4-2013

Reading Gaudí's Great Book of Nature: Reconsidering the Peripheral Reception of Proto-Environmental Architecture

Mark Pantano
University of Pennsylvania

Follow this and additional works at: http://repository.upenn.edu/uhf_2013

Part of the Architectural History and Criticism Commons

http://repository.upenn.edu/uhf_2013/4

This paper was part of the 2012-2013 Penn Humanities Forum on Peripheries. Find out more at http://www.phf.upenn.edu/annual-topics/peripheries.

This paper is posted at ScholarlyCommons. http://repository.upenn.edu/uhf_2013/4
For more information, please contact libraryrepository@pobox.upenn.edu.
Reading Gaudi's Great Book of Nature: Reconsidering the Peripheral Reception of Proto-Environmental Architecture

Abstract
At the turn of the 19th century, Catalan architect Antoni Gaudi gave physical expression to an environmental consciousness that was emerging from the peripheries of many Western societies in the midst of industrialization. Significantly, most of Gaudi's famous works stand at the physical periphery of Barcelona, affirming the moral supremacy of natural settings over the urban core. Within his intellectual context, Gaudi surpassed all standards of environmental sensitivity. He innovated structural systems by combining ruled geometry with natural anatomies. Further, his projects utilize recycled and local materials as well as prefabricated construction, methods that even contemporary green architects have not fully explored. Beyond proto-environmentalism, the reception of Antoni Gaudi's work depends entirely on peripheral conditions. Barcelona, a politically inconsequential city with burgeoning industrial wealth, sought to establish a central identity in part through cultivating a unique taste for exuberant architecture. These conditions converged in a culture that financed and celebrated Gaudi's vision. However, both Spain's peripheral location in Europe and the dominance of modernism in mainstream architecture sharply curtailed Gaudi's global impact.

Keywords
proto-environmentalism, Gaudi

Disciplines
Architectural History and Criticism

Comments
This paper was part of the 2012-2013 Penn Humanities Forum on Peripheries. Find out more at http://www.phf.upenn.edu/annual-topics/peripheries.
READING GAUDÍ’S GREAT BOOK OF NATURE:
RECONSIDERING THE PERIPHERAL RECEPTION OF PROTO-ENVIRONMENTAL ARCHITECTURE

Spanish Catalan architect Antoni Gaudí (1852-1926) derived many structural and aesthetic innovations from intensively studying the natural environment. Soon after his death, Modernisme architecture in Barcelona rapidly declined in favor of the austere Noucentisme style. Abroad, Gaudí found an unlikely fan in the modernist Le Corbusier, who remarked after a 1928 visit that “what I had seen in Barcelona was the work of a man of extraordinary force, faith and technical capacity, manifested throughout his life in the quarry.”\(^1\) However, Le Corbusier conceded that “[he] was sufficiently indifferent to other people’s opinion to take a keen interest in it.”\(^2\) For much of the twentieth century, the vast majority of people, both academics and otherwise, had remarkably little to say about Gaudí. Here, I consider Gaudí within his geographic, political, and ideological context to understand how his architecture meets and exceeds cultural norms and environmental ideologies in turn of the century Barcelona. I also articulate how Gaudí’s shifting acclaim and marginalization became intrinsically linked with local and global shifts in cultural centers and values. This framework can ultimately be applied to

---

2 Le Corbusier, 22-23
additional architects and time periods to more thoroughly explore the history of proto-environmentalism and environmentalism in architecture as contemporary society seeks to build a legacy of sustainability.

ART AND POLITICS IN GAUDÍ SCHOLARSHIP

Local artists best preserved Gaudí’s legacy through the 20th century – representations of Gaudí line the walls of the Fundacio Joan Miro and the Dali Museum in Figueres. In some ways, his localized artistic fame served as an important incubator for ideas. While Pablo Picasso lived across the street from the Palau Guell, he saw Gaudí’s trencadis every day.³ Salvador Dali became intimately familiar with Gaudí’s work while developing his own language of surrealism.⁴ However, serious academic publications of Gaudí’s work did not accumulate until the 1980s.

After decades of being forgotten, a group of Japanese artists and architects emerged in the 1980s as the first cohesive center of serious Gaudí appreciation. The Japanese admired Gaudí’s attention to detail, his focus on ergonomics, his, his ability to enliven simple materials, and his relentless dedication to artisanal craftsmanship.⁵ The American academia followed within a decade, along with the German engineering community. Now, Gaudí’s architecture has risen to become an international phenomenon.

Gaudí’s marginal position in academia represents a logical consequence of the overwhelming international embrace of traditional modernism, popularized starting in the late 1920s. Spain’s peripheral location in Europe and 1930s civil war rendered Barcelona’s unable to export culture. Even after the war, Francisco Franco spent forty years aggressively stifling

Catalan culture and Gaudí scholarship to impose totalitarianism in Spain. Consequentially, architects and art historians have not fully analyzed the implications of Gaudí’s architecture.

Given the importance of nature to Gaudí, it may be no coincidence that his rebound in popularity follows the rise of environmentalism. In 1962, Rachel Carson’s *Silent Spring* catalyzed the environmental movement. Ten years later, the Club of Rome coined the word “sustainability” in the modern sense. While Gaudí does not qualify as a “green” architect by twenty-first century standards, he meaningfully explored the relationship between architecture and its natural context. Examining Gaudí’s architecture through the lens of environmental stewardship illuminates opportunities to apply his solutions to future works. It also frames analysis of the history of the intersection of the built and natural environments, long at the periphery of academic discourse.

**METHODODOLOGY: FROM PERIPHERY TO CENTER**

Despite rising popularity, a thorough study of Gaudí’s work faces significant challenges. Little Gaudí scholarship has been translated from Catalan or Spanish. Few publications claim academic pedigree, and must be critically considered. Isabel Artigas has published a comprehensive building by buildings guide to Gaudí’s architecture. Additionally, Gijs van Hensbergen’s biography invaluably synthesizes Gaudí’s personal development and place in contemporary society. A more recent series of publication by Mark Burry, current executive architect of La Sagrada Familia, illuminates many of Gaudí’s complex geometries.

Gaudí lived as an artist, not an academic. The writings of contemporary architects such as Domenich i Montaner, Gaudí’s most influential professor, and Henry Van de Velde, founder of the Art Nouveau movement in Belgium, serve as a proxy to understand Gaudí’s thinking. While these authors contextualize intellectual movements throughout Gaudí’s world, Gaudí

---

6 Van Hensberger, xxix
architecturally expressed his ideas and influences to a degree of originality beyond his contemporaries. While Gaudí made hundreds of drawings, a militia in the 1937 Spanish Civil War burned almost all of them when raiding his studio on the grounds of La Sagrada; only his student projects remained. All of his models were smashed along with the drawings, but Gaudí’s geometric rigor provided enough clues for their contemporary reconstruction.

In addition to the lack of primary evidence, the ergonomic and temporal qualities of Gaudí’s architecture provide compelling reasons for a personal visit. No guidebook, however well written, can explain how it feels to turn a doorknob in Casa Milá or sit in a custom bench at Casa Calvet. Spending two weeks in Barcelona also allowed me to thoroughly understand not only the works for themselves, but also how they fit into Barcelona’s urban fabric, and alter the built landscape at different times of day. While visiting each of Gaudí’s works, I took notes and sketched forms, focusing on local lore and unpublished details. La Sagrada Familia in particular required a site visit because the interior space was completed and consecrated in 2010. Little has been published since that time. Continuing construction will last until at least 2026, so I was able to watch contemporary artisans firsthand as they build a building designed 100 years ago.

Ultimately, visiting the works in context led to insights which substantially inform my analysis. I had the good fortune to win both a Penn Climate Action Grant from the Center for Undergraduate Research and Fellowships and a Mellon Fellowship from the Penn Humanities Forum which enabled my travel to all of Gaudí’s important buildings in Catalonia.

After introducing the important buildings for my study, I will contextualize Gaudí first within Barcelona itself and then in the environmental philosophy of industrializing Europe. I will also recount Gaudí’s insistent observation of nature and its application into his architecture. Next, this paper asserts that Gaudí’s environmental considerations exceed those of his
contemporaries through his culturally sensitive practices, his construction innovations, and the sustainable features of his designs. Lastly, I will speak to the enduring applicability of Gaudí’s methodologies. Importantly, the frameworks I have developed to analyze Gaudí’s place in the history of environmental architecture remain applicable to many other architects and time periods. As Gaudí’s work emerges from the peripheries of architectural history, his unique environmental sensitivities show promise of informing contemporary innovation in sustainable design.

**INDIVIDUAL IMPORTANT MONUMENTS**

Gaudí’s current fame comes after constructing only a few dozen works during his lifetime. Several serve as important evidence for this paper. Adorned with tiles depicting the marigold fields once located on the property, Casa Vicens (fig. 1) represents an early confluence between *Modernisme* and Gaudí’s original style. His earliest house originally occupied a garden lot in an outlying neighborhood, and expressed a geometric interpretation of the Moorish architecture of the Alhambra which inspired Gaudí’s earliest work. Both the exterior and interior feature decorative arts, including natural stone, tile, woodcarving, wrought iron, and textured wallpapers.

Eusebi Guell, a wealthy industrialist from a patrician family, became Gaudí’s most important patron and close friend. In 1886, he commissioned Gaudí to build his family’s city residence (fig. 2) adjoining his father’s property in the Raval, a then-declining neighborhood in Barcelona’s gothic quarter. The house significantly experiments with the catenary arch and

---

Fig. 1. Casa Vicens, Gràcia
parabolic dome, important features of Gaudí’s later works. It displays a wealth of decorative arts, a centralized organization, and perspectival tricks to distract from the house’s cramped neighborhood.

In 1900, Guell, inspired by English garden suburbs, asked Gaudí to design infrastructure for an elite subdivision in the hills above the city called Park Guell (fig. 3). Two fairytale gatehouses frame the entrance to the park, manufactured of prefabricated elements and covered in trecadiz mosaic. Gaudí conceived a system of naturalistic rock viaducts set on inclined columns to minimize site impact. At its center, the park features a Doric colonnade originally intended to serve as a neighborhood market. Above, a sinuous trencadis bench surrounds an open space affording views to the city. The subdivision failed, and instead Guell gave the land to the city as an urban park after its completion in 1914.

Though his construction masks most of the original structure, Gaudi’s Casa Batlló (fig. 4) located on the prestigious Passeig de Grácia is actually a 1904-06 renovation of an unremarkable 1877 townhouse. Like many residential buildings in Barcelona, Casa Batlló contains a storefront on the street, a grand apartment for the principle family on the first floor, and tenant apartments...
above. The townhouse explores a nautical motif, clad in scaly, iridescent tiles and punctuated by yawning windows framed in bonelike columns, or complemented by sinuous balconies. A biomorphic lustre tile roof, perhaps alluding to the dragon famously killed by Barcelona’s patron Saint Jordi, crowns a double attic built for ventilation. Inside, flowing plaster walls and ceilings painted with small, scale-like geometries form the visual backdrop for a relatively open floor plan. Handcrafted woodwork, iron, and colored windows complete an artisanal interior paid for with industrial wealth. The rear courtyard features extensive use of trencadís mosaic tile.

Located a few blocks up the Passeig de Gràcia, Casa Milá (fig. 5) remains the last building completed in Gaudi’s lifetime between 1906 and 1910. Colloquially known as La Pedrera, meaning “the quarry,” the large apartment block prominently features austere prefabricated stone cladding regulated by large windows and wrought iron balconies. The building presents as a single mass which curves around a major corner, and is organized around two major interior courtyards where Gaudí introduced an exuberant polychromatic paint scheme. Gaudi’s sculptural rooftopscape of chimney stacks, stair towers, and ventilation units forms Casa Milá’s most famous attribute, and was originally intended to be crowned by a giant statue of the Virgin Mary. The building incorporates
exceedingly modern technologies, including steel framing allowing for flexible planning, and even a subterranean garage.

Though still incomplete, the Crypt at La Colonia Guell (fig. 6) manifests Gaudí’s most striking structural experiment. For a church in an industrial workers’ colony outside the city, Gaudí designed a double stacked nave, and calculated the catenary structure using a hanging funicular model of chains weighted with lead shot proportional to structural loads. Industrial slag forms the primary building material, and other waste products from the factory make up most of the decorative materials. Construction halted in 1916 with only the lower level completed.

The Expiatory Temple of La Sagrada Familia (fig. 7) endures as Gaudí’s most famous and important building. Gaudí acted as chief architect from 1883 until his death in 1926, by which point it had become his exclusive project. The church, financed entirely by penitential donations, will eventually rise to be the tallest in the world. It utilizes a hyperbolic construction system of inclined columns and ruled geometries to articulate its structure, requiring no buttressing. The
Nativity Façade drips with stonework and concrete molded into organic sculptural forms recounting the early life of Christ. All of the bell towers take the form of rotational paraboloids. Mosaic tile work and text sparsely add another layer of decoration to the façade. A schoolhouse on the grounds uses conoid forms for structural integrity. As the temple remains a construction site and will not be completed for several decades, it serves as a laboratory for how Gaudí’s technologies can be enhanced by modern technologies.7

GAUDÍ’S BARCELONA

Catalonia has long been a semiautonomous region. As economic and cultural conditions around Barcelona diverged from the rest of Spain in the 1880s, a new nationalism arose. These sentiments consolidated into the Renaixença, a movement reasserting regional culture based on the search for national identity in Catalonia’s history. It’s most important periodical, La Renaixença, actively promoted these ideals, and documented modern design alongside articles pertinent to Catalan culture. In an 1878 edition, prominent architect Lluis Domenech i Montaner published his article “In Search of a National Architecture,” an intellectual basis of Modernista architecture which called architects to promote Catalan identity through the built environment.

Another more progressive cultural review, *L’Avenc*, also strongly influenced taste in Barcelona by emphasizing cultural openness.

Despite the expressiveness of Barcelona’s individual facades, the highly regulated, chamfered blocks of the Eixample define the urban landscape of the city. Without the order imposed by Ildefons Cerda’s 1857 plan (fig. 8), Barcelona’s eclectic architecture could easily devolve into visual chaos. Cerda further believed good city planning made people healthier. The interiors of all blocks were designed to be shared gardens, and all streets were lined with trees to filter the air. He also believed that a rational city plan could abet the municipal government in confronting economic, administrative, and legal concerns, as the city could be managed systematically.\(^8\) Cerda conceptualized the street as an extension of the house, which could profoundly mediate the interaction between civic and domestic life.\(^9\) The wide boulevards and garden courtyards manifest a philosophy which prefaces public spaces surrounded by the built environment. Barcelona’s physical form was not an end, but rather a tool for holistic development.

The lack of governmental intervention liberated much of the architectural exploration which flourished during this time, but it also meant that the national government did not invest or build major public works in the city.\(^10\) Private and local sources supplied the vast majority of capital needed for Barcelona’s expansion through bonds and real estate speculation.\(^11\) Yet well before anyone began constructing housing, Barcelona extended the street grid and accompanying infrastructure through the 1880s and 1890s.\(^12\) By advancing so much money into the construction

---

9 Soria i Puig, 28
11 Sola Morales, 125
of the new district, the city proved its interest in the high quality expansion of the city. This played large role in reassuring the public in the successful future of the neighborhood, and attracted the industrial elite in droves to construct elaborate buildings by the turn of the century.

Partly as a response to highly standardized building massing, architects fixated first and foremost on ornamentation as a means for expression. In England, William Morris and John Ruskin’s Arts and Crafts movement sparked renewed interests in the decorative arts, which gained influence in the United Kingdom and United States. *Modernisme* reflected and exceeded these contemporary movements. Wrought iron, sgraffito, stained glass, carved wooden doors, and elaborate stonework, and mosaics adorn Barcelona’s buildings in abundance. All of these techniques take advantage of both native artisans and industrial processes. Beyond buildings, furniture, painting, and even things as mundane as door handles from the time period often explicitly exhibit the curvilinear forms and attention to detail characteristic of *Modernisme*.

However, in many cases the decorative arts did not literally seek to reintroduce historical forms. Rather, they created new, moralizing forms using traditional techniques. Especially as urban expansion brought unprecedented social ills, idealistic planners believed that inserting visual allusions to God and nature could temper behavior.

Beyond decorative arts, architects rediscovered and honed vernacular construction techniques. Rafael Guastavino perfected the Catalan Vault (fig. 9), eliminating the need for piers in expansive spaces, and causing brick to become a delicate surface material. Antoni Gaudí experimented with traditional materials to develop the catenary arch for structural purposes, allowing him to emulate traditional arcuated spaces without buttressing.
Augmenting this rebirth of nationalism, many of Barcelona’s most prominent architects ascended to important political positions, abetting architectural aspirations with civil power. Of all of Gaudi’s works, Casa Calvet’s conventional facade would render it insignificant. However, it won the Arts Building Annual Award given by the City Council for the best new building in Barcelona in 1900, demonstrating the widespread societal and governmental support for *Modernista* architecture.

Pluralities of wealthy people seeking validation from society rarely experiment freely with architecture. However, in Barcelona’s rapidly shifting context, the elites demanded an architecture which could respond rapidly and exuberantly. Barcelona’s bourgeois enjoyed significant economic and political power which higher authorities left largely unchecked. Spain’s loss of Cuba in 1898 proved an unexpected boon to the city’s industrial elite, as repatriated capital flowed to Catalonia. For the first time, many of Barcelona’s established rural families sold their family seats to move to the Eixample. Identity had become more fluid, and that the elites recognized industry as the new bedrock of social capital. In a materialistic society, every family tried to out-decorate the others’ townhouses (fig. 10). The city plan strictly regulated building massing, so applied façade decoration became a singular tool for the bourgeois to differentiate their taste and wealth. Architectural whimsy became a tool to avoid anonymity and broadcast success in a new social order.

**TURN OF THE CENTURY PROTO-ENVIRONMENTALISM**
Gaudí did not primarily address contemporary sustainability concerns, yet his deliberate consideration of natural structures, forms, and settings surpasses typical turn of the century proto-environmentalism. Developing an understanding for how Gaudí’s contemporaries regarded nature allows for an accurate characterization of Gaudí’s environmental attentions in context. Largely, turn of the century proto-environmentalism emerged throughout Western Europe and North America as both a result of and an antidote to rapid industrialization.

As politicians recognized the impacts of centuries of heavily managed land use across Europe, and the increasing encroachment of urban development Germany established a forest conservancy, and France passed a wave of motions to preserve open land. By the turn of the 20th century, many countries throughout the Western world actively invested in the preservation of their open spaces, flora, and fauna. As advances in mass printing propagated developments in the natural and physical sciences, an active group of amateur botanists emerged. The advent of mass transportation enabled families to escape industrial cities and experience nature, forging a direct relationship and sensitivity to the natural world. These individuals drove England to pass the world’s first air pollution law in 1863, followed by an international air quality agreement in 1886. Finally in 1909, the International Congress of the Protection of Nature began meeting in Paris. These ventures were isolated, yet demonstrated that an incipient mass of people recognized the implications of human interaction with nature. By and large, the first proto-environmental movement had coalesced over the course of Gaudí’s career.

As industrial cities emerged to become a new urban archetype, problems with infrastructure, sanitation, and poverty expanded at an unprecedented scale. These social issues became comingled with conservation to form the intellectual backbone of a pro-nature school of

---

thought. Many European philosophers focused on these ills as evidence of the moral instability of urban society. Religious institutions especially focused on the link between poor living conditions and social ills. According to a pamphlet on overcrowding by the London Congregational Union, “that people condemned to exist under such conditions take to drink and fall into sin is surely a matter or little surprise,” suggesting that a return to rural life may better serve society. In Barcelona, the rapid construction of the prosperous Eixample neighborhood dramatically changed the character of the older districts of the city. An exodus of the wealthy from traditionally mixed neighborhoods led to unsanitary conditions, rising vice, and fewer empowered citizens able to organize resources to drive positive development.

Such complaints became incorporated into the underlying ideology of the Arts and Crafts movement. John Ruskin, the intellectual center of the movement, published “Unto this Last” in 1896, and argues that wealth and honesty cannot coexist. Further, he admonishes that natural resource extraction by industry undermines the ability of the environment to serve industry in the future, a philosophy which largely

---

15 Ealham, Chris. Una Geografía Imaginada: Ideología, Espacio Urbano, y Protesta en la creacion del Barrio Chino de Barcelona c.1835-1936. 59
anticipates current sustainability philosophy. These international concerns manifested themselves within Catalonia both intellectually and visually; one of *Modernisme’s* most important sources was English Arts and Crafts. Artisans crafted elaborate stone, wrought iron, and other organically inspired details to ground otherwise ordinary urban buildings with moralizing forms and traditional human craftsmanship.

City planning strategies arose to reintroduce nature into urban life as a response to these conditions and ideas. In England and America, the picturesque garden suburb emerged as an escape from the industrial city for the emerging middle class. Frederick Law Olmsted became famous for constructing major urban parks in Boston, New York, and Chicago. Barcelona’s entire expansion plan revolved around the premise of inserting nature into the center of the city’s dense urban fabric. Courtyards, trees, and wide streets ensure that Barcelona’s elite citizens enjoy the moralizing effects of nature in their everyday lives.

While progressive city planners, social organizers, and amateur scientists in the leisure class all began to critically appreciate the impacts of the natural environment on the human experience, these lines of thought remained separate. Alone, each impacted a small number of people. Therefore, these examples cannot be considered a holistic environmental movement. The best framework for understanding proto-environmentalism as it pertains to Gaudí is as a series of related, peripheral ideas.

Primarily, Gaudí responds to this intellectual and sociopolitical climate. Gaudí’s urban architecture fits within the environmentally conscious Cerda plan, and even exceeds its progressive intentions. The façade of Casa Milá, for example, originally functioned as a vertical

---

16 Ruskin, John. *Unto this Last*. London: George Allen, 1896. 75  
17 Sola-Morales, 24  
18 Soria i Puig, 19
garden for hanging plants. However, most of Gaudí’s projects sit at the metropolitan periphery of the city, much closer to the elements of nature they incorporate. The Park Guell intended to serve as exactly an English garden suburb, and even La Sagrada Familia sat outside of the built city when constructed to capture breezes and to remove pilgrims from the temptations of urban life.

Gaudí’s devout Catholicism abetted popular philosophy on the moralizing role of nature. Especially later in life, his fervent adherence to Church values drove him to incorporate nature into buildings to remind society of God’s rules. The powerful Catalan Catholic church embraced *Modernista* architecture as a platform for reintroducing moral messages to society. Famously, Gaudí planned the Casa Milá as a pedestal for a giant statue of the Virgin Mary, only for his plan to be rejected by the owner during construction. Gaudí grew up in a small religious village attending Catholic schools. Often sick as a child, he spent significant time exploring and observing the countryside and local quarry when he could not attend school. His father, a blacksmith, taught him the moral value of artisan craftsmanship, which Gaudí brought to his work in Barcelona. Gaudí also grew up making pilgrimages to the Virgin of Montserrat, a holy statue residing in a monastery set in an unusual mountain formation. Part of the cult of Montserrat includes integrating culture and nature, so Gaudí viewed this practice as a higher calling than simple ornamentation. Religious inspiration extended to formal explorations. Gaudí once remarked, “originality consists in returning to the origin,” which to him meant God’s creation. Overall, Gaudí must be viewed as someone who went far beyond the thinking of his

---

19 Fornes, 200
20 Sola-Morales, 79
21 Fornes, 224
22 Van Hensberger, 6
23 Van Hensberger, 134
24 Van Hensberger, 138
time. He mixed personal conviction with fledgling social values to intentionally consider the social and moral impact of nature for every element of his architecture.

**OBSERVING NATURE**

Gaudí’s early projects primarily include formal allusions to the natural world. Many consider the Casa Vicens, begun in 1883 in the Gràcia section of Barcelona, to be Gaudi’s first important work.25 The building’s abstract geometries recall Gaudí’s fascination with the Alhambra and other examples of Moorish architecture.26 However, the building also exhibits compelling use of naturalistic elements. Yellow floral tiles covering the façade remember the zinnias on the property. The wrought iron fence abstracts palm fronds to form a modular system. Interior surfaces effloresce in elaborately carved fruits, vines, trellises, and trees rendered in wood and tile. The combination of these elements demonstrates Gaudí’s sophisticated ability to integrate multiple sources of inspiration to form one cohesive design.

Gaudí’s interpreted organic details throughout his career. Elephant feet inspired the viaduct at Bellesguard, a mansion above the city.27 In the Park Guell, a dragon covered in trencadis mosaic greets visitors. To create the sculptural details of La Sagrada Familia’s Nativity Façade, Gaudí cast plaster molds of live plants, animals, and people to ensure accuracy.28 Gaudí even capped the towers with forms resembling Catalanian seashells with the hope that wind would blow through and make noise.29 Indeed, some of the forms Gaudí introduces go beyond visually observable phenomena. Inspired by the spiral growth of trees in the Catalonian countryside, Gaudí generated the form for the columns at La Sagrada Familia by superimposing two polygons which spiral in opposite directions as they rise. This transitions the columns from a

---

26 Artigas, 44
27 Artigas, 265
28 Fornes, 108
29 Van Hensbergen, 251
polygonal base to an almost round crown, and demonstrates that Gaudí understood not only natural forms, but the processes by which they are generated.³⁰

Gaudí’s architecture adeptly modulates between broad, naturalistic gestures and thoughtful details. The geomorphic solid and void composition of Casa Milá recalls a desert landscape or rock formation when viewed from afar. Inside the courtyard, a polychrome mural envelops a staircase covered in architecturally interpreted palm leaves and draped with live palms. The nearby Casa Batlló initially captivates with its biomimetic roofline and bonelike stonework. The intricate mosaic façade and interior paint, both recalling fish scales at a very detailed size, illustrate Gaudí’s ability to mediate scale and relate part to whole. This allows him to create convincingly naturalistic designs demonstrating the extent of his fervent study and intention.

Gaudí’s intense observation of natural forms extended to ergonomics. Taken together, these design considerations recall the wider rise of empathy theory in European art at the turn of the last century popularized by Hector Guimard and Theodor Lipps, which asserts that humans relate to naturalistic forms. The handrails along the staircases at Casa Batlló perfectly conform to the hand, while doorknobs in the Casa Milá comfortably fit both right and left handed users. Gaudí also designed furniture for the city of Barcelona and for many of his clients using the same principles. The arms of Gaudí’s chairs and benches conform to human anatomy, while the seats carefully consider human bone structure. Later, Gaudí simplified his furniture, deliberately prioritizing human ergonomics over applied ornament.³¹

While many art historians include Gaudí within the framework of Modernisme, several characteristics differentiate Gaudí’s buildings. Most of Barcelona’s Modernista buildings integrate a variety of historical references and organically inspired details to compose sublimely grotesque facades for otherwise ordinary buildings. Considered the epitome of Modernisme style, Domenich Montaner’s Palau de la Musical Catalana (fig. 11) cloaked a thoroughly modern steel frame building with a rationalist floor plan in floral tile and glazed landscapes. Gaudí focused less on nature in ornament and more on natural systems. This geometric rigor and calculated physical study separates Gaudí from his contemporaries. Unlike many of Barcelona’s other architects confined to the rectangular city grid, Gaudí designed several freestanding structures, such as La Sagrada Familia and the gates for the Guell estate, which interpret natural structures generate massing. Even his Casa Milá barely resembles other townhouses in the city as it undulates around the block. Gaudí’s formal explorations distance him from the mainstream. Through his study of ergonomics and naturalistic spacemaking, Gaudí exceeds the pervasive standards for design in his time and must be viewed as a significant and deliberate contributor to the history of naturally-aware architecture.

**CULTURAL ECOLOGY**

Gaudí integrates cultural sensitivity with environmentally sound practices. Sustainability presents a multifaceted challenge to contemporary architects to create compelling buildings

---

32 Sola Morales, 24  
33 Modernisme Route. Barcelona: IMPUíQV, 2005. 55
which will remain environmentally, economically, and culturally viable in the long run. Even when analyzed against this modern standard of sustainable design, Gaudí’s architecture merits recognition.

Adamant Catalan nationalism, religious intensity, and passion for his native landscape helps explain the thorough regional awareness inherent to Gaudí’s works. As someone who largely did not collaborate with other architects, Gaudí especially did not identify with any foreign schools of thought.34 This allowed him to ignore criticisms and work from personal convictions in a regional context.35 For his few major works outside of Catalonia, such as the Bishop’s Palace at Astorga and renovations to the Cathedral of Palma at Mallorca, Gaudí conducted exhaustive climactic and sociological studies of the region to ensure cultural and ecological sensitivity.36 While this distinguished Gaudí from his peers, it cast him into the periphery of architectural practice.

Gaudí’s architecture takes advantage of local artisanal traditions. In the late 19th century, Barcelona still had many traditional craftspeople exploring the decorative arts.37 Gaudí and most of his contemporaries sought to articulate cultural continuity by applying artisanal craftsmanship to modern buildings. At the Palau Guell, Gaudí devoted much of his budget to the application of decorative arts to reinterpret the architecture of the Hagia Sophia and the Great Mosque at Cordoba for contemporary Barcelona life.38 Beyond wrought iron, stonework, and woodcarving, the Palau Guell also introduced an early iteration of trencadis mosaic on the roofscape, celebrating and reinterpreting Spanish and Moorish tile traditions. At the Casa Batlló, Gaudí

---

34 Artigas, 9
36 Artigas, 168
38 Artigas, 152
specifically introduced the Islamic tradition of lustre tile to the roof, clearly incorporating Spain’s Moorish past into his vision of independent Catalan culture.

A large part of Gaudí’s innovation stemmed from creating new forms using traditional building techniques, visually bridging the gap between past and future. For his early career, Gaudí refused to use any of the new materials made available as part of the world fairs, especially cement. Cement did not comply with traditional Catalan construction techniques such as the Catalan Vault. As Gaudí moved away from historical styles in any capacity in the Casa Milá and the Sagrada Familia, he reconciled use of new materials by including them in nonstructural capacities. In the Casa Milá specifically, Gaudí created concrete panels manufactured offsite for installation on the building’s steel frame, demonstrating both a structural experiment and an economically sensible system.

Gaudí also conformed traditional building techniques to original geometric explorations. Gaudí perforated the ceiling of Las Sagrada Familia with skylights in the form of hyperboloids of one sheet, a complex ruled geometry which maximizes the amount of light admitted to the space. To construct the sometimes massive forms, Gaudí reinterpreted the traditional Catalan Vault. At the Collegi de les Teresianes, square brick columns anchor a much more sophisticated system of catenary arches above, demonstrating Gaudí’s willingness to hybridize his innovations with traditional structural systems for practical purposes and visual effect.

The originality of Gaudí’s buildings does not undermine their compatibility with the urban landscape, an important step towards cultural sustainability. For many of his projects, Gaudí worked in elite sections of the Eixample, where the strict building code and converging

---

40 Espel, 8
41 Burry, 38-42
tastes established a cohesive urban landscape. In his Casa Batlló, Gaudí renovated an otherwise ordinary townhouse beyond recognition and covered the façade in lustre tile. While the biomorphic roof is unique, it subtly mediates a difference in cornice heights between the neighboring structures. However, because the surrounding buildings also utilized elaborate, polychrome decoration schemes and asserted varying decorative styles, the block remains visually coherent in its disunity. Even in the Park Guell, Gaudí sought a scheme for creating home sites that would minimally impact the preexisting landscape. The resulting viaducts serve to enhance the hillside rather than to mask it, as well as to frame many views of the city below.

In many cases, cultural and environmental sustainability have intrinsic links. In 1888, a group of Teresian Nuns commissioned Gaudí to design a school in the Sant Gervasi district in the hills above the city (fig. 12). Confronted with a limited budget and a preexisting building footprint, Gaudí elected to use seven types of local stone for construction. In doing so, Gaudí elevated vernacular materials to high art while minimizing the need for imported materials and associated transportation impacts. Even at the Palau Guell, a project with an unlimited budget, Gaudí chose to use stone from Eusebi Guell’s local quarries as the primary building material. Unlike any of Gaudí’s other projects, the Palau Guell stands in the heart of the Gothic Quarter, an area which demands sensitivity to the cultural landscape. To create an appropriate structure, Gaudí proposed 26

---

42 Permanyer, 48  
43 Artigas, 267  
44 Fornes, 62
iterations of the façade to best conform to the preexisting street wall and interject parabolic elements. The local stone helps integrate the structure to the historical urban fabric.

**INNOVATIONS IN CONSTRUCTION**

Over the course of his career, the originality of Gaudí’s architecture shifted from primarily including natural forms to primarily deriving structural methodologies from systems observed in nature and geometry. Gaudí believed that nature is rarely appreciated for its organizational principles. Therefore, despite the structural complexities of his architecture Gaudí never behaved as an engineer; instead of calculating forces before building his work, Gaudí tested his ideas with models. Gaudí’s architecture largely consists of repeating geometries and can often be constructed and interpreted without a plan. His long lasting architecture demonstrates the success of his unique methodology. For him, these explorations were spiritual as well as practical. In Gaudí’s words, “seeking out rules of nature is collaborating with the creator.”

Structurally, Gaudí only used geometrically defined surfaces, and explicitly avoided freeform surfaces in an industrial era. La Sagrada Familia incorporates rotational paraboloid towers, hyperboloid fenestrations, and hyperbolic paraboloids which mediate the complicated geometric transitions between windows or from window to wall. Importantly, all of these forms can be derived from structures in nature, such as flowers, interdigital skin, and spider webs. Even where these surfaces serve decorative purposes, they maintain geometric rigor. The sculptural

---

47 Forneres, 231
48 Espel, 7
49 Van Hensberger, 138
finials found atop La Sagrada Familia, for example, are actually relaxed tetrahedral fractals.\textsuperscript{51}

Taken together, these forms represent Gaudí’s ability to generate unusual and interesting forms using very straightforward logic.

The Schools at La Sagrada Familia (fig. 13), built for workers’ children in 1909, utilize a stunningly simple application of ruled geometries. For the roof, Gaudí conceived an undulating row of conoids from crossbeams which invert as they cross the central beam. This structure sits on a complementary system of curving walls, which lock together to form a rigid and incredibly durable structure using minimal materials. Both the walls and roof were constructed using a double layer of brick loosely based on Guastavino’s Catalan Vault technique. This allows the nonstructural interior partition walls to move and adapt space to program. Gaudí originally intended the school structure to be temporary. The fact that it has been moved on site several times testifies to the enduring flexibility of Gaudí’s structural system.\textsuperscript{52}

At La Sagrada Familia, Gaudí specified 22 varieties of local stones to serve as columns. While at first glance color seems to be the significant difference between the materials, Gaudí actually specifically chose stone which would be able to support the variable load above. The columns below what will eventually be the highest bell tower in the world are made of extremely

\textsuperscript{52} Museum of the Schools of the Sagrada Familia. Exhibit Text. Visited June 2012.
strong porphyry. Less dense stones are used in the nave. All of the columns sit at an incline to absorb lateral forces without buttressing, which Gaudí detested.\textsuperscript{53}

Gaudí’s exploration of the catenary arch became fundamental as his career progressed. The catenary is a curve formally similar to a parabola. It represents the shape of a chain hanging from either end and supporting only its own weight. The advantage of a catenary curve in architecture comes from the fact that all lateral and vertical forces are perfectly balanced. When compared to a semicircular arch, an inverted catenary does not require buttressing, simplifying structure and saving material. While the Palau Guell became Gaudí’s first experiment with parabolic arches in 1886, in 1887 he refined the parabola to catenary arches to form the formal and structural basis of the Collegi de les Teresianes.\textsuperscript{54} Notably, by removing buttressing and requiring minimal materials for construction, catenary arches enabled Gaudí to increase the amount of natural light in his buildings.\textsuperscript{55} A network of catenary arches also formed the backbone of the roof structures at both the Casa Batlló and the Casa Milá. These forms departed from rectilinear conventions of Barcelona’s urban architecture while minimizing cost.\textsuperscript{56}

To generate the forms of a church at La Colonia Guell, a textile worker’s colony run by Gaudí’s famous patron, Gaudí invented a system of physically modeling catenaries (fig. 14). Gaudí intended the church to have both a lower and upper nave.

\textsuperscript{53} Museum of La Sagrada Familia. Wall Text. Visited June 2012.
\textsuperscript{54} Fornes, 85
\textsuperscript{55} Fornes, 85
\textsuperscript{56} Fornes, 203
stacked on top of each other, though only the lower nave, known as the crypt, was completed. To create his funicular model, Gaudí hung chains weighted with buckshot in proportion to their structural loads from the ceiling and from each other to generate perfectly balanced curves. He then photographed the model extensively and inverted the photos to understand the spacial qualities of the model. Gaudí did not run a single mathematical calculation, yet subsequent computer simulations of his model confirm its structural viability.\textsuperscript{57}

Gaudí applied this evolving system when designing the columnar system for La Sagrada Familia. Though he did not create an additional funicular model for the space, Gaudí relied heavily on plaster models to develop his designs. When Gaudí first became project architect in 1883, he inherited an earlier set of gothic plans which he carried to completion in the crypt and apse. As his ownership of and devotion to the project grew, he developed a set of models which utilized parabolic forms in the nave and for all vaulting. However, as the size of the church expanded with Gaudí’s ambitions, he developed a third set of models based on hyperboloid structure. This dramatically heightened the nave of the church. More significantly, it gave rise to the branching column structure inside, where columns incline to seemingly impossible angles and grow out of each other to support the roof. The evolution of his model highlights Gaudí’s constant quest for innovation born of an intense desire to understand the forms and structures of nature.

READING SUSTAINABILITY INTO ARCHITECTURE

Today, sustainable architecture responds to a growing awareness of the finite resources available on Earth and the delicate natural systems harmed by anthropogenic activity. Gaudí’s architecture did not intentionally address these fears, nor could it have without the development

of modern science. Nonetheless, many of Gaudí’s construction systems and material choices anticipate current practices.

Gaudí covered many of his buildings in elaborate polychrome mosaics, creating a technique known as trencadis using broken tile or other ceramics. To complete the mosaics, workers hunted for pieces of broken ceramics in local dumps and ceramics factories. The technique became a relatively inexpensive method for decoration and for negotiating the complex geometries of Gaudí’s buildings. Examples of trencadis can be found on almost all of his buildings, including Casa Batlló, Casa Milá, La Sagrada Familia, and especially the Park Guell. Gaudi’s ability to find beauty in found materials and recycled objects enhances the originality of his designs.

Gaudi’s creative use of found and indigenous materials matured at the Crypt of La Colonia Guell. For the walls and structural columns, Gaudí used rough cut industrial slag and misshapen bricks produced as a byproduct of factory operations. Even the stained glass window muntins are made from discarded needles once used for textile production in the neighborhood. These materials not only enhance church beauty, but also integrate the church into its natural landscape.

A surprising number of Gaudí’s buildings feature prefabrication in parts of their construction. In this way, Gaudí anticipated current interest in high-tech fabrication, which reduces waste and cost without sacrificing the originality of buildings. In the Park Guell, the entrance wall and both of the gatehouses feature a crenelated system made up of identical concrete elements placed in various orientations for visual effect. The exterior wall system of Casa Milá demonstrates that towards the end of his career, Gaudí began to recognize the

---

58 Fornes, 163
60 Park Guell Interactive Exhibit. Visited June 2012.
structural possibilities offered by coupling prefabricated elements with a standard steel frame construction method. This type of mass-customization has become an ideal of many architects today.

In addition to the low impact hardscaping at the Park Guell, Gaudí designed a sophisticated rainwater collection system for the park. The columns which support the central terraces serve to capture rainwater and direct it to a subterranean cistern.\textsuperscript{61} This water circulates through fountains in the park and can be used to irrigate plantings. However, Gaudí’s choice of local plants both at the Park and in his other projects minimizes the need for artificial irrigation and thereby reduces water usage.

Gaudí explored passive heating and cooling throughout his career with mixed results. The Palau Guell originally did not have any heating system, which saved energy at the expense of comfort.\textsuperscript{62} In both the Casa Batlló and the Casa Milá, Gaudí honed the technique of constructing a double “sombra sombrilla” roof (fig. 15). Basically, this structure consists of a series of catenary vaults which create an attic space between two roofs. This space traps air and shades and insulates the occupied spaces from weather conditions, a form of passive climate control.\textsuperscript{63} The roof structures

\textsuperscript{61} Artigas, 267
\textsuperscript{62} Fornes, 51
also allowed for natural ventilation, minimizing the need for mechanical systems to
thermoregulate the buildings and associated energy costs.

By incorporating so many systems that mitigate impact on the environment, Gaudí’s
architecture clearly surpasses any standards of environmental consideration at the time and place
of construction. Realistically, Gaudí did not fully develop many of these systems. While Gaudí
could not have considered contemporary climate change concerns and resource management
practices when making design decisions, the connection between his works and contemporary
practice compels further interpretation and application.

CURRENT AND FUTURE INNOVATIONS

Modern technology allows current architects to explore Gaudí’s architecture more
thoroughly than ever before. The ongoing construction of La Sagrada Familia presents an
important case study in the viability of Gaudí’s architecture 90 years after his death. Parametric
computer modeling software acts as an archaeological tool. Because the geometries at Sagrada
Familia are so rigorous, Gaudí’s thinking can be reconstructed electronically for analysis.64

These same technologies allow Sagrada Familia construction to proceed with minimal
waste. Parametric models can be adjusted for site measurements without reconstructing an entire
drawing, saving time. Additionally, this ensures that materials will fit, minimizing material
requirements and construction time.65 Construction adapts to current conditions and knowledge.
As many of the stones specified by Gaudí have become increasingly expensive and impossible to
find in the quantities required for construction, veneers are used.66 Prefabrication and CNC
milling speed construction with no loss in accuracy. The current team of architects chose cork

63 Fornes, 203
64 Burry, G36
65 Burry, G83
66 Espel, 10
flooring from Portugal because of its sustainable growth and acoustical properties. Gaudí’s techniques can be adapted to the modern world.

Biomimicry and resource conservation hold important promise for the future of architecture as designers seek to integrate the built and natural environment. Gaudí developed a significant framework for studying natural systems and applying them to architecture which remains underused. Gaudí’s structural innovations and exploration of the catenary arch hold promise of enlivening architecture while minimizing material requirements. Even as Gaudí’s buildings have become popular tourist attractions and spurred increased study, current architectural practice would benefit from incorporating Gaudí’s process.

**A GLOBAL METHODOLOGY**

Gaudí’s architecture could only have risen to local prominence under the unique sociopolitical and economic conditions of turn of the century Barcelona. Yet in becoming a symbol of Catalan cultural independence from Spain, his society proudly relegated him to the periphery of mainstream Western architectural development. Today, Gaudí enjoys a global audience. However, the international community must avoid the trap of relegating Gaudí’s works to mere tourist attractions. After thorough consideration, Gaudí’s widely celebrated artistic genius represents icing on the cake, not his most important contribution. Gaudí’s ability to synthesize complex issues and create elegant design solutions holds promise to serve as a model for architects and engineers today, who are increasingly cognizant of the complexity of the built and natural environment. Today’s design community, armed with powerful knowledge, holds a transformative opportunity to apply Gaudí’s methodology to contemporary construction.

This research began as a topical study of Gaudí’s work. However, understanding the man required development of nontraditional lenses for historical analysis. Contextualizing Gaudí in
his intellectual, political, economic, and cultural world became the only fair method of analyzing his contribution to the discourse of environmental architecture. Conscientiously reading modern green building techniques into architecture, aware of the inherent anachronism, highlighted how Gaudí’s achievements reached beyond his contemporaries.

Most importantly, this methodology can be applied to other historical figures and movements. This framework will enable historians and architects to accurately characterize the narrative of the relationship between built and natural space and trace its evolution. Gaudí is one of many figures who can inform contemporary society and architectural practice with new or underexplored building technologies. Perhaps there is possibility to discover that Gaudí has peer architects throughout world history, especially as study of vernacular building techniques and non-Western architects expands. Sustainability concerns will continue growing as environmental consequences of human activity reveal themselves. This type of research will become increasingly instrumental to architectural development and even anthropological understanding of how humans interact with their environment.
Works Consulted:


**Partial List of Sites and Museums Visited:**

Casa Calvet
Casa Gaudi
Casa Milá
Casa Batlló
Casaramonas Factory Complex, now Caixaforum
La Colonia Guell
Finca Guell
Fundacio Miro
German Pavilion for the 1928 Barcelona Expo
Hospital de Sant Pau
Monastere de Montserrat
Museu del *Modernisme*
Museu Nacional de Catalunya
Museu Picasso
Palau Guell
Palau de la Musica Catalana
Parc de la Ciutadella
Park Guell
Sagrada Familia
Schools of La Sagrada Familia
University of Barcelona