulation. Finally, ideas from photosynthesis and the functioning of the human eye can be used to produce energy and attain self-sufficiency in temperature and light. Through a methodical, deliberate design process, bio-learning as a practice can offer a way to bridge disciplines and seize available scientific opportunities without amalgamation or pastiche.

7. Conclusions

The ideals of classical Rome and Greece have served as the primary sources of inspiration for architects for many years. The many historical idioms of the nineteenth century are then discussed. They started looking for what that new modern architecture would look like, therefore rejecting all the styles of the past and searching for the style of the new modern period. The extent to which nature may serve as an inspiration for building was then found. Gaudí was the artist among thousands who understood the power of these two forces and purposefully created works with them in mind. Gaudí was adding natural perfection to man's faulty effort by replicating God's creation. Nature has had a significant influence on art, from two-dimensional cave paintings to the Sagrada Familia's towering sculptured steeples. Their relationship has achieved extraordinary success, and their masters and creations are both of unparalleled beauty. His work and design style has gained international recognition as a result of his accomplished design and religious commitment. The use of nature and modernism, the cornerstones of one of the most influential painting styles in history, Art Nouveau, come to represent Antoni Gaudí's 38 Casa nation.

It might be argued that learning about nature, bio-learning, and living things inspires solutions and ways of doing things. The Green planet is a way of thinking. It is essential. For the survival of the earth, we must "live Green," in "Green architecture," in "Green cities," and on a "Green planet." And because bio-manufacturing sits at the nexus of nature and computation, it becomes a pillar of our "Green future." As a result of the art's ability to control both from "within". The "green economy" that humanity needs today justifies all of this. In conclusion, all new construction needs to be self-sufficient. Any technical defense against this is now obsolete. Everyone should begin with a good sustainability design. In biological synergy with nature, learning from it (bio-learning), using digital tools for a correct adaptation to our time, and conceptualizing its design and architecture (bio-digital architecture).

References

- [1] Becker V. (1985). *Art Nouveau Jewellery. E, P. Dutton*, New York.
- [2] Bergós, Juan. (1974). Gaudí, el hombre y la obra. *Universidad Politécnica de Barcelona, Barcelona*, pp. 18 and 104.
- [3] Bonet, Jordi. (2000). L'últim Gaudí / The Essential Gaudí, *ECSA / Pòrtic*, Barcelona, p. 12.
- [4] Casa Batlló. (2012). Gaudí's Work of Art: Casa Batlló Barcelona. [Online]; Accessed on: 28th September 2022; Available: <http://www.casabatllo.es/en/history/casa-batllo/gaudi-work-art/>
- [5] Casa Batlló. (2012). History: Casa Batlló Barcelona. [Online]; Accessed on: 28th September 2022; Available: <http://www.casabatllo.es/en/history/casa-batllo/history-building/>
- [6] Casa Batlló. (2012). A Visit to Casa Batlló: A modernist house in Barcelona. [Online]; Accessed on: 05th October 2022; Available: <http://www.casabatllo.es/en/visit-us/information/visit/>
- [7] Casa Batlló. (2012). The Building: The Floors. [Online]; Accessed on: 06th October 2022; Available: <http://www.casabatllo.es/en/history/floors/>
- [8] Cremona I. (1984). Il tempo dell'art nouveau: modern style, sezession, jugendstil, arts and crafts, floreale, liberty. *Al-lemandi*, Torino.
- [9] Dell'Acqua, A. C.; Franzoni, E.; Sandrolini, F.; Varum, H. (2009). Materials and Techniques of Art Nouveau Architecture in Italy and Portugal: a First Insight for a European Route to Consistent Restoration. *Restoration of Buildings and Monuments*, vol. 15, pp. 129–144.
- [10] DK Studio Architecture. The Defining Features of Art Nouveau Design and Architecture. DK Studio Architecture. [Online]; Accessed on: 12th October 2022; Available: <http://www.studiodk.com/blog/history-of-art-nouveau-architecture>
- [11] Dollens, Dennis. (2017). *Metabolic Architectures: Turing, Sullivan, Autopoiesis & AI*, ESARQ (UIC), Barcelona.
- [12] El Gazzar, Nadine T., Estévez, Alberto T., Abdallah, Yomna K. (2021). Bacterial Cellulose as a Base Material in Biodigital Architecture (Between Bio-Material Development and Structural Customization), *Journal of Green Building*, vol. 16, num. 2, College Publishing, Glen Allen, pp. 173-199.
- [13] Encyclopedia Britannica. (2002) Art Nouveau, artistic style. *Encyclopaedia Britannica* [Online]; Accessed on: 28th September 2022; Available: <https://www.britannica.com/art/Art-Nouveau>
- [14] Encyclopedia Britannica (Saint George). "Saint George," *Encyclopaedia Britannica* [Online]; Accessed on: 28th September 2022; Available: <http://www.britannica.com/EBchecked/topic/229970/Saint-George#tocBiblio>.
- [15] Estévez, Alberto T. (2002 A). Gaudí. Susaeta, Madrid.
- [16] Estévez, Alberto T. (2010). Application of Life information in Architecture: Biodigital Architecture and Genetics", in Aaron Sprecher, Shai Yeshayahu, Pablo Lorenzo-Eiroa (eds.), *LIFE in: formation / On Responsive Information and Variations in Architecture ACADIA 2010*, ACADIA, New York, pp. 168-173.
- [17] Estévez, Alberto T., Urbano, Judith. (2020 B). Back to the Basics: Return to the Origin, Gaudí and Nature, in Jacqueline A. Stagner, David S-K. Ting (eds.), *Green Energy and Infrastructure: Securing a Sustainable Future*, CRC Press / Taylor & Francis Group, Boca Raton, pp. 273-286.
- [18] Estévez, Alberto T. (2003). Genetic Architectures /Arquitecturas Genéticas. in VV.AA., *Genetic Architectures/Arquitecturas Genéticas*, Sites Books / ESARQ (UIC), Santa Fe/Barcelona, pp. 4-17.
- [19] Estévez, Alberto T. (2015). Biodigital Architecture & Genetics: writings / escritos, ESARQ (UIC), Barcelona.
- [20] Estévez, Alberto T. (2014). Learning from Nature: Architecture and Design in the first Biodigital Age. in Alberto T. Estévez (ed.), *2nd International Conference of Biodigital Architecture & Genetics*, ESARQ (UIC), Barcelona, pp. 8-23.
- [21] Estévez, Alberto T. (2002 B). Antoni Gaudí: Arquitectura cromática. in Judith Urbano (ed.), *Gaudí a París l'any 1910*, Sites Books / ESARQ (UIC), Santa Fe / Barcelona, pp. 7-10.
- [22] Estévez, Alberto T. (2020 C). Sustainable Living? Biodigital Future!. in Jacqueline A. Stagner, David S-K. Ting (eds.), *Sustaining Resources for Tomorrow*, Springer International Publishing / Springer Nature, Berlin, pp. 137-162.
- [23] Estévez, Alberto T. (2021). Sustainable Nature-Inspired Architecture. in David Ting and Jacqueline Stagner (editors), *Sustainable Engineering Technologies and Architectures*, AIP Publishing, Melville, NY (USA).

- [24] Estévez, Alberto T. (2002 A). Gaudí, *Susaeta*, Madrid.
- [25] Estreicher K. (1986). Historia sztuki w zarysie. 7th ed. *PWN*, Warszawa.
- [26] Ching, Francis D. K., Shapiro, Iann M. (2014). Green Building Illustrated. *John Wiley & Sons, Inc.*, Hoboken.
- [27] Gijs van Hensbergen. (2001). Gaudí. *Harper Collins*. New York, XXVI.
- [28] Jennifer Hawkins Opie. (2000). Art Nouveau 1890–1914. *V&A Publications*.
- [29] Jeremy Berlin. (2010). The Big Idea: Biomimetic Architecture. National Geographic, [Online]; Accessed on: 28th October 2022; Available: <http://ngm.nationalgeographic.com/2010/12/big-idea/gaudi-text>.
- [30] Jordi Oliveras. (2012). “Gaudí, Antoni,” in Grove Art Online, *Oxford University Press, n.d.* [Online]; Accessed on: 24th October 2022; Available: <http://www.oxfordartonline.com/subscriber/article/grove/art/T030991>
- [31] Kubalska-Sulkiewicz K., (2005). Słownik terminologiczny sztuk pięknych wyd. PWN.V. Warszawa.
- [32] Laurence Buffet-Challié. (1982). The Art Nouveau Style. *Rizzoli*, New York, 9.
- [33] Marci Vitruvii Pollionis. (1565). De Architectura libri decem, cum Commentariis Danielis Barbaris Venetiis. *Apud F. Franciscium Senense & Ioan. Crugher Germanum* (liber II, caput V: 56-60).
- [34] Maria Antonietta Crippa. (2003). Antoni Gaudí, 1852-1926: From Nature to Architecture. *Köln*, Taschen, 9.
- [35] Marinelli, L.; Scarpellini, P. (1992). La sagramatura. Una tradizionale tecnica di finitura delle cortine laterizie bolognesi. In: *Scienza e Beni Culturali. Le superfici dell'architettura: il cotto. Caratterizzazione e trattamenti. Atti del Convegno di Studi Bressanone*, Libreria Progetto Editore, Padova, pp. 37-47.
- [36] Michèle Lavallée, (2012). “Art Nouveau,” in Grove Art Online, *Oxford University Press, n.d.* [Online]; Accessed on: 26th October 2022; Available: http://www.oxfordartonline.com.ezproxy.jccc.edu/subscriber/article/grove/art/T004438?q=art+nouveau&search=quick&pos=1&_start=1#firsthit.
- [37] National Geographic. (2010). Barcelona’s Natural Wonder. *National Geographic*. Basílica de la Sagrada Família [Online]; Accessed on: 20th October 2022; Available: <http://www.sagradafamilia.cat/sfup/prensa/2010-09-01-01.pdf>
- [38] Okoń W. (2001). Stanisław Wyspiański. Wrocław: Wyd. Dolnośląskie.
- [39] Paul Greenhalgh, ed. (2000). Art Nouveau: 1890-1914. *Harry N. Abrams*, New York, 18.
- [40] Pękala T. Secesja. (1995). konkretyzacje i interpretacje. Lublin: Wydawnictwo Uniwersytetu Marii Curie-Skłodowskiej.
- [41] Sandrolini, F.; Franzoni, E. (2006). Recovery of Art Nouveau European architecture: materials, technologies, degradation and conservation strategies. In: *Proc. Int. Conference “Heritage protection: construction aspects”*, J. Radic et al. Eds, Dubrovnik, Croatia, pp. 379-384.
- [42] Taut, Bruno. (1919). Die Stadtkrone. Eugen Diederichs, Jena.
- [43] Temple Expiatori Sagrada Família. The Tree Structure. *n.d.* [Online]; Accessed on: 26th September 2022; Available: http://www.sagradafamilia.cat/sfeng/docs_instit/estructura2.php?pa=tree.structure.
- [44] Tietz, J. (2000). Story of Architecture in the 20th Century. Konemann.
- [45] Veiga de Oliveira, E.; Galhano, F. (2003) Portugal de Porto. Arquitectura tradicional portuguesa. *Publicoe Dom Quixote*, Lisboa.
- [46] Wallace, A.R. (1905). My lie: A record of events and opinions. *Chapman and Hall*. London, [Online]; Accessed on: 10th October 2022; Available: http://darwin-online.org.uk/converted/Ancillary/1905_Wallace_A237/1905_Wallace_A237.2.html
- [47] Wallis M. Secesja. (1984). Warszawa: Wyd. Arkady.
- [48] Weisberg F. (1986). Art Nouveau Bing: Paris Style 1900. *Harry N. Abrams*, New York.
- [49] Zerbst R. (2004). Antoni Gaudi: wszystkie budowle. Köln: Taschen.