Evaluating Progressivism: A Critique of Biomimetic Architecture

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INTRODUCTION

It would seem that since humanity first began building settlements and creating tools that it has been marching tenaciously upon a path of progress. So intertwined have been the actions of humanity with advancement, that the ages themselves take title from the character of human creation. The Stone Age, The Bronze Age, and the Iron Age are each characterized according to the level of sophistication reached by humans through progress. Steady progress through Antiquity and the Middle Ages inevitably lead to a critical mass of knowledge, which manifested itself as the Enlightenment and ultimately the Industrial Revolution. By the beginning of the twentieth century, American culture was being characterized by the Progressive Era, which sought to fundamentally change the country from every angle.

But progress has its price; technology and innovation often march forward without regard for the obstacles in their paths. For this reason we question the validity and sustainability of our ideas regarding what was, is, and will be considered progress. If we are to properly and justly ascribe meaning to nascent movements in progressivism, then we must strive to understand them objectively as they exist within a cogent historical context. Only through such historical systems can the characteristically ephemeral nature of "style" be eliminated, and consideration of the validity of such progress made.

The following discourse considers biomimicry as one such progressive trend, and aims to examine its validity and relevance, particularly as it relates to architecture. Establishment of validity will be accomplished through examination of its historical context, definition of its typologies and methodologies, taxonomic categorization of its terminology, a discussion of its contemporary portrayal, and provision of a series of illustrative examples to augment the observations offered. These observations, characterizations, and conclusions, will be discussed through conceptual consideration of how "second nature" and humanities innate biophilic tendencies have given rise to biomimetic architectural methodologies.

ORIGINATION

Architects have often looked to nature for inspiration. In speaking of the early evolution of architecture, Vitruvius states:

> "They began by imitating the nests of swallows and the way they built, they constructed better and better kinds of huts as time went on."[1]

Several hundred years later, Laugier's primitive hut was not imagined without columns as trees, and a roof with forest canopy. Since then architects have imagined a future with an architecture derived from nature.

> "It is no longer from wooden frames or huts that it will obtain its origin, nor from the human body whose proportions it will use to regulate its relationships; it is nature itself, in its abstract essence, that it (architecture) takes for its model. It is nature's order par excellence that becomes its archetype and its genius….This art imitates its model less in material than abstract qualities. It does not follow it but goes alongside. It does not make things it sees, but watches how they are made. It is not interested in the results but in the cause in producing them."[2]

SECOND NATURE

These words from 1788 were written during the Enlightenment as science departed from natural philosophy, and reductionism created highly specified fields of study.[3] This is perhaps when scholars began feeling the detachment of humans from nature, a process, which began at the end of the Neolithic Age and the dawn of the Bronze Age when humans began building permanent settlements. In speaking of the Neolithic transition of wandering hunter-gatherers to permanent settlers, Norman Crowe states that:

> "Our new lives as dwellers in permanent houses and settlements must surely have radically altered our view of nature and even of ourselves in relation to it. Now we could begin to see nature as that which lies outside and beyond the village rather then something of which we are a complete and inextricable part. It became possible to see the natural world as something that we might exploit and control for our own benefit."[4]

Nature, for the first time was an idea apart from ourselves. As a separate entity nature's inherent entropy could be feared and its resources exploited. From a position of detachment from the natural world mankind's perception of nature and perception of itself developed into two distinct realms: nature and the man-made world, a "second nature". This "other" world was described by Cicero in the first century BC:

> "We enjoy the fruits of the plains and the mountains, the rivers and the lakes are ours, we sow corn, we plant trees, we fertilize the soil by irrigation, we confine the rivers and straighten or divert their courses. In fine, by means of our hands we essay to create as it were a second world within the world of nature."[5]

Herein lies the significance of architecture's position within this progression, since it is the means and process through which humanity distinguishes itself from all other actions and creations in the natural world. Landforms evolve, and animals build shelter, but neither occurs with the passion or intent of the human animal. The honeybee constructs elegant geometries with precision and efficiency, but does so as the result of encoded behavioral actions and responses. Its actions, while gracefully choreographed, are ultimately devoid of the intent and transcendental creative forces which act through the human hand to create the poetic grandeur of architecture. Following the emergence of "second nature" humanity became obsessed with the expansion and perfection of this second world through architectural expression.

> "If human beings had been content for several thousand years to roam shelter less and with only limited technology, why, all of a sudden, should they become seemingly obsessed with architecture, with not just settling down in one fertile place protected from the elements but erecting buildings and cities that contested with nature itself for grandeur?"[6]

"Second nature" with which man had become obsessed, was fundamentally defined as being apart from nature. However, mankind's history with, evolution within, and ongoing dependence upon nature collectively caused man's creations to manifest a natural origin, one of an animal whose physiology and, more importantly, psychology had evolved in a natural world.

> "The man made world is an alternative nature, so to speak, created by artifice and born as a human reflection of the wonder we find in the natural world- the heavens, the seasons, the landscapes and seascapes, plants and animals."[7]

The "wonder" referred to results from the perfection present in the design of natural things. No object designed or created by the human hand can rival the beauty, intricacy, complexity, or efficiency of those created in the natural world. The grandest of cathedrals is dwarfed both in scale and grandeur by the mountain vista, or a sunrise. We strive to create perfection and beauty that might humbly rival that of the "great architect", and so look to such creations as models.

Contrarily, theory and philosophy regarding the way in which humans describe or define what is natural has itself been a source of contention. Acknowledgment of an origin to humanities perception of itself apart from nature necessitates consideration that prior to this origin, the human animal was in fact an animal. And like any natural creature existed as one with nature, both in substance and action.

> "But what is nature? For is custom not natural? I am afraid that nature is itself only a first custom, as custom is a second nature.[8]

Pascal's "custom" refers to the human custom of creating artifacts, and custom in this context is synonymous with human nature. Pascal illuminates the notion that, being creatures of natural origin neces-

sitates consideration that our nature as beings must itself be considered natural. Pascal questions that human nature and by extension its artifacts are an equally valid form of the natural world.

WIDENING THE GAP

Retrospectively, consideration of the concept of "second nature" includes a spectrum of interpretations. The extremes of this spectrum, one the romanticizing of an architecture that honors the natural world and the other a critique of architecture's environmental accountability, while opposed, ultimately result in a separation between humankind and its relationship to nature. Following humankind's psychological evolution from "natural" beings to ones apart from nature, a systemic widening of this gap can be traced through time. Perhaps the greatest of such forces was the Industrial Revolution, which increased this gap exponentially as mass production and technology enabled human populations to exist without the need for direct or intimate contact with nature. "Progress," by way of human industrial efforts, created a system of resource extraction, production, and disposal fueled by an attitude towards domination of the natural world. Human's progressed and the natural world suffered.

The Industrial Age fueled the opulence and unprecedented expansion of the Gilded Age, which was in some ways countered by the Progressive Era's pragmatic overtone. Although this "progressive" overtone embraced technology, innovation, and science, it simultaneously furthered the gap between humans and nature. Progress as it was defined by the era, was the improvement of culture, government, society, and science through technology and policy. The cost of this "progress" went seemingly unnoticed until the Environmental Movement of the 1970's, by which time America had "progressed" significantly in its destruction of the natural world. The Modernist Movement, in the early twentieth century completed this ongoing separation as it reveled in the mass-produced machine aesthetic.

BRIDGING THE GAP: BIOPHILIA

The gap between humanity and the natural world was, and is, not without its counterpoint. It would seem that despite the tendency of humanity's progressivism to detach it from nature, our psychological connection to it is a defining human characteristic. Biophilia describes the human emotional, psychological, and physiological affinity to living things and systems.

Biophilic design advocates believe that our natural inclination evolved and became biologically encoded as it was and is instrumental in enhancing human physical, emotional, and mental well-being. People evolved in a natural world and received sensory information from environmental features such as light, sound, odor, wind, weather, water, vegetation, animals, and landscapes. Contrary to this, human agriculture, fabrication, technology, industrial production, engineering, and the modern city constitutes only a small fraction of human history, and so, it is with a physiology, and psyche adapted to nature that we experience the world and more importantly the built environment. [9]

This observation is the basis upon which biophilic design proponents base their arguments, many of which are substantiated by growing sets of scientific evidence. For example, studies of recovery times for hospital patients which have views of outdoor landscapes versus those that do not are shorter, or productivity and absenteeism of employees that have views of the outdoors or daylight in their offices are higher and lower respectively, apparently due to their connection, or lack there of, to the outdoors. These results typify a physiological and psychological connection. One that's mechanism may not be easily pinpointed but that's effect cannot be ignored. Research regarding the biophilic inclinations of humans is growing, but its proponents are confident that these obvious connections will lead to further interdisciplinary investigations, strengthening the argument for design processes, which capitalize on biophilic principles.

FLATTERING MOTHER NATURE: BIOMIMICRY

If we are nature-loving creatures, then it is from that propensity that we look to living things for inspiration and innovation. One contemporary thrust of such progressivism is Biomimicry, as it has been described by Janine Benyus.

> "Living things have done everything we want to do, without guzzling fossil fuel, polluting the planet, or mortgaging their future. What better models could there be?"[10]

> "What you see out there works, the failures are fossils."[11]

Biomimicry, as defined by Janine Benyus, falls identifiably into the arc of design discourse, defining a relatively long life as a process for technological development based upon systems observed in nature. Benyus described and popularized the term "biomimicry" in her seminal book "Biomimicry, Innovation Inspired By Nature," in 1997. Biomimicry is the "imitation of life," and we can observe three specific ways in which it has been defined by Benyus within the fields of science and design. The first is the consideration of nature as a model, through which humans can imitate and take inspiration from its designs and processes, thus solving human problems. Second, is the consideration of nature as a measure against which we might critique the viability, and sustainability of our decisions. Finally biomimetic dogma considers nature as mentor. This aspect of the field strives for a change in collective mentality regarding the natural world, from exploitation to education, trying to harvest ideas instead of resources.

Benyus argues that the basic logic of biomimicry is undeniable, since its definition is based on the idea that, any challenge we might face on Earth has during the last 3.8 billion years, been solved by some organism. These solutions are the result of 3.8 billion years of natural selection and evolution, and so, have the benefit of an inconceivable number of iterations. These natural chains of events act to create nearly perfect solutions to life's challenges. The broad range of human issues, which might benefit from biomimicry, demonstrates the ubiquitous potential of the field to solve a broad array of human problems. Within this range, Benyus introduces a further categorical aspect of biomimicry. First, and perhaps most simply, one can be formally biomimetic by imitating the shapes of living things. Secondly, biomimics can imitate biological processes. Finally, biomimicry occurs on the level of biological systems. Mimesis on this level looks to imitate the complex interactions and relationships between organisms, particularly the finely tuned networks of organisms and relationships, which occur within ecosystems.

BIOMIMETIC DEVICES ARE SECOND NATURE

Biophilia, biomimicry, biotechnology, biological analogy, bionics, biognosis, zoomorphic, organic, geomorphic, biometaphoric, and biomorphologic among others, are terms that architects, designers, engineers and scientists are using to describe human efforts of various kinds. Benyus' work has been instrumental in bringing the ideas of biomimicry to the forefront of contemporary thought. While "trendy" definitions of biomimicry are certainly based on sound logic and rigorous efforts toward sustainability, they do not consider the aesthetic or spiritual ways that humans have "imitated life" for hundreds of thousands of years. Nor do they consider the myriad of aforementioned terminologies that might be considered synonymous. The portrayal of these ideas as being simply a part of current trends in sustainability, though generally positive, is not accurate. This deficiency highlights the need for a more inclusive redefinition of biomimicry. Norman Crowe states:

> "That is to say that nature, as our first environment, was our primordial source of external knowledge and the subject of our speculation about ourselves in relation to all else. By extension of our imaginations, we created our cosmologies from what we observed firsthand in nature: life and death, the passing of the days and the seasons, the geometry of the compass rose, the dome of the sky, and the spatial richness of the earth and the endless variety of living things throughout the land and sea. Having once departed Eden by creating a "second nature" all our own, it has been our task to nurture and perfect it ever since – even, it seems, to the detriment of the natural world out of which it was formed.[12]

Although biomimicry is an emergent field of study, this distinction is only true because prior to being defined as such the "act" of biomimicry was a nameless human activity. With this point considered it can be argued that the earliest human inventions, innovations, and technologies were very likely to have been conceived by our ancestors drawing creative inspiration from the natural environment, our "primordial source of external knowledge", with which they were so intimately connected. "If a tiger's tooth can pierce my flesh then perhaps the instrument that I need to pierce the flesh of an animal should have a similar shape." Early man encountered only his natural environment, and made adaptations through use of his intellect by observing the successful strategies, processes, and physical forms within that environment. From this argument one might assert that man's acquisition of knowledge began as a purely mimetic progression, of which biomimicry was an essential part. This assertion might be expanded to claim that biomimicry is a fundamental and fundamentally human ability without which our ancestors might still be living in caves (although living in caves might itself be an act of biomimicry).

A DIAGRAMATIC DISTINCTION

Acknowledgment of humanities long tradition of imitating nature calls for the creation of a taxonomy of human progress as it relates to mimesis. Prior to making such distinctions regarding biomimicry and the terminologies associated with it, it becomes essential to consider the definitions of technology and biotechnology as a basis for this proposal. The former (technology) is the making, usage and knowledge of tools, techniques, crafts, systems or methods of organization in order to solve a problem or serve some purpose. The latter (biotechnology) is any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use. With these fundamental definitions it becomes possible to make a series of distinctions regarding the terminology of biomimicry.

This examination assumes that humans, through mimesis of the natural world, created artifacts that can be distinguished as technological, aesthetic, or spiritual. In all three realms this mimesis occurred through observation of organic and inorganic elements of that natural world. The organic imitations, whether aesthetic, spiritual or technological, can be called biomimicry since regardless of purpose they do in some way "imitate life." Furthermore, functional biomimetic artifacts can be distinguished as biotechnology or bionics, while spiritual and aesthetic biomimicry can be more specifically described as biometaphoric, zoomorphic, or organic.

EXAMPLES

To illuminate the methodological and typological applications of biomimicry consider Velcro, invented by Swiss electrical engineer George De Mestral in 1948. De Mestral observed the microscopic structure of burrs (seeds) that would stick to his dog's fur[13]. From this observation De Mestral developed Velcro, which functioned in the same way. De Mestral's invention was the creation of biotechnology through formal biomimicry. To clarify it should be noted that the process by which burrs form was not imitated, nor was the reproductive "system" of the plant that created them.

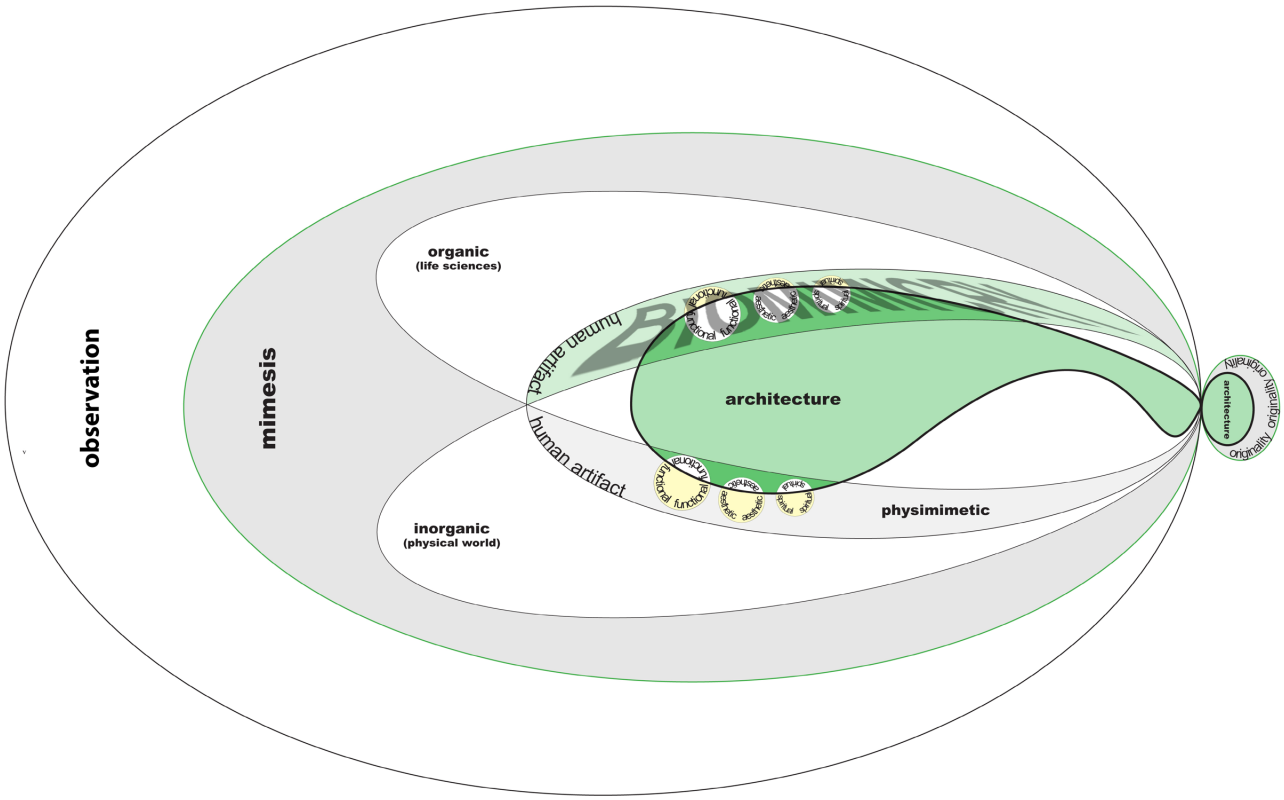

Figure 1. Diagram of Human Endeavor

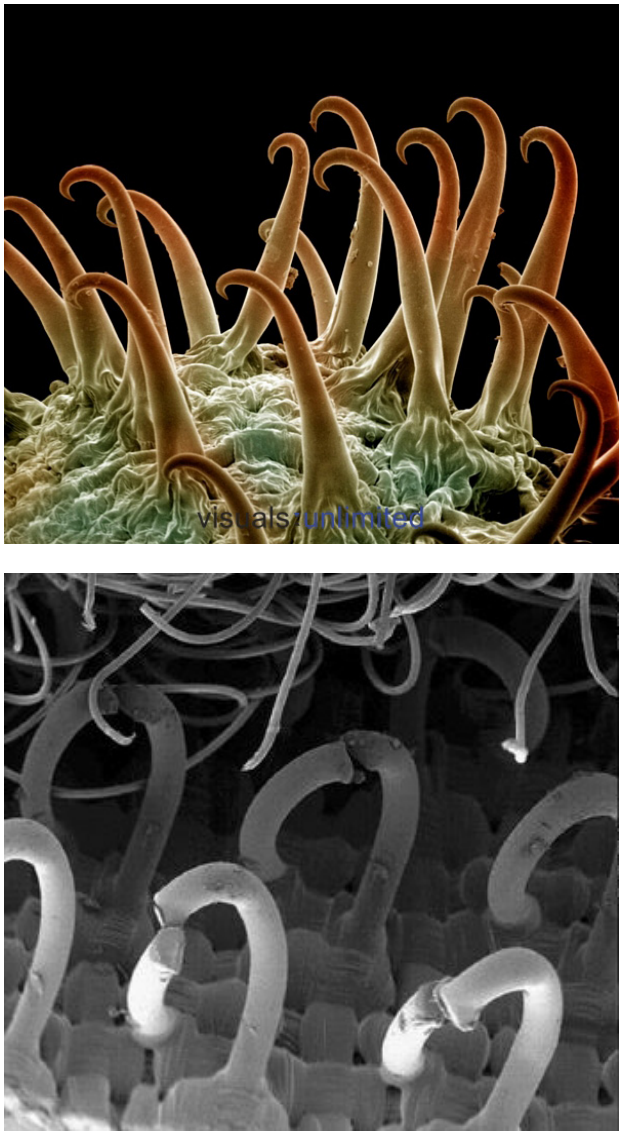

Figure 2. Microscopic view burrs (left), Velcro (right)

The translation of one's "imitation of life," into a clear technological application, based on formal biomimetic typology is clear in the case of De Mestral, but less so in more contemporary examples.

Neri Oxman's descriptions of "The New Materiality," as well as variable property design (VPD), "a system in which material assemblies are modeled, simulated and fabricated with varying properties in order to correspond with multiple and continuously shifting functional constraints,"[14] require a greater degree of examination in order to determine their biomimetic "value." Oxman's design of a chaise lounge chair is based on her observations regarding nature's inherent anisotropy, or the characteristic of having a physical property that has a different value when measured at different directions or locations within living matter. This property of living forms is inherent and ubiquitous in nature, since the development of biological systems occurs at the molecular level, allowing for an intricate degree of heterogeneity. Substance, density, directionality, etc, can alternate indefinitely in response to constantly changing demand within the system. This is fundamentally different from the way humans manufacture goods or create architecture. Oxman's chaise lounge therefore takes its form from VPD, and is therefore a byproduct of the function of varying materiality. "If nature could grow a chaise lounge, would it look like this?" While the chaise is seductively organic, if its form was truly a byproduct of functionality it can be argued that it uses an excessive amount of material. This point illuminates the unavoidable presence of the intent of the designer in even the most honest biomimetic examples. While Oxman's design process might be described as biomimetic, the manufacturing process, utilizing such technologies as 3D printing, is not. In this case biomimicry is expressed through the *process* of form making in natural systems. Here the form is considered secondary to the functional requirements of the system, the organic aesthetic is not biomimetic, because imitation requires intent.

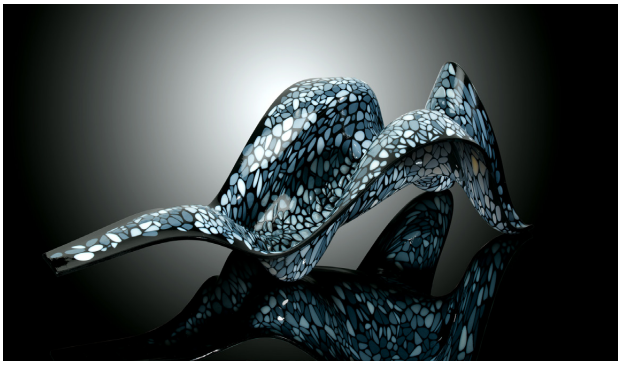

Figure 3. Chaise Lounge Neri Oxman

Finally consider the Eastgate Center Building in Harare, Zimbabwe[15]. This building, designed in part by Arup, is an example of systems based biomimicry. The building mimics the environmental control strategies of a termite mound, which maintains a constant internal temperature despite large temperature changes outside. This buildings mimicry is purely functional, and therefore can be described

as biotechnology. It is also important to distinguish that the biomimicry displayed in this example is of the *system* used by termites not the *process*. Although cooling of their mound might be interpreted as a process, it can be argued that the process involved is the one through which the termites build and disassemble tunnels and vents with layered mud and saliva. To mimic such a process would require a similar mechanism of manufacturing and dynamism. Instead a system is constructed, from ordinary materials, that function in a similar way. This system makes the building aesthetically non-biomimetic yet functionally biomimetic via application of biotechnology or bionics.

Figure 4. EastGate Center Building, Zimbabwe

CONCLUSIONS

Upon humanities tenacious path of progress there exists a paradoxical junction between architecture and biomimicry. Janine Benyus states that, "living things have done everything we want to do." However, while this dogmatic tenet of the movement is based on sound logic it is not entirely inclusive with regard to architecture. Since, as established through this discourse, nature does not create buildings, nor does it create with intent. Therefore the implications of biomimetic principles to architecture necessitate methodological application that requires analysis and consideration beyond that required for other disciplines.

Beauty in nature is a byproduct of functionality, as are its intricacy, complexity and ultimate efficiency. Architecture can be expressive, aesthetic, spiritual, wasteful, and opulent. In nature form expresses function, while in architecture form expresses intent. These interdisciplinary inconsistencies are both obstacles and opportunities for architects. Architects define "second nature," and through that definition can choose to apply nature's lessons while simultaneously expressing humanities unique position within the natural world, as a transcendent living being. By doing so the divergent paths of architecture and biomimicry can converge and ultimately enrich the progressive trajectories of both disciplines.

In seeking semantic clarity it must be concluded that the biomimetic building does not exist, but that architects might utilize biomimetic methodology as a tool for the intended form or function of their buildings. Since humans cannot grow architecture, biomimetic design methodology must be applied with conscience acknowledgment of this interdisciplinary limit. Negotiation between this limit and architectural application requires sedulous translations between scale, materiality, process, form, and techniques of assembly and construction. Biomimetic methodology requires careful examination and thorough understanding of the physical, chemical, and evolutionary forces that underlie the forms, processes and systems observed in nature. Only through such diligence can architecture progress through biomimicry. Though progressivism of humanities biomimetic actions have increased in their complexities, Norman Crowe reminisces about their humbler origin:

> "Ice age artisans remembered the beasts that inhabited their world, and they re-created images of them on the wall's of caves, imbuing the images with spiritual power beyond simple recognizable representation. Raised to the level of artistic expression, the figures on the walls are made to transcend factual nature by means of that remarkable human capacity to re-create from nature's example

> – to imitate nature, an act of the human will that the Greeks called mimesis. The capacity of homo faber to "image" permits him to move from substance to meaning and back again as he establishes his place in the broader realm of nature. In this way we explore nature, not only to satisfy immediate needs of survival but to search for immortality and meaning in it as well."[16]

Human progress was once as simple as development of the inclination to paint on cave walls and through doing so ascribe meaning to the world through abstract imagery. It would seem that the Progressive Era could include all of human history since despite all obstacles human ingenuity and curiosity push incessantly forward, led boldly by science and architecture.

ENDNOTES

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3 Phillip A. Reed, "A Paradigm Shift: Biomimicry," *Technology Teacher*, January 204: 23-27.
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10 Janine Benyus, *Biomimicry: Innovation Inspired By Nature* (New York, NY: William Morrow and Company, Inc., 1997)
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