Cooper-Hewitt Museum of Design and Technology (C-HMD+T): Biomimetic architecture as part of nature

Isabel Marisa Corsino Carro
University of South Florida

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Cooper-Hewitt Museum of Design and Technology (C-HMD+T):

Biomimetic Architecture as Part of Nature

by

Isabel Marisa Corsino Carro

A thesis submitted in partial fulfillment of the requirements for the degree of Masters of Architecture School of Architecture and Community Design College of The Arts University of South Florida

Major Professor: Steven Arthur Cooke, M. Arch Theodore Trent Green, M. Arch Mark Weston, M. Arch

Date of Approval: March 24, 2009

Keywords: Biomimicry, Architecture, Sustainability, Technology, Museum, New York City

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I dedicate my Master's Thesis Project to: God who has guided me in life, my parents Isabel and Mario Corsino, my grandfather Mario Corsino and Javier Valencia. I admire, love and respect you all. Thank you for being there for me at all times. God bless you and I love you!
I would like to thank my committee members: Steven Arthur Cooke, Theodore Trent Green, and Mark Weston. You have all pushed me to go further into my research and inspired me do better. I would also like to thank Wes Frusher from the University of South Florida Mechanical Engineering Department for letting me use the 3D printer.
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Cooper-Hewitt Museum of Design and Technology:
Biomimetic Architecture as Part of Nature

Isabel Marisa Corsino Carro

ABSTRACT

If architects are to create a sustainable world, one in which we are accountable to the needs of all future generations and living creatures, we must recognize that our present form of designing buildings is deeply flawed. Being the number one cause of emission gases, building design needs to be revolutionized to be able to surpass such climatic changes and finally harmonize with nature. To create a sustainable future and solve the global warming crisis,
architects need to incorporate nature within design through the process known as biomimicry. Janine Benyus, the author of Biomimicry: Innovation Inspired by Nature, stressed how nature teaches to solve human problems. After billions of years of research and development within nature, Benyus believes that nature has perfected itself and has the key to human survival. Through biomimicry, architects can find solutions to design problems and apply them to sustainable design. Sustainable design has not reached its peak in uniting both aesthetics and performance within the design industry. Until now, architecture focuses more on human needs and economics, putting aside what is best for the environment thus leaving a conflict between human and nature.

This thesis presents an investigation into biomimicry and its architectural applications. It is inspired by organisms
within nature. The final design project will be based on the studies of organisms and how these can be incorporated on a building’s entire design program including skin, structure, journey and circulation. From these studies, I will synthesize the important components and ideas of these organisms and interpret them into the building’s design. The building typology chosen for this project is the museum typology which function as a living organism. The project will be site specific thus designing a museum that adapts to the site’s specific surroundings.

The goal for this thesis is to discover organisms within nature that can be incorporated and reinterpreted into sustainable architecture. It is also crucial to discover and study the complex systems within nature so that architects can incorporate ideas from it to improve architecture design.
PROLOGUE

Problem within Architecture: Disconnection with Nature

Cave, Industrial Revolution and the Result

It all started in a cave. Man’s first dwelling was not even designed by him, it was concocted by nature. The cave gave man shelter, safety, and warmth from the outdoors. Man has come a long way since his first dwelling. In today’s society humans cannot conform to just the basic needs safety, warmth, and shelter to live. Instead architecture is seen as a luxury rather than a basic necessity. It all started in the 19th century with the Industrial Revolution where major changes in agriculture, manufacturing, and
transportation had an effect in both the socioeconomic and culture of the time. It marked a major turning point in human society from a manual labor based economy to a machine economy. This brought machines such as the steam engine as well as the exploitation of fossil fuels. After the Industrial Revolution, nature was conceived as ethically abundant. Man at this point in time did not think about the future in terms of what the emissions of the fossil fuels were going to contribute to the environment. Ever since then, humans have become dependent on fossil fuels.

Result: Climate Change

As a result, man’s desire to dominate nature has caused nothing but damage and the destruction of the environment. Greed and economic gain have been human so-
Man’s way of thinking is closed minded and focuses only on benefiting himself. Humans act as parasites within nature where they feed off from the Earth and do not contribute back. What happens when humans completely destroy and feed off nature’s limited supply? The war between humans and nature has to be stopped. If it is not stopped, in the process of nature rebooting itself it will end with the entire human race. We have the ability to become resilient, overcome the disturbance and survive.

Nature has been reacting towards what man has done to the Earth. All of the weather changes that we see today are nature’s reaction to human society’s dreadful habits and living styles. For many, climate change may still seem abstract, its impact felt mainly in the world’s remote
wild places. In reality, it is already affecting us where we live, in the form of extreme weather events such as heat waves, droughts, floods, and more intense hurricanes. Kevin Trenberth, head of the climate-analysis section at the National Center for Atmospheric Research and a lead author on last year’s IPCC Fourth Assessment Report, stresses such things. “It’s variable from year to year, then suddenly in 2003 we (in Europe) got a record-breaking heat wave. That drought and heat wave would not have occurred without global warming.” Nor, he says, would Hurricane Katrina have been so severe. “Record-high sea-surface temperatures in the Atlantic contributed to it. Six to 8 percent of the rainfall in Katrina can be attributed to global warming.” Hurricane Katrina killed an estimated 1,500 people or more. Europe’s heat wave killed as many as 35,000.
Building sector’s contribution to Climate Change

The building sector is responsible for the largest consumption of fossil fuels and natural resources within the United States and the rest of the world today. Data from the US Energy Information Administration (USEIA) illustrates that buildings are responsible for almost half (48%) of all energy consumption and Green House Gas emissions annually; globally the percentage is even greater. Seventy-six percent (76%) of all power plant-generated electricity is used to operate buildings (within the industrial, commercial, and residential operations). The residential operations sector consumes 21% or 20.4QBtu. Unless architecture community acts now, emerging economies will follow current design and building practices leading disastrous global consequences. Change can start now by helping reduce the carbon footprint within...
families in the United States. Other data shows how the average American family contributes about 50,000 pounds of carbon dioxide a year to the atmosphere—9 more times per capita than in Botswana and 19 times more per capital than in India. It also shows that about half the carbon dioxide comes from our homes and half from our vehicles. A house in the United States can consume about 34,618 pounds annually. Home heating and cooling as well as lighting systems emit the highest amount of Carbon Dioxide emissions every year. In order to stop the global warming crisis, architects have to design more meticulously by beginning to apply sustainable design within the building industry. Looking back at nature and sustainability is the solution to today’s global warming crisis.

### Table 5. World Energy-Related Carbon Dioxide Emissions, 1990, 2005, and 2030.

<table>
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<tr>
<th>Year</th>
<th>Estimated Emissions (Million Metric Tons)</th>
<th>Change from 1990 (Million Metric Tons)</th>
<th>Average Annual Change from 1990 (Percent)</th>
<th>Change from 2005 (Million Metric Tons)</th>
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<tr>
<td>1990</td>
<td>21.226</td>
<td>6.825</td>
<td>32.2%</td>
<td>14.274</td>
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<tr>
<td>2005</td>
<td>28.051</td>
<td>21.099</td>
<td>99.4%</td>
<td>50.9%</td>
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<td>2030</td>
<td>42.325</td>
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Table 3. World Energy-Related Carbon Dioxide Emissions by Region, 1990-2030 (Million Metric Tons Carbon Dioxide. Percent Shares of World Emissions)

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<td>OECD</td>
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<td>OECD North America</td>
<td>5.754</td>
<td>6.559</td>
<td>7.109 7.048 7.033 6.300 6.071 (9.1%)</td>
</tr>
<tr>
<td>Canada</td>
<td>485.823</td>
<td>488.896</td>
<td>508.868 677.798 784 (9.1%)</td>
</tr>
<tr>
<td>Mexico</td>
<td>200.370</td>
<td>205.430</td>
<td>210.484 215.542 265 (1.1%)</td>
</tr>
<tr>
<td>OECD Europe</td>
<td>4.161</td>
<td>4.373</td>
<td>4.543 4.612 4.678 4.765 4.806 4.834 (0.1%)</td>
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<tr>
<td>OECD Asia</td>
<td>1.541</td>
<td>2.148</td>
<td>2.774 2.849 2.822 2.557 2.143 2.157 (0.0%)</td>
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<tr>
<td>Japan</td>
<td>1.008</td>
<td>1.242</td>
<td>1.230 1.186 1.101 1.195 1.164 1.170 (0.0%)</td>
</tr>
<tr>
<td>South Korea</td>
<td>241.688</td>
<td>500.659</td>
<td>612.632 666 693 (1.3%)</td>
</tr>
<tr>
<td>Australia/New Zealand</td>
<td>251.418</td>
<td>444.474</td>
<td>495 517 540 (0.5%)</td>
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<tr>
<td>Total OECD</td>
<td>11.396</td>
<td>13.680</td>
<td>13.583 13.389 13.473 13.746 13.086 15.426 (0.8%)</td>
</tr>
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<td>Non-OECD</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Non-OECD Europe and Eurasia</td>
<td>4.198</td>
<td>2.797</td>
<td>5.665 5.966 5.350 5.308 5.655 5.811 (1.3%)</td>
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<tr>
<td>Russia</td>
<td>2.276</td>
<td>1.659</td>
<td>1.695 1.769 1.902 1.984 2.020 2.117 (0.9%)</td>
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<tr>
<td>Other</td>
<td>1.822</td>
<td>1.128</td>
<td>1.169 1.272 1.249 1.524 1.506 1.649 (1.5%)</td>
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<tr>
<td>Non-OECD Asia</td>
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<td>2.717</td>
<td>3.177 3.111 3.337 3.394 3.456 3.545 (0.9%)</td>
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<tr>
<td>China</td>
<td>2.241</td>
<td>4.737</td>
<td>5.233 5.335 6.214 9.475 10.747 12.607 (3.3%)</td>
</tr>
<tr>
<td>India</td>
<td>458.127</td>
<td>1.117</td>
<td>1.164 1.349 1.604 1.818 2.019 2.238 (2.6%)</td>
</tr>
<tr>
<td>Other Non-OECD Asia</td>
<td>607.157</td>
<td>1.037</td>
<td>1.083 1.238 2.336 2.014 2.917 3.237 (2.4%)</td>
</tr>
<tr>
<td>Middle East</td>
<td>3.6%</td>
<td>6.0%</td>
<td>6.5% 6.2% 6.2% 7.1% 7.4% 7.7% (10.8%)</td>
</tr>
<tr>
<td>Africa</td>
<td>549.947</td>
<td>1.042</td>
<td>1.096 1.245 1.395 1.515 1.492 1.210 (1.4%)</td>
</tr>
<tr>
<td>Central and South America</td>
<td>3.1%</td>
<td>2.3%</td>
<td>3.5% 3.5% 3.5% 3.7% 3.7% 3.7% (3.8%)</td>
</tr>
<tr>
<td>Brazil</td>
<td>3.2%</td>
<td>6.8%</td>
<td>6.8% 6.2% 4.1% 4.1% 4.1% 4.1% (4.6%)</td>
</tr>
<tr>
<td>Other Latin America</td>
<td>216.310</td>
<td>1.350</td>
<td>1.356 1.417 1.502 3.041 3.582 3.903 (2.3%)</td>
</tr>
<tr>
<td>Total Non-OECD</td>
<td>9.938</td>
<td>13.689</td>
<td>14.957 19.092 22.289 34.606 36.787 (2.5%)</td>
</tr>
<tr>
<td>Total World</td>
<td>12.226</td>
<td>27.070</td>
<td>26.631 31.100 34.339 37.035 39.591 42.325 (1.7%)</td>
</tr>
</tbody>
</table>

1 Values in parentheses indicate percent share of total world absolute change.
2 Includes 56% of non-OECD oil producers.

Note: The U.S. numbers indicate carbon dioxide emissions attributable to renewable energy sources.

Is Sustainability as a Part of the Solution to Climate Change?

Architects believe that sustainability is the means to repair the flaws of poor building design as well as the solution to the global warming crisis. The proponents of sustainable design believe that the global warming crisis can be resolved by using innovative strategies and industrial practices which reduce the environmental impacts associated with goods and services. Sustainable design (green design) is considered a means of doing that while maintaining a good quality of life by using clever planning substituting less harmful products and processes for the conventional. The principles of sustainable design are: low-impact materials, energy efficiency, quality and durability, design for reuse and recycling, service substitution, renewability, and healthy

Figure 5. Windmill solar farming.
buildings. Although sustainability is a good start to repair the imperfections of building scheme it is not enough to solve the problem that society faces today.

Sustainability is lacking the integration of nature within design. Architects should study nature's systems and incorporate them into building designs. In order to survive all that is occurring, architecture needs to adapt and mimic nature’s perfect performance as well as aesthetics. A building can no longer sustain the role of a dead organism nor of a precarious parasite, instead a building has to resurrect into a living life form that can sustain and maintain a natural balance within itself. Organisms are naturally sustainable in their own environment. Such information just simplifies the line of thought as nature has already produced the master design. The next step is to interpret and incorporate such information just simplifies the line of thought as nature has already produced the master design. The next step is to interpret and incorporate such
system into our present-day society.

What Can We Do?

As a society, facing the largest problem that humanity has ever seen, we have to take responsibility regarding the global warming crisis. Climate change is something that cannot be ignored, with all of the data that is available humans must react quickly in order to survive. Humanity does not have the luxury of emitting more CO$_2$ emissions any longer. We need to stop all carbon emissions as soon as possible. Sustainability is seen as the solution to the global warming crisis but it has not been exploited to its full extent. There is a need for an Eco-Revolution where sustainable design goes beyond what is seen today.
Humans finally have to accept that we are part of nature and live in peace. Architects have the power to direct humanity into living sustainably and living in harmony with nature, but where do we begin?

Biomimicry: Studying Nature and Incorporating It into Architecture

Nature has been continuously perfecting itself for billions of years. Through time, nature has distiller what works and what does not work. For over a millennia, organisms that we see today have gone through several modifications to become more efficient in nature. The Earth itself has become a testing center for organisms, rather like a trial and error laboratory. The organisms that have the correct modifications will survive while the ones that do not will perish.
What does this teach us? Nature has provided a base that we are able to study. Now we are able to study successful organisms within nature and find solutions to problems that we face everyday. Nature has provided us with a framework of constant improvement and this is what we need to study and incorporate in our daily lives. For this thesis, biomimicry will focus on how we can learn from nature, distill the ideas, qualities, and characteristics of natural forms and systems that can be applied to architecture.

My interests in biology and design prompted my inquisition in to incorporating natures design and construction methods into architecture design and construction. I have been looking at biomimetic types of architecture approaches that have been pursued by other architects. It is believed that there will be a trend towards biomimicry within the ar-
chitecture field. This is the next innovative field within architecture. The benefits which suggest a growing trend within biomimicry is that it can aid in slowing the climate change crisis as well as be a large contributor to sustainable design. Many fields have begun to incorporate biomimicry. A great example of biomimesis within our daily lives is Velcro. Within the architecture field, the Water Cube has been a successful biomimetic project. The Water Cube has redefined the structural field and has opened new doors to sustainability within the architecture community.

My intent is to study biomimesis through the study of organisms, distilling ideas from these organisms and incorporating these ideas into an architecture design. Biomimicry is the main topic of this thesis. Through the use of biomimesis I will study a site as well as a building typology and look
for systems within nature that would work excellently for the site and building typology. The project will act as a living organism: it will be site specific and if you move it, the building would die. The museum typology was chosen and the site location will be in New York City for the thesis. The thesis design will be the expansion of the Cooper-Hewitt National Design Museum on the adjacent lot that is now holding the current museum’s garden.
INTRODUCTION

What is Biomimicry?

**Biomimicry:** (from the Greek bios, life, and mimesis, imitation) is the discipline that studies nature’s brightest ideas and then imitates these designs and processes to solve human problems.

Janine Benyus is the leader within the biomimicry community. In her book, Biomimicry: Innovation Inspired by Nature, she discusses that human beings should consciously emulate nature’s genius in their designs. Benyus co-founded the Biomimicry Guild, the Innovation Consul...
tancy. These organizations help professionals interested in innovation to learn from and emulate nature’s systems in order to design sustainable products, processes and policies that create proactive solutions to people’s lives. Benyus is also the President of the non-profit Biomimicry Institute and its mission is to bring in biomimicry into our culture through the promotion of transferring ideas, designs, and strategies from nature to sustainable human systems design.

Benyus believes that nature has already solved many of the problems that we are facing today. Within biomimicry, what works within the natural world is as important as what lasts. Nature has 3.8 billion years of research and development, where fossil remains are the product of failure, and the organisms that still exist have perfected their way of survival. The organisms that still exist in the planet can give us
the secret to survival.

The conscious emulation of nature’s genius by humans is the correct path to a sustainable future. The more we accept and adapt to this type of natural system, the more we will understand that we are part of it instead of above it. and the more likely we humans can endure and survive on earth.

If humans want to be successful in emulation nature’s genius, then we need to look at nature in a different manner. Within Biomimicry, nature is look upon as a model, measure and mentor.

1.) **Nature as a model**: Biomimicry is a science that studies nature’s models and emulates or
takes inspirations from their designs and processes to solve human problems.

2.) **Nature as a measure**: Biomimicry uses an ecological standard to judge the rightness of human innovations. Through billions of years of existence, nature has learned: what works, what is appropriate and what lasts.

3.) **Nature as a mentor**: Biomimicry is a holistic way of viewing and valuing nature. It introduces an era based not on what we can extract from the natural world, but on what we can learn from it.

Biomimicry as a Growing Trend within Professional Fields
Innovators in many fields of study: architects, engineers, designers, and more are starting to implement biomimicry as a tool to create more sustainable designs. Be- nyus had a chart named Design Spiral which is a guide to aid innovators to use biomimicry within their fields. The Design Spiral can be used to seek the challenge, seek nature for some type of natural system inspiration, then synthesize what was studied within the natural system and incorporate it into a sustainable design.

Architects should start to get into the biomimetic field as soon as possible. As biomimicry is the new up coming trend, several architects have started to look as this field. The next chapter will discuss this.

Direct Approach of Biomimicry in Architecture
The proposal is to apply nature’s concepts within sustainable design. Sustainable design should integrate aesthetics and performance like nature’s living organisms. Buildings should behave like organisms and provide back to the environment. For example, housing should adapt to the weather patterns that affect the specific area. Hurricane prone areas should have houses that react to the harsh weather like a living organism. The house should protect itself and the people that inhabit it. Architects can study different organisms and how they react to certain environments and situations. Iwamoto Scott’s Bubble House is a good example. The skin of the house is a water filter that wraps around the building’s façade and funnels rainwater where it is purified by ultraviolet light. The roof has pillows filled with salt solution that absorb the heat when it is warm outside.
and when it is cold the salt solidifies and releases heat acting as an insulator. With a combination of quantitative and qualitative research, a house will be designed with the principles of nature within sustainability. A combination of data and personal observations will provide a multidimensional approach to the design project and to the result. Although, this is just a small contribution to solving the global warming crisis, it is a start. As humans, we have to accept that we are part of nature and finally live in peace without hurting the planet. If the global warming crisis is solved there will be a brighter and better future for human society.
CONCEPT & OBJECTIVES

Poster board used for the final presentation.

Biomimicry:

(from bias, meaning life, and mimetic, meaning to imitate) is a relatively new science that studies nature, its models, systems, processes and elements and then imitates or takes creative inspiration from them to solve human problems sustainably. Biomimetics is the word most frequently used in scientific and engineering literature that is meant to indicate the underlying biological paradigms present keeping each species functioning in its own unique way. In her 1997 book, "Biomimicry: Innovation Inspired by Nature", author Janine M. Benyus introduces biomimicry, presents examples, and explains why the field is important now. She writes, "Our planet’s most (plants, animals and microbes) have been patiently perfecting their ways for more than 3.8 billion years ... turning rock and sea into a life-friendly home. What better models could there be?" The book lists numerous examples of people who are studying nature’s achievements, including photosynthesis, natural selection, and self-sustaining ecosystems, among others. Benyus then explains how these researchers use the inspirations found in nature to emulate “life’s genius” for the purpose of improving manufacturing processes, creating new medicines, changing the way people grow food, or harnessing energy.

For Theses 1 Final presentation, there have been several changes within the program. It has been determined that it will not be possible to design both the museum and the apartments for the rest of the thesis. The focus will be the museum. The concept of Biomimicry is complex and designing a tower has its complexity. Furthermore, the main idea is Biomimicry and this will be the main focus for the end of this semester and Thesis 2.
EXTENDED PROJECT DESCRIPTION

Introduction

Biomimicry has become an innovative field within architecture. It is believed that this will be the next upcoming trend in architecture because of the “Green” design trend within today’s society. Today, you see many companies, commercials and products that are becoming “Green”. Sadly, becoming “Green” is the new trend and that should not be that way due to the fact that we humans do not have the luxury to continue to live the way we are living as well as continue to contaminate the planet. Climate change is on the sire and sustainable design (green design) is the answer to this serious global dilemma. Sustainability has begun to
address the climate change crisis but it is lacking the integration with nature. This is where biomimicry comes in.

Biomimicry studies organisms that have been successful within nature and these can be implemented into solving our problems. This will be a growing trend within the architectural community because people are starting to embrace sustainable design (green architecture). We have seen well known architects and architecture firms such as: Herzog and de Meuron, PTW Architects, and Santiago Calatrava hop on the “Green” trend. These architects and their firms have seen the upcoming trend within biomimicry and its vast opportunities. This is why now it the time for architects to look at biomimicry as a new mode for design.

Biomimicry as a Growing Trend in Architecture
Innovators in many fields of study: architects, engineers, designers, and more are starting to implement biomimicry as a tool to create more sustainable designs. Be- nyus had a chart named Design Spiral which is a guide to aid innovators to use biomimicry within their fields. The Design Spiral can be used to seek the challenge, seek nature for some type of natural system inspiration, then synthesize what was studied within the natural system and incorporate it into a sustainable design.

Within the architecture community there are two types of approaches to biomimicry: aesthetics and performance. There has been a constant debate within architecture about these two approaches. It has been observed that architects are designing based on biomimicry with the principles of form. In this case, it is believed that architects that just de-
sign on form are not really focusing biomimicry or returning back to nature.

There are a lot of projects within the architecture community that evoke the presence of biomimicry. A great example would be Frank Ghery’s and Eugene Tsui. Is a design successful if mimics the form of a biological entity? Does the design or project solve or try to address any problem by just looking like a biological organism? This is a delicate debate but for this thesis it is believed that just looking like an organism created by nature is not the solution to the problem nor is it solving any problem within the design. A building that formally mimics a biological being is very meaningful but there is a need for more substance. There has to be a reason for the design to “look” like something within nature way beyond aesthetics. This is where performance comes
Building Typology Proposal: Museum Extension Data

The thesis project can be applied to any building typology but for the amount of time given and to focus just on the biomimicry aspect of the design rather than the programmatic and the liberty that can be designed, the museum building typology was chosen. Designing a museum gives the opportunity of being more free with the design than in comparison designing a hospital. Because the biomimicry field is so innovative and young, the museum application is perfect for it. The project will be site specific. The museum will address the site conditions and restrictions. The intent is to design a site specific museum with the principles of biomimicry design.
Master's Thesis Focus: Objectives

These are the objectives that this thesis is trying to address:

- To design a building incorporating biomimicry within the design.
- The design has to have an element involving sustainability.
- The design has to address the site’s real constraints.
- To experiment with new materials and ways of construction.
**BIOMIMICRY CASE STUDIES**

Introduction

For this Thesis project, there has been several case studies that have been studied. Due to biomimicry being an innovative movement within the architecture community, there are not many building case studies due to the fact that most are just mimicking the form. This thesis is not inclined in just copying the form of a natural system. The form of the final project will be found as a final product and will not be applied in the beginning of the conceptual design.

Case Study B1_Jellyfish House

Jellyfish House is modeled on the idea that, like the
sea creature, it coexists with its environment as a set of distributed, network senses and responses. Jellyfish does not have a brain, no central nervous system, no eyes, and its shape consists largely of the water around them. These creatures sense light and odor, are self-propulsive, bioluminescent and highly adaptive to the changes within the waters. The intent of the Jellyfish House is like jellyfish, the house attempts to incorporate new materials and new digital technologies material and digital technologies in a innovative and sustainable manner. The Jellyfish House was designed with a skin that has some of the changing qualities that the Jellyfish has. The skin system consists of a deep parametric skin that reacts to the outside and the inside of the home. The skin pattern was designed from the efficient geometries from the Voronoi diagram and the Delauney geometries. The architecture firm mentions that the buildings performance is reflected upon the efficiency of the skins thickness.
The house’s location is on Treasure Island, located on a flat, artificial island built off the adjacent island of Yerba Buena in the middle of San Francisco Bay. Treasure Island was originally owned by the military but was recently decommissioned and now the land is being redeveloped to create new residential areas. As seen in other sites that have been used by the military, the site suffers from environmental hazards. The soil within the site is toxic and approximately 5 feet had to be removed in order to remediate the site. This project proposed to work around this dilemma by adding wetlands to purify the intoxicated site. The wetlands act as a filter system in the island thus becoming an efficient productive system within the site and naturally filtering storm water.

The Jellyfish House looks at this filtration system to
be incorporated within the design. The skin of the house traps, stored and filters rain and gray water for the use of the house. The water is filtered through the cavities of the skin that is coated with titanium dioxide and exposed to ultraviolet light from the sun. The titanium dioxide absorbs the vary harmful ultraviolet rays, and only lets in the visible blue light to purify the water and emitting a glowing skin within the building.

Jellyfish House combines this system with latent heating and cooling using phase change materials layered into the skin. Conceived as a largely transparent fluid filled ‘water jacket’, areas of the skin pattern and thickness transform to become quilted baffles that contain hydrated salt, a form of salt water. This material fluctuates between solid and liquid states heating or cooling the surrounding air.
As a case study, the Jellyfish House is seen as a project that evoked the ideas of biomimicry. The building’s skin as a water filtration system is an excellent biomimetic approach to the design. The buildings focus was on how can the skin react to the natural surroundings by contributing something to the area. It is believed that the biomimetic aspect of this building was not really adapted by the jellyfish but by the surrounding wetlands that were used to purify the contaminated soils within Treasure Island. The notion of the Jellyfish House applying the biomimetic aspect of the jellyfish is only within the aesthetic realm.

Case Study B2_The Bird’s Nest

Beijing’s National Stadium, also known as the Bird’s Nest, was the stadium used for the 2008 Summer Olympics. Located in the Olympic Green, the $423 million stadium is
the world's largest steel structure. The design was awarded to a submission from the Swiss architecture firm Herzog & de Meuron in April 2003, after a bidding process that included 13 final submissions. The design, which originated from the study of Chinese ceramics, implemented steel beams in order to hide supports for the retractable roof; giving the stadium the appearance of a “Bird’s nest”. Ironically, the retractable roof was later removed from the design after inspiring the stadium’s most recognizable aspect. Ground was broken in December 2003 and the stadium officially opened in June 2008. A shopping mall and a hotel are planned to be constructed to increase use of the stadium, which will host football events after the Olympics.

In 2001, after Beijing had been awarded the right to host the 2008 Summer Olympics, the city held a bidding process to select the best arena design. Multiple requirements
including the ability for post-Olympics use, a retractable roof, and low maintenance costs, were required of each design. The entry list was narrowed to thirteen final designs. The “nest scheme” design became official in April 2003. At $423 million, the stadium was built for one-tenth the cost that it would have cost to be built in the West.

Beijing National Stadium was a joint venture among architects Jacques Herzog and Pierre de Meuron of Herzog & de Meuron, project architect Stefan Marbach, artist Ai Weiwei, and CADG which was lead by chief architect Li Xinggang. In an effort to design a stadium that was “porous” while also being “a collective building, a public vessel”, the team studied Chinese ceramics. This line of thought brought the team to the “nest scheme”. The stadium consists of two independent structures, standing 50 feet apart: a red concrete seating bowl and the outer steel frame around it. In
an attempt to hide steel supports for the retractable roof, required in the bidding process, the team developed the “seemingly random additional steel” to blend the supports into the rest of the stadium. Twenty-four trussed columns encase the inner bowl, each one weighing 1,000 tons.

Despite random appearance, each half of the stadium is nearly identical. After a collapse of a roof at the Charles de Gaulle International Airport, Beijing reviewed all major projects. It was decided to eliminate the retractable roof, the original inspiration for the “nest” design. The removal of the elements helped to bring the project under the reduced construction budget of $290 million, from an original $500 million. With the removal of the retractable roof, the building was lightened, which helped it stand up to seismic activity; however, the upper section of the roof was altered to protect fans from weather. Due to the stadium’s outward ap-
pearance, it was nicknamed “The Bird’s Nest”. The phrase was first used by Herzog & de Meuron, though the pair still believes “there should be many ways of perceiving a building.”

Ground was broken, at the Olympic Green, for Beijing National Stadium on 24 December 2003. At its height, 17,000 construction workers worked on the stadium. All 110,000 tons of steel were made in China, making the stadium the largest steel structure in the world. Beijing National Stadium officially opened at a ceremony on 28 June 2008. The eastern and western stands of Beijing National Stadium are higher than northern and southern stands, in order to improve the sight lines. A 24-hour per day rainwater collector is located near the stadium; after water is purified, it is used throughout and around the stadium. Pipes placed under the playing surface gather heat in the winter to warm the sta-
dium and coldness in the summer to cool the stadium. The Bird’s Nest capacity is 81,000 people within the stadium. Within the project temperature and airflow of every surface were optimized to increase ventilation.

Beijing National Stadium hosted the Opening and Closing Ceremonies, athletic events, and football final of the 2008 Summer Olympics, from 8 August to 24 August 2008. Though designed for track & field events of the Olympics, the stadium will continue to host sporting events, such as football, afterwards. A shopping mall and a hotel, with rooms overlooking the field, are planned to help increase use after the Olympics.

The Bird’s Nest has become an icon of architecture and design ingenuity. Since its creation, it has created some controversy within the architecture community. The build-
ing’s elegance is well known and as well its sustainable aspect, but is it really sustainable? This question came from the notion that the Bird’s Nest is made by over 100,000 tons of steel. The notion of the biomimetic aspect of a nest is present, but was there such a need for so much material to be used especially now knowing how expensive steel is. It is believed that this building is quite beautiful and attractive but it does not really convey what biomimesis is all about. There is no efficiency in material within the Bird’s Nest design. The Bird’s Nest is another aesthetic biomimetic building.

Case Study B3_The Water Cube

Beijing National Aquatics center, also known was the Water Cube is located right beside the Bird’s Nest in the Olympic Green for the swimming competitions of the 2008 Summer Olympics. Despite its nickname, the building is a
rectangular box, not a cube. Construction started on December 24, 2003, and the Center was completed and handed over for use on January 28, 2008.

In July 2003, the Water Cube design was chosen from 10 proposals in an international architectural competition for the aquatic center project. The Water Cube was designed and built by a consortium made up of PTW Architects (an Australian architecture firm), Arup international engineering group, CSCEC (China State Construction Engineering Corporation), and CCDI (China Construction Design International) of Shanghai. The Water Cube’s design was initiated as a team effort: the Chinese partners felt a square was more symbolic to Chinese culture and its relationship to the Bird’s Nest stadium, while the Sydney based partners came up with the idea of covering the ‘cube’ with bubbles, symbolizing water. The water cube has set a new standard in en-
environmental sports design, not only in China but throughout the world.

Comprising a steel space frame, it is the largest ETFE clad structure in the world with over 100,000 m² of ETFE pillows that are only 1/125 of an inch in thickness. The ETFE cladding allows more light and heat penetration than traditional glass, resulting in a 30% decrease in energy costs. The skin system is based on the Weaire-Phelan structure, a structure devised from the natural formation of bubbles in soap foam. The complex Weaire-Phelan pattern was developed by slicing through bubbles in soap foam, resulting in more irregular, organic patterns than foam bubble structures. Using the Weaire-Phelan geometry, the Water Cube’s exterior cladding is made of 4,000 ETFE bubbles. The Water Cube has the capacity to hold 6,000 people. The building’s site is approximately 7.9 acres.
Figure 30. Soap bubbles.

Figure 31. Interior image.

Figure 32. Construction of the space frame.
Case Study B4_CRMA_ Nox Architecture

How can there be gaps in continuous surfaces? One might expect that in curved surfaces holes have to be cut out later, it is more logical to have holes and curvature co-emerge with the form. Instead of thinking of holes as subtractions, we consider them as internal edge conditions. The hole need not be an absence but an element that adds structure.

The question that Nox Architecture wanted to ask was: how can there be gaps in continuous surfaces? Nox architecture firm wanted to study the possibility of having voids within a curved surface but not as a subtraction. Usually in
design voids are taken after a form is created but in this process there is an interest of holes and curves co emerging as edge conditions. The firm talks about holes as becoming parts of the buildings structure.

The biomimetic application was taken out of the repetition within nature. Within this project the repetition within cells was largely studied. When cells start to compress with each other, these create some spaces that seem to create a backbone/structure that supports all cells together. It looks like a fibrous string that holds the “voids” together. A spider web is a good example of this.

The project is a compact structure that contains two concert halls with offices, restaurant-bar, library and music studios. There are some distinct areas within the project that are open to transformations throughout the day. The bar-
restaurant can be changed into a discothèque in the evening and the disco can be changed into a large hall. The patio can be changed from a dance space into a terrace, the halls can be connected or disconnected by means of mobile partitions. The structure was designed as a generic system that is synthesized from the cell structures. The voids within the building are a reaction to the surroundings. Like the concept, the building tried to fuse the notion of void and structure. The project is like a warehouse, it is open inside and the structure is what holds it in. The building has no internal columns so it lends itself to a open and free plan. It is believed that there was also some studies of exoskeletons due to the shell typology is evokes.

This project is quite interesting within its biomimetic approach. Nox architecture firm is well known as a research firm interested in the design process. They create several
prototypes of a building but with the notion of the biomimetic idea. In comparison to the prior case studies, this building has no technological edge that the other buildings have. Its simplicity and thoughtful analysis of merging voids as part of the structural system is quite interesting and inspiring. As seen in other projects, it seems that they also study exoskeleton systems. Although the building does convey some sort of live animal form from its aesthetic level, it also functions in the biomimetic performance level as well through its use of efficient material and the idea of structure and void.
SITE

Possible Sites

There are three possible sites for the Master’s Thesis project. All sites had to be in the proximity of a large museum complex in a well known city. Cities that held this possibility was Washington and New York City. Both cities are well known for their arts and history. To narrow down to the chosen site, there are other elements that were looked at to choose the appropriate site.

Smithsonian Museum Complex: Washington, DC

The Smithsonian Museum Complex is well known
the excellent collection of the arts. In 1829 English scientist James Smithson left his fortune to the people of the United States to found an institution for the “increase and diffusion of knowledge.” Smithson’s impetus in providing for a research and educational institution in a new country on another continent remains a mystery. His bequest sparked widespread debate over what such a national institution might be. Once established, the Smithsonian Institution became part of the process of developing the U.S. national identity. The Smithsonian Institution is now the world’s largest museum complex, composed of a group of national museums and research centers housing the United States’ national collections in natural history, American history, air and space, the fine arts and the decorative arts, and several other fields ranging from postal history to cultural history. The Institution includes 19 museums, four research centers, the National Zoo, the Smithsonian Institution Libraries
(a research library system), the Smithsonian magazine, the Smithsonian Institution Press, a Traveling Exhibition Service, an Office of Education, and a number of other offices and activities. Most of its facilities are located in Washington, D.C., but its 19 museums, zoo, and 9 research centers include sites in New York City, Virginia, Panama, and elsewhere. It has over 136 million items within its collections.

The Smithsonian is a world known and respected American institution. The only concerns within this site is if the location of the project is appropriate. Is Washington, DC a mecca of the arts? This research is looking for the appropriate site as well as its city. The city needs to be vibrant and rich in culture, truly a center of the artistic world.

Metropolitan Museum of Art Extension: NYC, NY
The Metropolitan Museum of Art is an art museum located on the eastern edge of Central Park, along what is known as Museum Mile in New York City. It has a permanent collection containing more than two million works of art, divided into nineteen curatorial departments. The main building, often referred to simply as “the Met,” is one of the world’s largest art galleries, and has a much smaller second location in Upper Manhattan, at “The Cloisters,” which features medieval art. Represented in the permanent collection are works of art from classical antiquity and Ancient Egypt, paintings and sculptures from nearly all the European masters, and an extensive collection of American and modern art. The Met also maintains extensive holdings of African, Asian, Oceanic, Byzantine and Islamic art. The museum is also home to encyclopedic collections of musical instruments, costumes and accessories, and antique weapons and armor from around the world. A number of
notable interiors, ranging from 1st century Rome through modern American design, are permanently installed in the Met’s galleries.

The Metropolitan Museum of Art was founded in 1870 by a group of American citizens. The founders included businessmen and financiers, as well as leading artists and thinkers of the day, who wanted to open a museum to bring art and art education to the American people. It opened on February 20, 1872, and was originally located at 681 Fifth Avenue. As of 2007, the Met measures almost a quarter mile long and occupies more than two million square feet.

New York City seems to be the most adequate city for the thesis project. New York is a mecca for the arts around the world. The city is well known for being a cultural
center. As a historic landmark within the art world, the Met would be quite an appropriate site for the thesis due to its location and the museum's prestige. The problem that would be faced if there would be an extension to the museum would be that the site is within Central Park. Central Park is an oasis within the city and people that live there have protected its sacredness. This is an issue that this possible site faces. To construct within Central Park is a sacrilege?

Cooper- Hewitt National Design Museum Extension: 
NYC, NY

Now that the thesis has narrowed down what city the project should be, final site has to be found where the project can be constructed with out building in sacred grounds like Central Park. Across from Central Park the
Museum Mile is located. Museum Mile, also known as 5th Avenue, is a mecca for the museum world due to the high volume of museums within the area. Museums such as the Guggenheim, the Met, and the Smithsonian Cooper-Hewitt National Design Museum are located in this area.

The Cooper-Hewitt is a museum that is part of the Smithsonian Institution. This museum is a satellite from the Smithsonian. Since its foundation in 1848, the Smithsonian has become the world’s largest and most visited museum and research complex. Cooper-Hewitt sits firmly within this constellation of intellectual inquiry. Art, History, and Science are the three main divisions of the Smithsonian. Smithsonian Art is a unique national collection of museums, archives, and programs, including Cooper-Hewitt, National Design Museum. The breadth of collections ranges from ancient Asia at the Freer and Sackler Galleries

Figure 44. Approaching the entrance.
to contemporary international art at the Hirshhorn Museum and Sculpture Garden. Cooper-Hewitt forms an important beachhead for the Smithsonian in New York—a world capital of design. The Museum also offers significant education programs, often with Smithsonian Affiliates, situated across the United States. Cooper-Hewitt, National Design Museum, Smithsonian Institution is the only museum in the nation devoted exclusively to historic and contemporary design. The Museum presents compelling perspectives on the impact of design on daily life through active educational and curatorial programming. It is the mission of Cooper-Hewitt’s staff and Board of Trustees to advance the public understanding of design across the twenty-four centuries of human creativity represented by the Museum’s collection.

The Museum was founded in 1897 by Amy, Eleanor, and Sarah Hewitt: granddaughters of industrialist Peter
Cooper, as part of The Cooper Union for the Advancement of Science and Art. A branch of the Smithsonian since 1967, Cooper-Hewitt is housed in the landmark Andrew Carnegie Mansion on Fifth Avenue in New York City. The campus also includes two historic townhouses renovated with state-of-the-art conservation technology and a unique terrace and garden. Cooper-Hewitt’s collections include more than 250,000 design objects and a world-class design library. Its exhibitions, in-depth educational programs, and on-site, degree-granting master’s program explore the process of design, both historic and contemporary. As part of its mission, Cooper-Hewitt annually sponsors the National Design Awards, a prestigious program which honors innovation and excellence in American design. Together, these resources and programs reinforce Cooper-Hewitt’s position as the preeminent museum and educational authority for the study of design in the United States.
Cooper-Hewitt, National Design Museum is housed in the former home of industrial magnate Andrew Carnegie. The sixty-four-room mansion, built from 1899 to 1902, is an impressive testament to the desire of Carnegie and his wife, Louise Whitfield Carnegie, to build a spacious, comfortable, and light-filled home in which to raise their young daughter, Margaret. The house was also planned as a place where Carnegie, after his retirement in 1901, could oversee the philanthropic projects to which he would dedicate the final decades of his life. From his private office in the mansion, Carnegie donated money to build free public libraries in communities across the country and to the improvement of cultural and educational facilities in Scotland and the United States.

The mansion was designed by the architectural firm
of Babb, Cook & Willard in the solidly comfortable style of a Georgian country house. When Carnegie purchased the land for the house, in 1898, he purposely bought property far north of where his peers were living. The relatively open space allowed him to build a large private garden—one of the only ones in Manhattan—that is still a beautiful, restful oasis today. The house is a fascinating study in innovative design. Completed in 1901, it was the first private residence in the United States to have a structural steel frame and one of the first in New York to have a residential Otis passenger elevator (now in the collection of the Smithsonian’s National Museum of American History in Washington, DC). Another innovation was the inclusion of both central heating and a precursor to air-conditioning. In the cellar a pair of enormous twin boilers ran by coal transferred from storage bin to furnace by a coal car that traveled over a miniature railroad track. The building received landmark

Chosen Site_ Cooper- Hewitt National Design Museum Extension: New York City, NY

The Cooper-Hewitt National Design Museum adjacent garden site was chosen as the appropriate site for the Master’s Thesis project. The museum is part of the prestigious Smithsonian Institution and the location within the Museum Mile is superb. This site is excellent for the thesis. The adjacent site to the Cooper-Hewitt lends itself for an extension to the museum as well as future mixed use development. The thesis project will be situated within this site due to its excellent location within New York which is a city well known for the arts.

Figure 53. Chosen site in NYC.
New York City is located in the Northeastern United States, in southeastern New York State, approximately halfway between Washington, D.C. and Boston. The location at the mouth of the Hudson River, which feeds into a naturally sheltered harbor and then into the Atlantic Ocean, has helped the city grow in significance as a trading city. Much of New York is built on the three islands of Manhattan, Staten Island, and Long Island, making land scarce and encouraging a high population density.

New York City (officially The City of New York) is the largest city in the United States, with a metropolitan area that is among the largest urban areas in the world. The city serves as one of the world’s primary global cities, exerting a powerful influence over worldwide commerce, finance,
culture, and entertainment. The city is also an important center for international affairs, hosting the United Nations headquarters. The city consists of five distinct boroughs: The Bronx, Brooklyn, Manhattan, Queens, and Staten Island. It is the most densely populated major city in the United States, with an estimated 8,274,527 people within an area of 304.8 square miles. The New York metropolitan area is also the largest metropolitan area in the country, with an estimated 19,750,000 people over 6,720 square miles New York is largely unique among American cities for its high use of mass transit, and the overall density and diversity of its population. In 2005, nearly 170 languages were spoken in the city and 36% of its population was born outside the United States.

Data

Figure 55. Chosen site in NYC adjacent site to the Cooper- Hewitt.
Country: United States of America
State: New York
Boroughs: Bronx
       Brooklyn
       Manhattan
       Queens
       Staten Island
Population: 8,274,527 people
           1rst in the US
Area: City: 468.9 sq. mi
      Land: 304.8 sq. mi

NYC: Mecca for the Arts & Museum Mile

New York City is famous for its cavernous avenues, excellent restaurants, world-class shopping, and reputation as a leader in the arts. With its wealth of attractions
to tempt any visitor, there are none more interesting than the museums located throughout the city’s five boroughs. New York City is home of hundreds of cultural institutions and historic sites, many of which are internationally known. Museum Mile is the name for a section of Fifth Avenue in Manhattan, running from 82nd to 104th streets in the Upper East Side in a neighborhood known as Carnegie Hill. The “MILE”, which contains one of the densest displays of culture in the world, is actually two blocks longer than one mile. New York City officially designated this segment as Museum Mile in 1979 because it is the location of nine museums, a tenth museum, the Museum for African Art, will be joining the ensemble in 2008, the first new museum since the Guggenheim in 1959. In addition to other programming, the museums collaborate for the annual Museum Mile Festival, held each year in June, to promote the museums and increase visitation.
Figure 59. Panorama image of New York City.

Figure 60. Panorama image of Cooper-Hewitt site.
Figure 61. Panorama image of Cooper-Hewitt from Central Park entrance.

Figure 62. Panorama image of Cooper-Hewitt site from Central Park.
Site: C-HNDM & Adjacent Garden

Cooper-Hewitt, National Design Museum, Smithsonian Institution is the only museum in the nation devoted exclusively to historic and contemporary design. The Museum presents compelling perspectives on the impact of design on daily life through active educational and curatorial programming. It is the mission of Cooper-Hewitt’s staff and Board of Trustees to advance the public understanding of design across the twenty-four centuries of human creativity represented by the Museum’s collection. The Cooper-Hewitt Museum wants to sell their garden lot to accommodate the new museum’s expansion. A good way to do this is by selling the land to a developer and form an agreement where the developer builds the new museum in return of the new land/air rights acquired to build a residential tower.
The program will accommodate the new museum extension and luxury apartments. The site is facing Central Park which makes this site prime lot to develop. The task will be to design both the museum and the apartments within the small lot.

Background Information: NYC Zoning Districts

The city is divided into three basic zoning districts: residential (R), commercial (C), and manufacturing (M). The three basic districts are further divided into a variety of lower-, medium- and higher-density residential, commercial and manufacturing districts. Any of these districts may in turn be overlaid by special purpose zoning districts tailored to the unique characteristics of certain neighborhoods. Some block fronts in residential districts may be overlaid as well by commercial districts providing for neighborhood

Figure 64. Zoning board with analysis.
retail stores and services. These overlay districts modify
the controls of the underlying districts. Moderate- and
higher-density residence districts are generally found close
to central and regional business districts, and are usually
well served by mass transit. These areas are characterized
by bulkier buildings, a wider range of building heights and
lower auto ownership than lower-density areas. Like the
lower-density residence districts, however, the character
of these neighborhoods varies widely. Some are defined
entirely by row houses, others by low apartment houses or
high-rise buildings and still others by a mixture of all build-
ing types.

The Cooper-Hewitt National Design Museum is
located in 2 East 91st Street, New York, NY 10128. The
zoning in this area is located within the most expensive
residential area within Manhattan, 5th Avenue. For zoning
requirements, the adjacent lot to the Cooper-Hewit is R-10.

R-10 is a higher density residence district and this is the highest zoning number within the residential zoning requirements. The following chart will demonstrate what zoning R-10’s requirements are within the Manhattan district.

Figure 65. Zoning rules within New York City diagrams.
### Table 13. R8-R10 Density Residence Districts

<table>
<thead>
<tr>
<th>Residential FAR (max)</th>
<th>R8HF</th>
<th>R9HF</th>
<th>R8A</th>
<th>R8B</th>
<th>R8X</th>
<th>R9HF R8A</th>
<th>R9 1°</th>
<th>R9X</th>
<th>R10</th>
<th>R90HF R10A</th>
<th>R10X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wide Street</td>
<td>0.94–6.02</td>
<td>6.02</td>
<td>6.02</td>
<td>4.0</td>
<td>6.02</td>
<td>0.99–7.52</td>
<td>7.12</td>
<td>9.0</td>
<td>9.0</td>
<td>10.0°/10.0°</td>
<td>10.0°</td>
</tr>
<tr>
<td>Narrow Street</td>
<td>6.02</td>
<td>6.02</td>
<td>6.02</td>
<td>4.0</td>
<td>6.02</td>
<td>0.99–7.52</td>
<td>7.12</td>
<td>9.0</td>
<td>9.0</td>
<td>10.0°/10.0°</td>
<td>10.0°</td>
</tr>
<tr>
<td>Community facility</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
<td>4.0°</td>
<td>6.0</td>
<td>10.0</td>
<td>10.0°</td>
<td>9.0</td>
<td>9.0</td>
<td>10.0°/10.0°</td>
<td>10.0°</td>
</tr>
<tr>
<td>Open space ratio</td>
<td>5.9–11.9 (range)</td>
<td>5.9–9.0 (range)</td>
<td>5.9–9.0 (range)</td>
<td>5.9–9.0 (range)</td>
<td>5.9–9.0 (range)</td>
<td>5.9–9.0 (range)</td>
<td>5.9–9.0 (range)</td>
<td>5.9–9.0 (range)</td>
<td>5.9–9.0 (range)</td>
<td>5.9–9.0 (range)</td>
<td></td>
</tr>
<tr>
<td>Lot coverage (max)</td>
<td>Corner lot: 70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td></td>
<td>Interior lot: 70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td>Base height (min/max)</td>
<td>Wide street: 60–85 ft</td>
<td>60–85 ft</td>
<td>55–60 ft</td>
<td>60–85 ft</td>
<td>60–85 ft (wide std)</td>
<td>60–102 ft</td>
<td>60–95 ft</td>
<td>90 ft</td>
<td>105–120 ft</td>
<td>60–85 ft (wide std)</td>
<td>123–150 ft</td>
</tr>
<tr>
<td></td>
<td>Narrow street: 60–85 ft</td>
<td>60–85 ft</td>
<td>55–60 ft</td>
<td>60–85 ft</td>
<td>60–85 ft (wide std)</td>
<td>60–102 ft</td>
<td>60–95 ft</td>
<td>90 ft</td>
<td>105–120 ft</td>
<td>60–85 ft (wide std)</td>
<td>123–150 ft</td>
</tr>
<tr>
<td>Building height (max)</td>
<td>Wide street: 120 ft</td>
<td>120 ft</td>
<td>75 ft</td>
<td>150 ft</td>
<td>143 ft</td>
<td>280 ft</td>
<td>170 ft</td>
<td>160 ft</td>
<td>210 ft</td>
<td>185 ft</td>
<td>185 ft</td>
</tr>
<tr>
<td></td>
<td>Narrow street: 105 ft</td>
<td>105 ft</td>
<td>75 ft</td>
<td>150 ft</td>
<td>143 ft</td>
<td>280 ft</td>
<td>170 ft</td>
<td>160 ft</td>
<td>210 ft</td>
<td>185 ft</td>
<td>185 ft</td>
</tr>
<tr>
<td>Rear yard depth (min)</td>
<td>30 ft</td>
<td>30 ft</td>
<td>30 ft</td>
<td>30 ft</td>
<td>30 ft</td>
<td>30 ft</td>
<td>30 ft</td>
<td>30 ft</td>
<td>30 ft</td>
<td>30 ft</td>
<td>30 ft</td>
</tr>
<tr>
<td>Off-street parking (min)</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
</tr>
</tbody>
</table>

1. Waived within Manhattan Core.
2. Wide street within Manhattan Core.
3. Up to 12 FAR with Inclusionary Housing bonus.
4. S.10 permitted in Manhattan Community District.
5. 40% in Brooklyn.
6. May also be mapped in the Special Long Island City Mixed Use Districts only.
7. In CDI, Brooklyn, 3.75 FAR and up to 5 FAR with Inclusionary Housing bonus.

### Table 14. PRC Types of Uses

- **A**: Food stores (larger than 2,000 sf)—high traffic volume
- **B**: Local retail or service uses (bakeries, restaurants, department and appliance stores)—high traffic volume
- **B1**: Offices and stores that sell large items (furniture, carpets, appliances)—low traffic volume
- **C**: Miscellaneous (courthouses, auto showrooms)—low traffic volume
- **D**: Places of assembly (theaters, bowling alleys, stadiums)—high traffic volume
- **E**: Outdoor amusement areas—high traffic volume
- **F**: Light manufacturing (ceramics, dental products, commercial laundries)—moderate traffic volume
- **G**: Storage uses (warehouses, trucking terminals)—low traffic volume
- **H**: Other uses (hotels, funeral parlors, post offices, boat rentals) with unique traffic characteristics

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69
Property Profile Overview

The property profile overview is the data given by New York City's zoning department. For The Cooper-He-witt, this is the property profile overview:

- **Residential Floor Area Ratio (FAR)**
- **Building Lot Dimensions:** 90' x 208'
- **Lot Area:** 18,880 sf
- **Total Building Area:** 75,520 sf
- **Lot Coverage:** 80%
- **Building Max Height:** 60-85' (wide street)
- **Perimeter:** 615’ 7 1/4”
- **Lot Size:** 4,360sf larger than 1/3 Acre- 14,520sf
- **Block Number:** 1502

Figure 66. Site analysis sketches.
Lot Number: 1
House Number Range: 2-16
Building Identification Number (BIN): 1046980
Department of Finance Building Classification: P7-Public Assembly
Landmark Status: Federal Government Bldg.
Special District: PI- Park Improvement
Buildings in Lot: 2
5 Storey Building
Building Height: 66'-2"
Figure 67.
Presentation board for the site analysis.
PROGRAM

Introduction

The project will consist of two programs: the museum extension and the apartment tower. The maximum building height is 80' which is approximately 6 to 7 floors. There is a need to propose the height restriction to go beyond the 80 feet, Density Bonus. Due to the project’s small site, a bit larger than 1/3 acre, the project proposes to go vertical and underground.

For Thesis 1 final presentation, there have been several changes within the program. It has been determined that it will not be possible to design both the museum and
the apartments. For the rest of the thesis the focal point will be the museum. The concept of Biomimicry is complex and designing a tower has its complexity. Furthermore, the main idea is Biomimicry and this will be the main focus for the end of this semester and Thesis 2.

Building typology proposal: Museum Extension Data

Gross Square Footage= 31,350sf
Gallery Space= 15,000sf
   Bio-Tech Gallery
   Innovation Gallery: Green by Design
   Exploration and Testing Gallery
Education Space=3,000sf
Library=1,000sf
Offices=1,500sf
Auditorium seats 155= 3,200sf
Special Events Space=2,000sf
Restaurant=3,650sf
Museum Store=2,000sf

New York City Museums are known worldwide for their high quality exhibits and permanent collections. Manhattan is home to most of the area’s museums including the Metropolitan Museum of Art, American Museum of Natural History and the newly renovated Intrepid Sea, Air & Space Museum. Many museums in New York City are internationally renowned and regarded as one of a kind. For example, the Guggenheim Museum, located along the famous “Museum Mile” (on Fifth Avenue in Manhattan, running from 82nd to 105th streets on the Upper East Side) is an architectural landmark with a permanent collection of impressionist, post-impressionist, early modern and
contemporary art. The Museum of Modern Art (MOMA), is located in midtown and is often regarded as the most influential museum of modern art in the world. Other NYC museums feature nature and life sciences, design, culture, history, music and even sports. There is even a group of Children’s museums. Millions of visitors flock to the New York City every year looking for inspiration, knowledge and the rare chance to view many of the world’s most important and influential art and historical treasures.
Figure 72. Program presentation board.
FIELD RESEARCH

Introduction: New York City Trip

My trip to New York City was short I knew from the start that I had to take advantage of the time I was going to be there as much as possible. My stay in New York as from October 3, 2008 to October 6, 2008. When I first arrived to New York City I felt overwhelmed by the energy the city has. The fast paced life is something I am not well accustomed to in Florida nor in my native home in Puerto Rico. The energy that this city had is truly remarkable. In some way, I felt that I was in another country. Rarely did I ever hear the English language being spoken. I believe that the museum in some way should convey the energy that this
city has. I believe that the fast paced energy is a natural aspect of New York City and should be incorporated into the museum’s design.

Itinerary

From October 3 to October 6 2008, I went to New York City for my Thesis study. There was two reasons why I went to New York City. I first had to go visit my site which is the adjacent garden lot to the Cooper- Hewitt Museum National Design Museum. I had the opportunity of staying close to the site. I also went to study different museums within the area. New York City is world recognized as a leader within the arts. This is well shown within the city’s world famous museums. I had a full schedule when I got to New York. Here is a description of the places I went in New York City.
Friday, October 3, 2008:
Arrived to New York City
Checked in at Helmsley Park Lane Hotel
Museum of Arts and Design
Walked around Central Park South and 5th Ave
Visited Site at the C-HNDM

Saturday, October 4, 2008:
Cooper-Hewitt National Design Museum
Guggenheim Museum
Metropolitan Museum of Art
Natural Museum of History: Hayden Planetarium

Figure 76. Cooper-Hewitt.
Figure 77. Hayden Planetarium.
Sunday, October 5, 2008:
Modern Museum of Art
Folk Art Museum
Skyscraper Museum
Museum of Sports
Museum of Sex
Times Square Visit

Monday, October 6, 2008:
Visited Site at the C-HNDM
Checked out from the hotel
Firm Visit: Ghery Technologies
Left New York City

Places Visited

For those 4 days, I visited several museums and
important sites within the New York City area. The several Museums visited were composed of small and large, well known and unknown museums. Some museums were very prestigious and other conveyed some sort of taboo within the community. I believe that the museums that were visited do demonstrate quality of ease of adaptation that the city has. New York City is so many things at the same time, that it is obligated to adapt really quickly to any changes within it. One day I observed that a man was wearing a t-shirt reading Z00 YORK. After reading that it came to me that New York City is indeed a melting pot of different people and this is reflected within the city’s museums. Therefore the Cooper-Hewitt National Museum of Design and Technology will fit perfectly within New York’s culture and museum matrix.
Figure 82. Folk Art Museum.

Figure 83. Skyscraper Museum.

Figure 84. Museum of Sports.

Figure 85. Museum of Sex.

Figure 86. Metropolitan Museum of Art.

Figure 87. Museum of Natural history.
Figure 88. Interior of Hayden Planetarium.

Figure 89. Interior of Natural Museum of History.

Figure 90. Interior of Metropolitan Museum of Art.

Figure 91. Interior of Metropolitan Museum of Art.

Figure 92. Interior of Guggenheim museum.

Figure 93. Interior of MOMA museum.
NYC_trip_OCT.3-6 08

From October 3 to October 6, 2008, I went to New York City for a thesis study. There were two main reasons why I went to New York City. First, I had to go to a conference which is the academic symposium of the Cooper-Hewitt National Design Museum. I was required to study different exhibitions from the world. New York City is world recognized as a leading city in the arts field and is where the world's best museums are located.

ITINERARY

I had a full schedule when I got to New York. Here is a description of the places I went in New York City. I had the opportunity of staying close to the sites.

Friday, October 3, 2008:
- Arrived in New York City
- Checked into the Holiday Inn Hotel
- Visited the Cooper-Hewitt National Design Museum
- Visited the Metropolitan Museum of Art
- Visited the Hayden Planetarium

Saturday, October 4, 2008:
- Cooper-Hewitt National Design Museum
- Metropolitan Museum of Art
- Natural History Museum of History

Sunday, October 5, 2008:
- Visited the Metropolitan Museum of Art
- Visited the National Museum of American History
- Visited the American Museum of Natural History

Monday, October 6, 2008:
- Visited the American Museum of Natural History
- Checked out
- Left New York City

Presidents Visited
- Cooper-Hewitt National Design Museum
- Metropolitan Museum of Art
- Natural History Museum of History

NYC trip presentation board.
Summary for Thesis 1

Final Thoughts

After looking again at the precedents and the field research, I discovered that I was missing something. Biomimicry is my focal point and I was not following it as I first intended to do. Now as I look back at all of the information, I acknowledge that I have ignored my site in all its context. I had forgotten where my museum is going to be located: New York City. New York City is a country of its own and has its own ecosystem. The city and the people that inhabit it have a particular attitude and energy that is distinct and unique. It would be a sacrilege for me not to look at these elements and design a museum without
accepting what New York City is. As a student of architecture and biomimicry I have to incorporate New York City’s ecosystem within the museum design. The museum should convey a biomimicry approach to the sites context. The museum should act as a part of New York City and if it is removed from the city, it would die like any other living organism. There are some elements that will give character to the museum: the site’s surroundings (Museum Mile/5th avenue, Central Park, Cooper-Hewitt), and the city’s culture and energy.

I will still focus on the skin of the project but now it will be in the adaptive aspect. This will be my focus for next semester.
Figure 95. Poster board for the conceptual design.
DESIGN

Introduction

For the Master Thesis 2 class students have to emphasize on the design concept of the Thesis. We have to gather all of the information and research that we had done within Thesis 1 and apply it to Thesis 2. Thesis 2 is the final semester because it will determine the outcome of the success or failure of the project. Early within the semester I started to apply natural systems that I had studied and incorporated them into the design.

Conceptual Design
Since the beginning, I was focused on the project being site specific. My goal was to design a project that if one would remove it from its context, it would not work and fall apart. I started looking at the site and what this site had that was unique. This last December, I had the opportunity to return to New York City and go back to the Cooper-Hewitt site. I believe that the first time I was at the site I took for granted what was there. There are several important elements within the site: it is in front of 5th Avenue, one of the busiest streets in New York City and above all, the site is located in front of Central Park. Central Park is a very large man made park within the city. It is an oasis for the busy hustle and bustle of New York. I believe that I was forgetting what made this site so unique. I knew then that I had to address these elements within the design.
Concept

New York City is well known for its tall buildings. Besides Central Park, the city is covered in concrete and steel. Cooper-Hewitt site is unique because it is between the nature that we know and what man has made. What happens if nature breaks out of the grid that man made for it in the city? What would happen if Central Park took its natural course and started to grow outside New York City's man made grid? This is where my design concept commences. What if this nature moved into the Cooper-Hewitt site and adapted itself to its surroundings like a living organism? My thesis design project has to adapt like a living organism. With the design concept in hand, I started to do some site models.
Figure 100. Conceptual design site plan.

Figure 101. Conceptual design ground floor plan.
Figure 102. Conceptual design cross section.

Figure 103. Conceptual design longitudinal section.

Figure 104. Conceptual design section.

Figure 105. Conceptual design section.
Figure 106. Concept interior rendering.

Figure 107. Concept interior rendering.

Figure 108. Concept interior rendering.

Figure 109. Concept interior rendering.

Figure 110. Concept interior rendering.

Figure 111. Concept interior rendering.
Figure 117. Analysis and diagrams.

Figure 118. Voronoi diagrams.
Figure 119. Analysis and diagrams.

Figure 120. Analysis and diagrams.
Figure 121. Analysis and diagrams.

Figure 122. Voronoi diagrams.
After doing these models I went directly into designing the museum. I tried to squeeze in the square footages and spaces required in the program. For Thesis 2 midterm presentation I was notified by my committee members that I had forgotten what my project was all about: Biomimicry. I was told that I should emphasize not on the building typology but rather study natural systems that I wanted to apply to the museum design.

After the midterm presentation, I started to do prototype systems of the skin column and structure. For the remaining part of the thesis I emphasized on doing research on structural systems within nature. As I looked as my previous research, I began to look at similarities that several natural systems had: repetition and a system of rigid shapes (triangles and circles). I notices that the organisms that I studied such as the bone structure, honeycomb, cells, crystals...
and radiolaria all had something in common: these systems are all structurally strong and rigid as well as they had a common shape within them: triangles. Triangles and circles are the strongest shapes within nature and when repeated create complex systems that are efficient as well as aesthetically pleasing. I wanted to apply this notion of natural triangulation and repetition within the design of the museum, in particular to the structure. For the final presentation, I focused on the structural systems within the museum building: skin system, column system and exterior structure system.

Structural Systems Applied from Biomimicry:
Column, Skin and Exterior Structure

For these studies I was able to make hand made models, computer generated models (3D Max, Rhinoceros 4.0, Google Sketch Up, Paracloud), sketches and 3D printing. I
was trying to sell all of the different ways I could study these structural systems. Each tool that I used to create these models helped me to understand how things are made. 3D printing was very helpful in this because it helped me figure out how something can be built and can stand. I had to create models from a computer and make them work in real life that were affected by gravity.

For the column system I wanted to apply the notion of how trees work within nature. One can observe that trees have a middle long trunk and open wide on the top (branches) and on the bottom (roots). What can be applied from the tree to the structure of a column system? What if we could use the material efficiency that trees have and apply them to columns? What could happen if columns moved free in like trees in the wind? All of these questions I was very eager to answer and discover. Another element that I wanted to study
for the columns was the idea of rigid shapes (triangulation and circles) and repetition. I created several prototypes with different applications: modularity, structural bracing, cross bracing, material efficiency, joints, connection to floor/ceiling, honeycomb structure, nurb systems and straight angle systems.

For the skin system I applied the same ideas of rigid shapes (triangulation and circles) and repetition. I also started to apply natural systems that I had studied earlier such as the human bone/skin, honeycomb, crystals, pores, and eye system.

The exterior structure system I studied how the skin and bone system works. For the project I wanted to invert this system and make the bone outside of the skin. The bone would support the skin as well as push away the slurry
wall around the building. The exterior skin system is an extra structure system which I believed would just be extra structure but after creating the section model I discovered that I actually needed this structure for the project to work.

Figure 131. Column system: triangulation

Figure 132. Column system: triangulation detail.

Figure 133. Column system: triangulation truss system study. How does the column connect to the floor and ceiling?
Skin prototype studies: How does the external structure attach to the skin and the outer slurry wall.
Figure 139. Skin prototype system.

Figure 140. Skin prototype system.

Figure 141. Skin prototype system.

Figure 142. Skin prototype system.
Figure 147. 3D print column.

Figure 148. 3D print column.

Figure 149. 3D print column detail.

Figure 150. 3D print column detail.
Table 15. 3D print skin.

Table 16. 3D print skin detail.

Table 17. 3D print skin detail.
Table 18. 3D print skin.

Table 19. 3D print skin detail.

Table 20. 3D print skin detail.
Figure 151. Biomimicry research board.

Figure 152. Biomimicry research large board.
Figure 153. Biomimicry research board.
Figure 154. Biomimicry research large board.

Figure 155. Biomimicry research board.
Figure 156. Biomimicry research board.
Figure 157. Analysis sketches board.

Figure 158. Analysis sketches large board.
Figure 159. Analysis sketches board.
Final Design

My final defense thesis presentation was March 24, 2009. All my committee members were present as well as two new members: my parents. My father Mario Corsino is a registered Architect in Puerto Rico for over 30 years and my mother Isabel Carro de Corsino is a registered Interior Designer. For my final thesis project I presented all of my work including the new work created after the midterm: 3D printed models of the biomimicry structure studies, 3D computer generated models, sketches as well as the final design project of the museum.

The C-HND+TM is located right on 5th Avenue, two blocks away from the Guggenheim museum. I knew that this project had to create a bold statement within the New York
City community. From the biomimicry studies that I had taken, I commenced to apply these ideas to the design.

I knew that the project had to react drastically to its surroundings. I knew that the building had to go underground. Second, the project had to have supporting elements: columns, exterior structure to hold the building from the ground and slurry walls. The design project reacted towards the site as if it came into the ground and suspended itself from the walls like a living organism. Also, I knew that the skin had to be porous to let light into the building. The columns also act as light wells that bring in light into the museum. A massive void in the middle of the project also act as a giant column and the vertical circulation. For the final presentation I presented the final design with: a context model (1/32” scale), a site model (1:20 scale), a section model (1/8” scale), site plan, floor plans, longitudinal/cross sections, interior/exterior
renderings and the animation that was the introduction of
the thesis presentation.
The city of New York, with an estimated population of 8.774.922 people, is the most densely populated major city in the United States. The New York metropolitan area is the largest metropolitan area in the country, with an estimated 19.750.000 people over 6.750 square miles. New York is largely, but not entirely, a multicultural metropolis, characterized by its high rate of immigrant arrivals, and the overall diversity of its population. In 2000, nearly 710 languages were spoken in the city, while 30% of its population was born outside the United States.

Figure 162. Site plan board.
Figure 163. Floor plans board.

Figure 164. Floor plans large board.
The Cooper-Hewitt Museum wants to sell their garden lot to accommodate the new museum's expansion. A joint venture was formed to buy the lot and form an agreement under which the developer builds a new museum in return of the new land use rights acquired to build a residential tower. The program will accommodate the new museum expansion with studio apartments. The sloping facing Central Park which makes this site prone to landslides. This task will be to design both the museum and the apartments within the small lot.

Cooper-Hewitt, National Design Museum, Smithsonian Institution is the only museum in the nation devoted exclusively to historic and contemporary design. The Museum presents compelling perspectives on the impact of design on daily life through active educational and community programming. In the message of Cooper-Hewitt's staff and board of trustees to advance the public understanding of design across the twenty-first century, the museum's collection...
Figure 166. Cross section board.

Figure 167. Cross section large board.
Figure 168. Cross section board.
Figure 169. Longitudinal section board.

Figure 170. Longitudinal section large board.
Figure 171. Longitudinal section board.
Figure 172. Section views board.

Figure 173. Section views large board.
Figure 174. Section views board.
Figure 175. Exterior views board.

Figure 176. Exterior views large board.
Figure 177. Exterior views board.
Figure 178. Interior views board.

Figure 179. Interior views large board.
Figure 180. Interior views board.
Figure 181. Exterior rendering.
Figure 182. Exterior rendering.
Figure 183. Exterior rendering.
Figure 184. Interior rendering.
Figure 185. Interior rendering.
Figure 186. Interior rendering.
Figure 189.  Context model.

Figure 190.  Context model.
Figure 191. Site model.

Figure 192. Site model.
Figure 193. Site model.

Figure 194. Site model.
Figure 195. Sketch section model.

Figure 196. Sketch section model.
Figure 197. Sketch section model.

Figure 198. Sketch section model.
Figure 199. Sketch section model.

Figure 200. Sketch section model.
Figure 201. Sketch section model.

Figure 202. Sketch section model.
Figure 203. Sketch section model.

Figure 204. Sketch section model.
Figure 205. Sketch section model.

Figure 206. Sketch section model.
CONCLUSION

The question of did I apply biomimicry into the design is yes, but I believe that there needed to be more research within the project. It is rather impossible to try to discover almost 4 billion years nature has perfected itself within 3 semesters of Thesis. I knew that I had achieved several of my goals but not all. Due to the shore time of this thesis I could only focus on the structural aspect of the project rather than the entire aspects of the project (circulation, materials, HVAC, light, etc.). For this project I will continue to develop the structural systems that I had studied to a point here the entire project could be built. After that, I would like to focus on the circulation and the material technology for the project. There are still a lot of questions that need to be answered. I
also discovered that what I was criticizing the problems from other projects like the Birds Nest, Jellyfish House and the Water Cube where the same problems that I encountered with my design. I have learned that Biomimicry is a new field that is in need of further research especially within the architecture field. This project has encouraged me to look outside of the box and think of the possibilities that we as architects can do for humanity. I believe that architects should go back to nature and study the natural wonders it has to offer because nature has already tested its natural systems. It is now our choice to walk the first step into the right direction. Due to my passion for this field I will pursue a PhD in architecture with an interest in biomimicry.
Figure 210. Thesis final presentation.

Figure 211. Thesis final presentation.

Figure 212. Thesis final presentation.

Figure 213. Thesis final presentation.
Thesis final presentation.

Figure 214.

Thesis final presentation.

Figure 215.

Thesis final presentation.

Figure 216.

Thesis final presentation.

Figure 217.
Figure 218. Thesis final presentation.

Figure 219. Thesis final presentation.

Figure 220. Thesis final presentation.
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