ADAPTABILITY
APOPTOSIS
AUTOIMMUNE DISEASE
BIOMINERALIZATION
BUDDING
COMMENSALISM
COMPOSITE MATERIALS
CONTROL
DEATH
DIFFERENTIATION
ECOSYSTEM
EMERGENCE
FEEDBACK
GENOTYPE-PHENOTYPE
FIBERS
FOLD
GANGRENOUS NECROSIS
HIERARCHY
HYBRIDITY
HYPERTROPHY
IMMUNE SYSTEM
INTELLIGENCE
ISOMERS
LIQUID CRYSTALS
MEMBRANE
MEMORY
METABOLISM
MITOCHONDRIA
MOVEMENT
PARASITE
REFLEX
RESILIENCE
RESUSCITATION
RHIZOME
SCAR
SKELETON
SELF-ORGANIZATION
SYMBIOSIS
SYNTHESIS
TRANSPORTATION SYSTEMS
TUMOR
VARIATIONS

THE EVOLUTION OF BIOLOGICAL DIMENSIONS IN ISRAELI ARCHITECTURE

YASHA J. GROBMAN

Architecture has a long history of looking towards biology and nature for inspiration, whether through the direct mimicry of nature's formal qualities, or through the application of performative aspects of natural organisms into architectural design.

Israel is an interesting case study for the employment of biological ideas in architectural design. As a relatively young country without a rooted architectural heritage and a longstanding religious exclusion of figurative motifs in architectural design, Israel has developed into a modernist laboratory for architectural experimentation in a variety of unique ways. Leading research in biology and technological development, combined with a continuing demand for new residential and office buildings, seemingly provides fertile ground for the development of interdisciplinary research on the connection between architecture, technology and biology; but is this really the case? The following text outlines milestones in the unique evolution of bio-inspired architecture in Israel, where recent technological advances are redefining the way architecture is designed and built.

1

2

3

Figure 1
Change to Casa Battlo By Antoni Gaudi, Barcelona, Spain. (1904-1906). Photo: Tato Grasso

Figure 2
Fish-like sculpture by Frank O. Gehry, Barcelona, Spain (1989-1992). Photo: Till Niermann.

Figure 3
Bird-like structure. Quadracci Pavilion at the Milwaukee Art Museum by Santiago Calatrava, Milwaukee, USA (1994-2001). Photo: Michael Hicks (Mulad).

ARCHITECTURE AND BIOLOGY

The connection between architecture and biology is multifaceted and longstanding; one of the earliest manifestations of this connection emerged with 'zoomorphic architecture'[1], where architectural elements or entire building forms derive directly from animals or plants. Movements such as Organic Architecture[2] and art nouveau[3] similarly focus on morphological connections between nature and architecture, but with more interpretive freedom. Examples include the buildings of Anatonio Gaudi [fig. 1], the fish structure by Gehry and Partners in Barcelona [fig. 2] and the Milwaukee Museum bird-like pavilion by Calatrava [fig. 3].

While formalist approaches to the connection between architecture and biology may be more obvious and familiar, more important advances in the synergy between architecture and biology lie in the application of functions derived from nature rather then a mere imitation of its form.

One of the leading approaches in this realm is generally known as biomimicry, literally referring to the imitation of biological mechanisms in architectural design. The term derives from Janine Benyus seminal book on the subject[4], but is also related to earlier terms of the same approach such as bionics ("biology" and "technics"), biomimetics and bio inspiration[5].

Architects, interest in biomimetic has grown rapidly in the current decade. Numerous products, such as 'clean glass,' which was inspired by the structure of the lotus leaves, have been developed based on insights from nature. Ideas from nature and biology have been used to design and build numerous research pavilions, which constitute a good scale for testing new ideas and methods in architecture [Fig. 4].[6]

1. Examples of buildings and building elements in this style can be found in Hugh Aldersey-Williams and Albert Museum Victoria, *Zoomorphic: New Animal Architecture* (London: Laurence King Pub. in Association with Harper Design International, 2003).

2. David Pearson, *New Organic Architecture: The Breaking Wave*, First Edition (University of California Press, 2001).

3. Frank Russell, *Art Nouveau Architecture* (London: Academy Editions, 1979).

4. Janine M. Benyus, *Biomimicry: Innovation Inspired by Nature* (New York: William Morrow Paperbacks, 1997).

5. Evidently, as opposed to the more formal approaches to nature in architecture, biomimicry has a strong connection to research. In the last fifteen years thousands of research papers have been published on the connection between design and architecture. A yearly

4

5

Figure 4
ICD/ITKE 2014-15 pavilion that utilizes a novel building method inspired by the underwater nest construction of the water spider. Photo: ICD.

Figure 5
FAB TREE HAB – Living Graft Prefab Structure. Creating homes from living trees by Mitchell Joachim, Lara Greden, Javier Arbona. Rendering: Mitchell Joachim, Lara Greden, Javier Arbona.

conference on "Design & Nature" is held since 2002 where each year, dozens of new papers and research studies are presented. This research focuses more on the industrial design scale than the building scale; however, numerous research studies on the architectural scale can also be found. More information on research and application of biomimetic ideas in architecture can be found in three recent books on that subject by Petra Gruber, *Biomimetics in Architecture: Architecture of Life and Buildings*, 1st Edition. (Vienna: Springer Vienna Architecture, 2010); Ilaria. Mazzoleni, *Architecture Follows Nature : Biomimetic Principles for Innovative Design* (Boca Raton, FL: CRC Press, 2013); and Michael. Pawlyn, *Biomimicry in Architecture* (London: Riba Publishing, 2011).

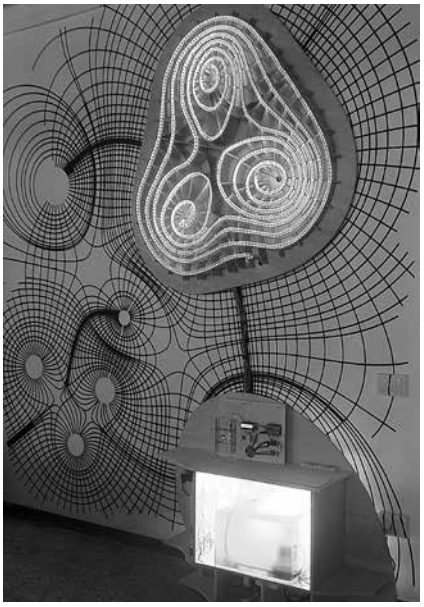
6. For more information on this approach see, Michael Hensel, Achim Menges, and Michael Weinstock, *Emergent Technologies and Design: Towards a Biological Paradigm for Architecture* (Abingdon: Routledge, 2010) and Achim Menges, "Biomimetic Design Processes in Architecture: Morphogenetic and Evolutionary Computational Design," *Bioinspiration & Biomimetics* 7, no. 1 (March 1, 2012).

Biomimicry has also given rise to a new approach to nature in architecture known as 'biophilic design,' which calls for achieving a reciprocal relationship between buildings and architecture. This new school of thought is replacing former ways of thinking 'sustainably,' which were focused on minimizing the effect of buildings on the environment.[7] This can be achieved by using biological matter as building materials, as suggested by Mitchell Joachim in his designs for homes created from living trees that employ computer numeric-controlled milling machines to prefab the scaffolding on which the trees will grow [Fig. 5].[8]

A similar but somewhat less radical 'biophilic approach' calls for embedding living biological elements, including plants or animal habitats, within buildings and other architectural structures. Although there are numerous examples of "green" architecture that employ plants on the building envelope, the most notable example is probably the green roof. As opposed to the traditional, single function, defensive approach to the building envelope, green roofs promote a rather heterogeneous approach, which conceives the envelope as a natural habitat for various types of live elements. Another notable example of embedding biological materials into the building's envelope has emerged recently with the use of algae in building facades. Algae is used to produce biomass or materials for the pharmaceutical and cosmetics industries. The building elements that contain algae are used to provide shade. Interesting examples are the Water Lilly projects by Studio Griffa [Fig. 6] and the only residential building to date in which this technology was implemented by Arup and Splitterwerk Architects.

THE BIOLOGICAL DIMENSION OF ISRAELI ARCHITECTURE

At the close of the 1960's a new architectural discourse emerged in Israel, promoted by a group of architects from the faculty of architecture at the Technion in Haifa, then the sole architectural institution in the country. Among the leading figures in this group were Al Mansfeld, Alfred Neumann, Zvi Hecker and David Yanai.[9] The discourse they initiated, which later grew into a



6

7

Figure 6
Water Lilly by Studio Griffa (2012). Photo: Studio Griffa

Figure 7
The Spiral House by Zvi Hecker. Ramat Gan. Israel (1984–1989). Photo: Aviad 2001.

movement of great significance known as "Israeli Formalism," explored complex morphological[10] systems and their possible implication for architectural design. Israeli formalism can be contextualized as as a local branch of the structuralist movement in architecture as it had been developing at the time in Europe, United States and Japan. Structuralism furthered the notion that all elements of culture find their relevance only in relation to their surroundings, emphasizing inter-connective concepts. David Yanai's work was distinguished from the other Israeli formalists in that he looked at architectural form as a genetic code that could be manipulated to provide solutions to diverse needs.[11] Yanai's approach can thus be defined as one of the earliest contemporary manifestations of the connections between architecture and nature in Israeli architecture.

While the 1980's were globally dominated by the rise of several logocentric styles such as Postmodernism and Deconstructivism, architecture in Israel seemed to be moving away from the collective trends and logocentric discourse of previous decades, towards individual expression. The few instances of biologically inspired architecture from this period were considered by the architectural community to be strange anomalies that were of little interest to the public at large. An interesting example of this trend is the Spiral House designed by Zvi Hecker (1984–9). The spiral form of the building, according to Hecker, conveys an argument for "the sheer necessity to bring the muscles and materials together[12]". The building envelope integrates various ornaments inspired by animal forms [Fig. 7]. Another notable example is the "Crazy House" by Leon Geneva (1985) in which vegetative elements are embedded in the building façade [Fig. 8].

The most controversial building of the period is Ram Carmi's proposal for the Israeli Prime Minister's house and office building. The controversy began

7. For more information on the connection of biophilic design to architecture see Stephen R Kellert, Judith Heerwagen, and Martin Mador, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*, 1 edition (Hoboken, N.J: Wiley, 2008).

8. See also Nina Tandon and Mitchell Joachim, *Super Cells: Building with Biology* (TED Conferences, 2014).

9. An early discussion of this group and architectural language took place in the "Israeli architectural formalism" conference in Tel Aviv university that was initiated and chaired by Eran Neuman on January 9th, 2008 at Tel Aviv University.

10. Morphology is a branch of biology dealing with the study of the form and structure of organisms and their specific structural features.

11. David Yanai's work on the genetic code was presented in retrospective exhibition titled "Architectural Planning and Research, 1957–2003."

8

9

10

Figure 8
The "crazy house" by Leon Geneva. Tel-Aviv. Israel (1985) Photo: Shmuel Browns

Figure 9
Private house by Simha Yom Tov and Ariell Tibi. Photo: Ariell Tibi

Figure 10
Ashdod Performing Center by Haim Dotan. Ashdod. Israel (2010). Photo: Haim Dotan

at P.K. Hoenich Gallery of Experimental Art and Architecture. The exhibition was initiated by Prof. Michael Burt, and was curated by architect Gadi Politi, who works with Yanai in his office in Haifa. A recent retrospective exhibition, curated by Eran Neuman, presented a broader view of these ideas took place at the Tel-Aviv Museum of Art in 2015. More detail can be found in the exhibition catalogue: Eran Neuman, (ed.), *David Yanai: Architecture and Genetics* (Tel Aviv: Tel Aviv Museum of Art, 2014).

12. "Spiral Apartment House," Zvi Hecker Official Website, http://www.zvihecker.com/projects/project_titel-30-1.html

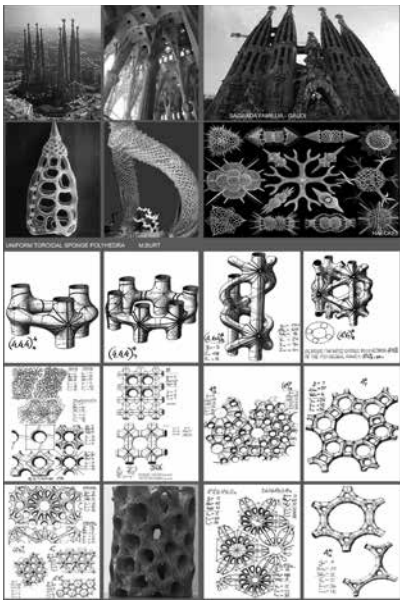
13. See Michael Jacobson's article on the proposal Michael Yaacobson, "פרסום ראשון: כך ייראה המעון הפרטי של ראשי ממשלת ישראל בירושלים," Xnet, accessed January 7, 2016, http://xnet.ynet.co.il/architecture/articles/0,14710,L-3110622,00.html. Also see Zvi Efrat's critique and Carmi's reaction

with the competition results, which were contested by several of of the finalists, who took the case to the Israeli court and lost. Carmi's design has several stages and options. The second option, which is the most controversial, was named by the media and by architectural critics as the "coral house" and was labeled by many as a "vagina with eyes." Carmi, however, did not refer to this building as being inspired by nature, but rather insisted that it is lyrical architecture that promotes artistic emotions. He argued that it should be examined at eye level rather than from the highly criticized aerial view.[13]

A different approach to zoomorphic architecture was taken by architects Simha Yom Tov and Ariel Tibi, who argued for "feminine" curvilinear environments inspired by nature for perceptual reasons and for the benefits of constructing with Ferro cement, a structurally efficient material that is also lightweight, eco-friendly, and cost effective. They designed and built numerous private houses that follow this approach [Fig. 9].[14] These trends continued to evolve into the first decade of the 21st century, with increasing morphological complexity attributed to advances in computation design and fabrication. A notable example is the Yitzhak Rabin Center in Tel Aviv designed by Safdie Architects (with associate architect Zahi Halberstadt), in which the roof is made from prefabricated composite material elements that represent pigeon wings as a metaphor for peace.

One of the most renowned contemporary Israeli architects working on bio-inspired architecture is Haim Dotan, whose work is characterized by curvilinear lines inspired by natural forms which are employed to create ecological environments. The structure for his Ashdod Performing Arts Center, for example, was inspired by the interaction of two sea waves or two seashells. This interaction reflects the programmatic connection between the

11



12

Figure 11
Porter School of Environmental Studies biological water purification system by Axelrod Grobman Architects, Geotectura and Chen Architects NCA, 2015. Photo: Shai Epstein.

Figure 12
Michael Burt's research on spongey geometries.

performance hall and the theater tower architecture [Fig. 10].[15]

It is difficult to talk about the connection between biology and architecture in Israel without mentioning recent interest, both publical and professional, in sustainable architecture. Sustainable buildings call for a heterogeneous and multifunctional approach to building elements, with the integration of biological systems within buildings. Israel has long dealt with sever water shortage, and has promoted the use of plants as biological filters in the purification of water for irrigation and domestic purposes. An example of this type of use is the building of the Porter School of Environmental Studies, which includes the first approved grey water system in a public building in Israel [Fig. 11]. Other biological systems that are employed in Israeli buildings include green roofs and indoor plants for air purification.

THE BIOLOGICAL DIMENSION IN ISRAELI ARCHITECTURE AND DESIGN RESEARCH

In parallel to new research on Israeli formalist design of the late 60's and early 70's, three new academic lines of research in this realm have emerged in the Faculty of Architecture and Town Planning at the Technion. The first line of research focused on architectural morphology and was connected to Israeli formalism as previously described. This line of research, which was promoted by Michael Burt and Avraham Wachman, focused on infinite polyhedra and other morphological ideas.[16] The research had a strong connection to biology and nature, as many of these approaches are based on references to the natural world. This line of research was later developed by Burt into a seminal examination and development of sponge structures, which is directly related to the morphological strategies of flora and fauna [Fig. 12].[17]

in an interview for "Cultural heroes" documentary at Modi. Anat, "*גיבורי תרבות - אדריכלות זה אני*", accessed January 7, 2016, https://www.youtube.com/watch?v=l3j0AQ4TlRk.

14. See Simha Yom-Tov, *Ferrocement in countries and Israel* (Technion – Israel Institute of Technology, Faculty of Architecture and Town Planning, 1990).

15. See "New-Wave in Ashdod - The Theatre has Opened," *Xnet*, accessed January 7, 2016, http://xnet.ynet.co.il/architecture/articles/0,14710,L-3095320,00.html.

16. See Avraham Wachman, Michael Burt and Menachem Kleinmann, *Infinite Polyhedra* (Faculty of Architecture and Town Planning of the Technion, Israel Institute of Technology, 1974).

17. See Michael Burt, "The Periodic Table of the Polyhedral Universe," *International Journal of Space Structures* 26, no. 2 (2011): 75–94.

The other two lines of research were computer aided design and Bio-Climatic architecture.[18] Both were initially promoted by Edna Shaviv, who founded the first research laboratory in Israel on bioclimatic design in the 1970's. The laboratory developed the foundations for later research on sustainable in architecture in Israel.

Explicit academic and design work on biomimcry in architectural design can be traced back to the early 2000's.[19] Current research on bio inspired architecture signifies a fundamental shift from the earlier research both in the magnitude and the approach of conducted research. It is characterized by an multidisciplinary approach that involves scientists from various disciplines, rather then concentrating solely on architecture. The span of research covers areas such as applying the impact that water flow bears on corals towards improving the airflow in buildings,[20] taking a multifunctional approach to designing waterfronts,[21] applying ideas from nature towards enhancing structural optimization,[22] and examining the connection between human feelings and architectural space via empirical electroencephalogram (EEG) examination.[23]

A VISION FOR THE FUTURE

Although some substantial advances in architectural design research have been achieved in the last decade, one of the challenges in fostering the connection between biology and architecture is overcoming the lingering perception of this connection as being primarily a morphological and ornamental one. This is but one aspect of a larger discourse in architecture which looks beyond style and form towards architectural performalism.[24]

The current focus on architectural technology as manifested through this exhibition will hopefully promote the increased integration of other disciplines into architectural research. This exhibition is an important step in shifting towards a more technological and scientific understanding of the discipline, one that will harness leading Israeli innovators towards developing new approaches and solutions for some of Israel's social and environmental challenges.

YAHSA JACOB GROBMAN is an architect and assistant professor at the Faculty of Architecture and Town Planning at the Technion-Israel Institute of Technology. He is principal and co-founder of Axelrod Grobman Architects. His research focuses on design computation and performance oriented architectural design and fabrication.

18. See for example Shaviv's report: *A Method for the Design of Fixed External Sun-Shades* (Technion-I.I.T., Center for Urban & Regional Studies, 1974).

19. See Caroline Hachem's thesis on "Biological Deployable Systems : Characterization and Architectural Application," 2004. See also Grobman studio work on cellular envelopes at http://grobman.net.technion.ac.il/

20. Bnaya Bauer, "Branching Morphologies - Cities and Corals" (Technion, Israel Institute of Technology, 2013).

21. Yasha J. Grobman and Roy Kozlovsky, "On the Shores of Architecture," *Rethinking Comprehensive Design: Speculative Counterculture, Proceedings of the 19th International Conference on Computer-Aided Architectural Design Research in Asia (CAADRIA 2014) / Kyoto 14-16, May 2014, 853—862,* 2

22. Liran Chechik, "Bio-mimetic paradigm for Structural Optimization" (Technion, Israel Institute of Technology, 2013).

23. Avishag Semesh, Moshe Bar and Yasha Jacob Grobman, "Space and Human Perception," *Emerging Experience in Past, Present and Future of Digital Architecture, Proceedings of the 20th International Conference of the Association for Computer-Aided Architectural Design Research in Asia (CAADRIA 2015) / Daegu 20-22, May 2015, 541-550,* 2015.

24. Yasha J. Grobman and Eran Neuman, (eds.), *Performalism: Form and Performance in Digital Architecture*, 1 st edition (London, New York: Routledge, 2011).