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FROM MULTIPLICATION TO BIOMIMETICS
– PLAYING WITH STRUCTURE AND ARCHITECTURAL
GAMES OR AN ACTUAL ATTEMPT TO SHAPE
OBJECTS IN THE 21ST CENTURY

OD MULTIPLIKACJI DO BIOMIMETYKI
– ZABAWA STRUKTURĄ I GRA W ARCHITEKTURĘ
CZY REALNA PRÓBA KSZTAŁTOWANIA OBIEKTÓW
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Abstract

Nature is a perfectly functioning system. Biomimetics (biomimicry) is based on analysis and transposition of processes occurring in nature to the level of technology. Architecture is a search of forms which are complementary to functional and structural solutions. There is a noticeable play with geometry, a play of shapes, and space for multiplication between these processes.

Keywords: biomimetics, biomimicry, bionics, bio-inspired architecture, mobile structures, temporariness, multiplication, fractals, game and play with structure

Streszczenie

Natura stanowi perfekcyjnie funkcjonujący system. Nurt biomimetyki (biomimikry) opiera się na analizie i przetransponowaniu procesów zachodzących w naturze na płaszczyznę technologii. Architektura to poszukiwanie form będących dopełnieniem rozwiązań funkcjonalnych i konstrukcyjnych. Pomiędzy tymi procesami zauważalna jest zabawa w geometrię, gra brył oraz przestrzeń multiplikacji. Architektura może stać się płaszczyzną do swojej gry i zabawy wychodzących znacznie poza swoje podstawowe pojęcia.

Słowa kluczowe: biomimetyka, biomimikra, bionika, architektura bio-inspirowana, struktury mobilne, tymczasowość, multiplikacja, fraktale, gra i zabawa strukturą

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1. Fun, game, multiplication

When analysing the motives for play in the architectural design process, the question arises of where the boundary between spontaneous, unlimited play and reality is. Following the words of Professor Wincenty Okoń¹ who is one of the greatest contemporary Polish educators, “fun is an action performed for your own pleasure and based on the participation of the imagination, which creates a new reality. Although this action is ruled by the principles originating in social life, it is creative in nature and leads to the individual discovering and transforming reality” [2, p. 3].

Architectural design, especially in its conceptual stage, becomes play in the creation of a new spatial-visual reality. At the same time, it might be asked whether the comparison of architectural creation and play is not an abuse. The fun remaining in the space of unlimited creativity is not intended to be a direct confrontation with reality, while the architectural process is being transformed to initiate real and responsible spatial dialogue. Play with architecture should be then perceived in a more general context.

The game becomes the next stage of play. The full spontaneity and freedom constituting the essence of play is transformed into a game by ordering and the imposition of certain rules and strategies. The next stage is the connection between game theory and the architectural process. Tadeusz Platkowski in his *Introduction to game theory* describes this concept as “the science of strategic action in conditions of conflict and cooperation”. He says that over past decades the feedback between game theory and numerous areas of science, e. g. biology, sociology, anthropology, psychology and economy has been noticeable [3, p. 6].

Is it possible to transpose the game and play concept to the architectural process? Architecture understood as a compilation of the search for the optimal function, a response to a sequence of spatial and context issues, adjusting the appropriate shape, selection of the optimal construction system and materials, and above all, providing an ideal space for users of the building, might become the field for game and play extending far beyond its basic concepts. Architecture is a search of forms which are complementary to functional and structural solutions. There is a noticeable play with geometry, a play of shapes and space for multiplication between these processes. This multiplication of forms, motives, and modules is perceptible from the first architectural solutions created by men. This process also occurs in nature. The compilation of these issues leads to the concept of fractals, which is understood as a multiplication of multiscale forms.

2. From the mechanical to the organic model

The beginning of the 20th century abounds with numerous discoveries in different areas, e. g. chemistry or electricity, causing an *atmosphere of technology* in Europe, “a moment later automobile – the tool of speed speed – captured the city, reduced distances, and commenced the age of machines which are entirely obedient to human dreams” [4, p. 11]. Futurism – launched in the 20th century – glorified technical and mechanical thought in

¹ Professor Wincenty Okoń (22.01.1914 – 18.10.2011) was a brilliant educator, creator of theory of teaching – learning process, the theory of multilateral education and a laureate of medal of Honour Member of the Games Research Association of Poland [1].

art and architecture. After joining F. T. Marinetti's movement, Antonio Saint'Elia published the *Futuristic Architecture* manifesto proclaiming that architecture should adopt the latest techniques and materials while rejecting previous historical styles. At the same time, modern principles of Futurism became extremes based purely on contemporary technical solutions and entirely rejecting the solutions developed by previous generations. Antonio Saint'Elia created visions of cities-megastructures as a system of precisely connected functional and structural elements. Futurism was based on the idea of dynamics of life. Hence, the presence in Saint'Elia's projects (i.e. La Citta Nuova, The New City) of the theme of dynamics expressed in the worship of technology and mechanics [4, p. 92–94].

The turn of the twenty-first century has brought an entirely different outlook on understanding and shaping contemporary architecture. In the wake of the search for an architecture outside architecture, its transgression and merging with different areas of science (e. g. biotechnology, chemistry), a new notion extending the basic understanding of the building began to appear in the architectural process. As a consequence, new architectural currents came into existence: *flexible architecture, responsive structure, portable, kinetic and elastic architecture* for instance. In recent architectural theories, the conceptual model of people's living environment has changed from the mechanical to the organic. Furthermore, the concepts of ecological and sustainable design have been reinstated by the interactions between local architectural solutions and the global environment.

The transposition of design concepts from the mechanical level to the fascination with nature has brought biomimetics (biomimicry), bionics and biomorphism to the architectural stage. A living organism is a perfectly functioning system and optimized structure adapted to the space of existence. Moreover, millions of years of evolution have enabled an efficient and flexible adaptation to environmental changes. The multiplicity of forms in an organic space leads to the conclusion that nature is an expert and specialist in shaping forms [5, p. 42–43].

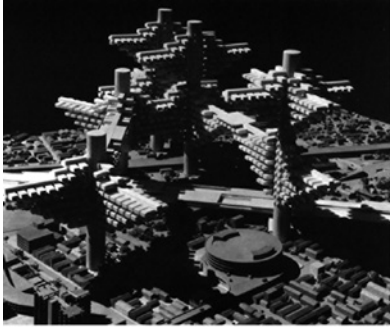
3. Multiplication of form as para-fractals

Most of forms in nature are created while minimizing material, energy, and space at the same time. Organic forms like fractals come into existence in multiscale and a variety of sequences. Nature can be described in mathematical language. One of the most significant relationships in nature is the golden ratio created by Leonardo Fibonacci².

The Fibonacci sequence is perceptible in plant structure geometry, or the DNA code. The logarithmic spiral also known as the golden spiral is created on the basis of the Fibonacci sequence. It is especially noticeable in the process of growth and formation of branches and leaves of plants (phyllotaxis), (ill. 1). The structure of branches and leaves is spirally formed around the trunk according to the principles of the Fibonacci sequence. It leads to maximizing the absorption of solar energy.

The concept of fractals was created and popularized by Benoit Mandelbrot in *The fractal geometry of nature*. At the end of the 19th century numerous examples of geometric objects

² The Fibonacci sequence is a series where every number is the sum of the two preceding numbers: 1, 2, 3, 5, 8, 13... As a result of division any numbers of sequences by the previous one the quotient 1.61804...(phi – the golden ratio) is obtained [5, p. 42–43].



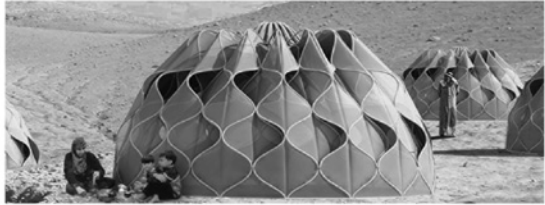
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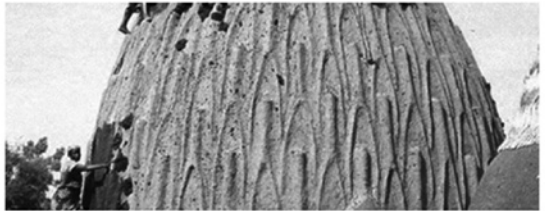
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Ill. 1. Phenomenon of phyllotaxis – shape of Aloe leaves [12]

Ill. 2. Clusters in the Air, 1962 r., [13]

Ill. 3. A part of Lotus Dome structure [14]

Ill. 4. Visualization of *Weaving a Home*, [15]

Ill. 5. A part of Mougoum tribe house [15]

relating to the concept of fractals began to appear: the Cantor set, Sierpinski carpet, van Roc curve and Julia set for instance [6, p. 19].

The multiplication of structural forms have followed urban planning. Para-fractal structures are especially visible, e.g. the traditional house of the Mougoum tribe in Cameroon³

³ Traditional houses of Mougoum tribe are shaped from modelled earth (the finest examples of this kind of building are to be found in Central Africa), [9, p. 35].

(ill. 5), in the spatial structures of cities e. g. Timbuktu or in characteristic ornamentation e.g. the Mudejar style (Morocco).

Multiplication of geometric forms is perceivable in numerous projects by megastructure architects, especially in the Japanese Metabolism movement. The manifesto *Metabolism 1960* describes the conception of Japanese architects' activity, presents the intellectual achievements of the Metabolists, a different way of looking at the environment, the natural shaping of architecture, and the dialogue between a space and its users. Following the words of Kisho Kurokawa, one of Metabolism's founders "I believe that what we called space, medium (...) and interspace are important in the formation of the relation between architecture, society and nature" [7, p. 92–94]. The multiplication of forms frequently used by Metabolist members is noticeable in examples such as the *Nakagin Capsule Tower* (proj. Kisho Kurokawa, 1972), *Clusters in the Air* (proj. Arata Isozaki, 1962), (ill. 2), *Helix City* and *Floating City Kasuniguara* (proj. Kisho Kurokawa, 1961) or in one of the most famous capsule projects – *Ocean City* (proj. Kiyonori Kikutake, 1968). The metabolist group created projects – conceptions directly in the earth, as an element of artificial topography, on water, or even in the air by creating vertical megastructures [8, p. 344–370].

In 1997 Michael Batty and Paul Longley created a fractal city motive by transposing the fractal concept to the area of urban planning: "fractal geometry explains not only the way in which order emerges from simple, logical elements, but also how complexity appears (...)" [7, p. 355–358].

From geometric multiplication and para-fractals there is a straight reference to bio-inspired architecture.

4. From bio-inspired architecture to biomimetics

The transposition of fractals to architectural language gives unlimited possibilities of creation. Geometric play transposed to a game of multiplication might provide extraordinary visual, spatial and functional effects. The essence of such creation is not only biomorphic structures⁴, but also an inspiration from nature by bringing processes in nature into engineering (biomimetics).

The next stage is bionics, which connects in a complementary way biology and technology. Bionics connects the analysis of building and functioning of living organisms with the use of these rules in non-organic devices.

5. Interactions and fusions

Thinking about bionics and architecture in the context of game and play it is possible to refer to my own fascination with responsive structures (based on electronic solutions), biomimetics (transposing processes from nature to the design level) and portable structures. Is

⁴ The biomorphical structures are objects of Ivre Makovecz, *Grosse Blume* by Bruno Taut or characteristic balcony structure in *Casa Batllo* (proj. Antonio Gaudi), [10, p. 45–46].

it possible to connect these structures, play not only with emblems but transfer of solutions to the design process?

Maybe some of the answers are included in one of the most poetic and sensual projects of portable architecture – the Lotus Dome⁵ (proj. Studio Roosegaarde). The responsiveness of the structure's wall to users reactions is possible by movable aluminium components controlled electronically. The structure of the Lotus Dome (ill. 3) installed in space becomes an interactive game of light and shadow, bringing unusual poetry to relation the space – structure – man.

The conceptual project of autonomous structure *Weaving a Home* (proj. Abeer Seikaly) is the connection between poetic, sensual structure and the actual attempt to shape light portable architecture. It answers the question of contemporary nomadism (ill. 4).

In an architectural context and with concepts of game and play – the ideal solution is to create appropriate interactions, proportional fusions of nature, architecture, living environment, and relations with users. Creating a process which goes significantly beyond an understanding of the function, form and structural system. As a consequence, architecture, understood as an integrally connected and well-functioning organism, could bring in the next stage of the design process.

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⁵ This project was awarded in Media Architecture Award 2012 in future trends category [11, connection: 12.06.2015]

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