



Ain Shams University
Faculty of Engineering
Department of Architecture

TOWARDS BIOGENESIS IN ARCHITECTURE

A strategic investigation into biological systems to reinterpret
“**form**” from a material perspective

By

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A Thesis Submitted to the Faculty of Engineering in Partial Fulfillment of
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Master of Science in Architecture

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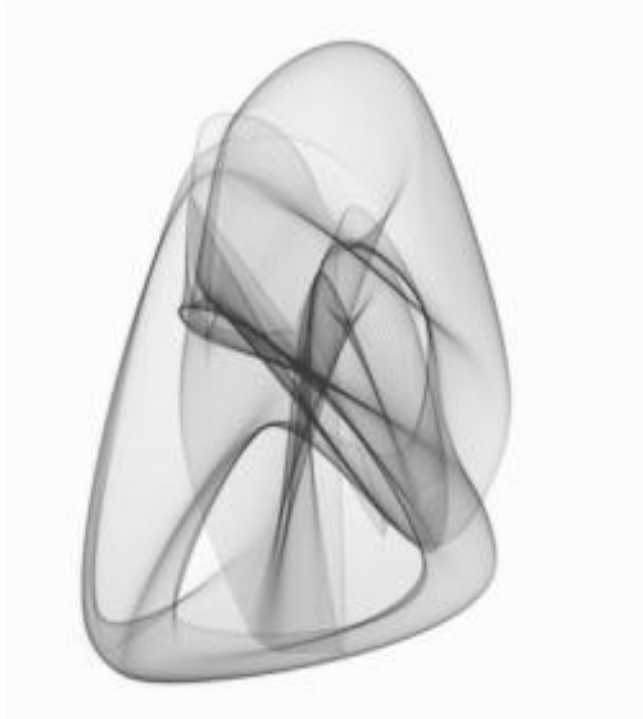
The work included in this thesis was accomplished by the author at the department of Architecture, Ain Shams University during the period from January 2012 to October 2013, as accepted by the examiners.

No part of this thesis has been submitted for a degree or a qualification in any other university or institute.

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Signature:

Date: / /



BIO-GENESIS

[From the Greek ***bios*** mean life, ***genesis*** means the beginning or the coming into being of something]

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Abstract:

Historically, architects used to draw what they could build, and built what they could draw. The straight lines and circular arcs drawn on paper using straight edge and compass have been translated into the materials made by the extrusion and rolling machinery. This reciprocity between the means of representation and production has not disappeared entirely in the digital age. With the introduction of the first programming languages in the late 1940s and the early 1950s, design methodologies have undergone several evolutionary changes, which provided opportunities for building more multifaceted and complex forms. Moreover, this has radically shifted our conception of the design process, as well as our understanding of geometrical forms as a function of performance instead of finite positions in space.

However, the materials perspective in these digital technologies has not yet been explored on the basis of the new possibilities disclosed by these very same tools; material considerations have almost exclusively focused on construction -techniques or as a post-rationalization design input. So far, the materialization of formal expressions instigated by such processes is primarily based on techniques of assembly, which do not negotiate the inherent morphological and performative capacities of the employed material systems that the tools put forward, resulting in a style driven or decorative computational form making processes.

The approach introduced in this dissertation contrasts previous ones that focused either on questions of representation and meaning in architecture, or, alternatively that have treated performance as synonymous to function placed in the context of post-design functional optimization. It attempts to investigate new strategies for sustainable and ecological design, in which forms are derived from the evolutionary development or 'Biogenesis' of natural forms, from their material properties and from their adaptive response to changes in their environment. Steering away from such words as 'green', 'ecological' or 'sustainable', and think about the word 'ecology' from afresh, as 'the relationship between an organism and its environment'. Through this approach, space can be perceived not as distributed geometries, but rather as a composite graft responding locally to flows of programmatic and environmental parameters. This is achieved through an attempt to engage architecture in an integrated approach – the synthesis of structure and natural processes results in an information-based design – therein promoted here is an act of prototyping akin to Nature's search for endless forms, from all this perhaps architecture can achieve a condition of robustness and sustainability.

The framework of this thesis should be regarded as an open-ended process of discovery. Future research and innovation can be continued with respect to similar focus. The goal of this thesis is to engage design problems with recent innovations in material-based computational design.

Keywords

Form; Hylomorphism; New Materialism; Gilles Deleuze; Biomimicry; Sustainability; Complexity theory, Emergence; self-organization; Digital Morphogenesis; Material-based computational design

Prologue

“To express is to drive. And when you want to give something presence, you have to consult nature. And there is where Design comes in. And if you think of Brick, for instance, and you say to Brick, ‘What do you want Brick?’ And Brick says to you ‘I like an Arch.’ And if you say to Brick ‘Look, arches are expensive, and I can use a concrete lintel over you. What do you think of that?’. Brick says: ...I like an Arch”

"Architecture is the reaching out for the truth."

- Louis Kahn

The prologue for this work have been adopted from the philosophical explorations of the architect Louis Kahn (1901- 1974), who proposed that buildings were not just inert configurations of form but “living organic entities”. He illustrated that form is the result of a profound and timeless understanding of the task it had to support.

The reason why Kahn’s quotations were included in this thesis goes beyond this strand of philosophical logic. The main analogy speculates on how does a material perform? Moreover, is there a way in which we could *predict* material behavior and organization within a given context? How do we **find** material form instead of **make** conceptual form?

The pioneers of this approach were: *Buckminster fuller*, *Frei Otto* and others. They followed Kahn’s conviction of a predetermined search for material form with regards to the synergetic relationship between performance and material integrity. Of particular interest in this respect are Otto’s membrane structures and pneumatic structure experiments that promote the formation of “minimal surfaces” which optimize structural loads.

By the beginning of the 21th century, the emergence of complexity theory has shifted the conceptualization of form from the macro scale to a concern for the operation of the complex systems that underlie formation. It is from the micro-scale local interactions of complex systems that behavioral strategies for the generation of composite

materials have emerged—strategies where architectural form, structure, and ornament emerge from the design of composite material behavior.

A number of contemporary architects have re-examined the works of Gaudi and Otto, and found in them sources of inspiration for the new morphogenetic generation of form-finding research. They extended their design approach based on physical form-finding dominated by presubscribed mono-functional programs to the inquiry of generating multi performance materialized form inspired by natural processes of shape formation; in which the structuring of material properties is merely a by-product of structural and environmental performance that generates design form. For example, Mark Burry, as architectural consultant for the completion of Gaudi's Sagrada Familia church in Barcelona, has been exploring digital techniques for understanding the logic of Gaudi's own highly sophisticated understanding of natural forces. Meanwhile, Lars Spuybroek of NOX has performed a number of analogue experimentations inspired by the work of Feri Otto as a point of departure for some innovative design work, which also depends on the more recent software developments within the digital realm. Pioneers such as Michel Hensel, Achim Menges and Michael Weinstock established Emergent Technologies and Design discipline group at Architectural Association in London. They promote a new approach to architecture practice that defines an interrelationship between design concepts, such as emergence and self-organization. These architects consider architectural structures as complex energy and material systems. In this process, the design shapes, evolves and behaves as part of an environment and in correlation with other active systems. They highly incorporate architectural design with construction and manufacturing processes, utilizing computational and practical methods.

Engaging digital design and fabrication technologies based on ideas derived from biological world, designers such as Neri Oxman (Materialecology), strives to imitate natural systems and their qualities such as multiple functionalities of living tissue and load bearing natural

vascular structures. Creating special material condition for light transmission and structural support, she uses fabrication techniques and machineries such as CNC machines, lay-up technologies and single and multi-material 3D printing, engaging materials such as flexible and rigid resin, wood and melted glass. She envisions materials and structures that can perform different levels of structural stability within a single material, alter their degree of transparency for different interior light conditions, ventilate through the embedded pores in surface, and ideally supply themselves with energy. Other designers such as, Jennie Sabin and Peter Lloyd Jones (Lab Studio), Andrew Kudless (Matsys), Tom Wiscombe (EMERGENT) and Chris Bosse are shaping the frontiers of a new paradigm in architecture through the corollary of material behaviors and fabrication processes

This research points towards that new 'performative turn' in architecture, a renewed interest in the principles of structural performance, and in collaborating more empathetically with certain progressive structural engineers. However, this concern for performance may extend beyond structural engineering to embrace other constructional discourses, such as environmental, economic, landscaping or indeed programmatic concerns.

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