

# ORIGINALS OF THE CONTEMPORARY GENERATIVE FORMS: TYPE OR INDIVIDUALITY IN ARCHITECTURE

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## PIERWOWZORY WSPÓŁCZESNYCH FORM GENERATYWNYCH: TYP A INDYWIDUALNOŚĆ W ARCHITEKTURZE

### Abstract

Debate about the shape and the meaning of architectural form, which took place at the beginning of the 20th. Century, is still actual nowadays. This dispute expresses best the dilemma, relating to the question of what decides about the quality of the architectural form: type or individuality? Contemporary generative forms, taking advantage of the information potential of the architectural software's language, are the expressions of seeking for the elaboration of prototypical solutions, and searching for their formal uniqueness as well. Paper aims to define a type in architecture from one side (*making of form*), and from the other – to express its individuality (*finding of form*). Genetic language and generative rules of forms' creation connected with analysis of methods of their transformation are the subject of the research. The following types of generative forms are distinguished: conversional, animated, metamorphic, algorithmic and transgenic.

*Keywords: digital architecture, genetic language of forms' creation, generative rules, transformations, computer simulations*

### Streszczenie

Spór o kształt i znaczenie formy architektonicznej, toczony na początku XX wieku, jest wciąż aktualny w dzisiejszych czasach. Spór ten najlepiej oddaje dylemat, dotyczący tego co decyduje o jakości formy architektonicznej: typ czy indywidualność? Współczesne formy generatywne, korzystające z potencjału informacji zawartej w języku architektonicznego oprogramowania, są ekspresją dążenia do opracowania prototypowych rozwiązań, jak i do poszukiwania ich formalnej unikatowości. Praca stawia sobie za cel zdefiniowanie typu w digitalnej architekturze z jednej strony (*tworzenie formy*), z drugiej zaś – wyrażenie jego indywidualności (*odkrycie formy*). Przedmiotem badań jest genetyczny język oraz generatywne reguły kreacji form w powiązaniu z analizą metod ich transformacji. Wyróżniono następujące typy form generatywnych: konwersyjne, animowane, metamorficzne, algorytmiczne i transgeniczne.

*Słowa kluczowe: architektura digitalna, genetyczny język kreacji form, generatywne reguły, transformacje, symulacje komputerowe*

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## 1. INTRODUCTION

The contemporary architecture is created in the context of information revolution on the turn of the 20th and 21st centuries; revolution, which focuses on the information gaining, control, stimulation and manipulation. The information becomes a basic environment of the architects' activity, but also – the material of forms' creation. Digital form, being a specific information code in the meaning of the data stream flowing through the spatial object and creating its structure, interacts with digital settings, trying to adapt to environmental variables. It is a subject of evolution and transformation, similarly to biological form. Therefore in description of digital architecture, there are often used such terms as genetic or generative form, which became into existence thanks to inner DNA code, and its functioning is determined by this code. As John Frazer notices:

“Architectural concepts are expressed as generative rules so that their evolution may be accelerated and tested. The rules are described in a genetic language which produces a code-script of instructions for form generation. Computer models are used to simulate the development of prototypical forms which are then evaluated on the basis of their performance in a simulated environment. A very large number of evolutionary steps can be generated in a short space of time, and the emergent forms are often unexpected.”<sup>2</sup>

Form in the term of genetic language is a synonym of the informed matter, defined by the internal algorithm (form's DNA) which determines the shape of the spatial structure and makes possible its transformations in the topological space.<sup>3</sup> The phenomenon of the genetic language consists in this that it allows to control of the whole process of creation and transformation of the architectural structures thanks to the interacting with their internal code on the level of software language, it means, the forms' creation and modeling (CAD: *Computer-Aided Design*), their production (CAM: *Computer-Aided Manufacture*) and control of their structural parameters (CNC: *Computer Numerical Control*).<sup>4</sup> For the architect, it signifies the possibility of complex design of more complicated spatial structures, characterized by the system features, through definition of dynamic relations between all elements of the structures, and between the structures and their context as well.

In digital architecture, there are various concepts in relation to the way of using of genetic language in the architectural forms' creation. These concepts differentiate themselves on the level of basic assumptions referring to the manner of interaction with forms' algorithms, in consequences of which diverse mutations of the genetic codes and multiple forms of the spatial structures are coming into existence. Change of the algorithm's notation on the level of the form's creation leads to appearing of the sequence of mutating forms (e.g. *Data-Driven Forms*, arch. Marcos Novak<sup>5</sup>), similarly to the interference into code's notation on the level of its interactions with environmental variables (e.g. *Digitally Grown Botanic Tower*, arch. Dennis Dollens<sup>6</sup>). Autonomous mutations of architectural forms without changing of

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<sup>2</sup> Frazer J., *An evolutionary architecture*, Architectural Association, London 1995, p. 9.

<sup>3</sup> Kwiatkowska A., *Architectural metamorphoses or how to order the information emptiness?* [in:] E. Duyan (ed.), *Theory for the sake of the theory 2*, DAKAM Publishing, Istanbul 2011, pp. 247–255.

<sup>4</sup> Dunn N., *Digital fabrication in architecture*, Laurence King Publishing Ltd., London 2012, p. 6.

<sup>5</sup> Zellner P., *Hybrid space: New forms in digital architecture*, Thames & Hudson, London 1999, p. 131.

<sup>6</sup> Dollens D., *Digital-Botanic Architecture: D-B-A*, Lumen Books, New York 2005.

their algorithms' notations could be also possible as the results of direct influences of the users or environmental variables on the spatial structures, having the internal codes (e.g. *body-buildings*, arch. Kas Oosterhuis<sup>7</sup>) or as the result of the autonomous evolution of the architectural software which can lead to coming into existence of the artificial intelligence and intelligent evolving forms (e.g. *Strip Morphologies*, arch. Daniel Coll and Capdevila, *HeliXHeXa*, arch. Paula Tomisaki<sup>8</sup>).

Generative forms, taking advantage of the algorithmic language of architectural software, have their origins in philosophy of the industrial and post-industrial eras. They are the expressions of trend to industrialize the architecture through initiation of the prototypical solutions that can be copied, transformed and fabricated in the automated process of production from one side, and they signify the wish to find the means to express their formal individualities at the same time. Visions of the architects of the 20th century, representing of the architecture of modernism and post-modernism, are continuation of these trends and the announcement of the later changes as well.

## 2. TYPE OR INDIVIDUALITY

At the beginning of the 20th. Century, there was a debate between the architects of uniformism and futurism (Muthesius vs. Marinetti<sup>9</sup>), which related to different way of defining of the quality and meaning of the architectural form. This controversy was best expressed by Cornelius Gurlitt: "The question of quality alone can no longer be decisive, but the word Form deserves to be set alongside it in the spearhead of our effort. So, then, another important question arises; the question: Type or Individuality?"<sup>10</sup> The concept of type and individuality in architecture pioneers the contemporary forms, according to Muthesius' ideas: "More than any other art, architecture strives toward the typical. Only in this can it find fulfillment."<sup>11</sup> Simultaneously, he assigned higher spiritual meaning to form, characteristic for the concept of individuality, which "is not the result of mathematical calculation (...) is not fulfilled by mere function (...) has nothing to do with systematic thought (...) Form (...) is for us a unique and shining achievement of human art."<sup>12</sup>

Architects of the 20th century, which followed this way of the thinking, aiming to define type in architecture from one side, and from the other – to deconstruct its concept by assignment of the individual features to it, created the foundations for future visions of generative forms. For example, the computer program allowed to insert the individual preferences of users to the functional program of flats in the architectural idea of *The Spatial City* – arch. Yona Friedman<sup>13</sup>. Projects of the prefabricated habitable cells, e.g. *Plastic Polyvalent Cellu-*

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<sup>7</sup> Zellner P., *op. cit.*, p. 72.

<sup>8</sup> Liu Y.T. (ed.), *Distinguishing digital architecture: 6th Far Eastern international digital architectural design qward*, Birkhäuser, Basel 2007, pp. 169, 178.

<sup>9</sup> Banham R., *Theory and design in the first machine age*, MIT Press, Cambridge 1980.

<sup>10</sup> *Ibidem*, p. 77.

<sup>11</sup> *Ibidem*, p. 75.

<sup>12</sup> *Ibidem*, p. 73.

<sup>13</sup> Alison J., Brayer M.A., Migayrou F., Spiller N., *Future city: Experiment and utopia in architecture*,

*les & Cellules Parasite* – arch. Chanéac<sup>14</sup> were very popular in the 60-ties. Architects often proposed such pattern of the cell which would liberate creative potential of the inhabitants and would make possible to create the houses' subtypes by themselves. Chanéac defined it as *habitat évolutif*<sup>15</sup> (*evolutive habitat*).

The significant influence on the spreading of the idea of type in architecture, defined in the context of system solutions, had spatial visions of Archigram, e.g. *Plug-in-City*<sup>16</sup> based on programmable and convertible elements of the structure or concept of arch. Cedric Price – *Fun Palace*, characterized by the prototypical and mechanical structure allowing for free programming of the interiors' arrangement, according to the idea of *do-it-yourself*. The next important step, on a way from the idea of form as a type / individuality to the concept of generative form, were projects of Charles & Ray Eames; architects fascinated by the modular game based on mathematical rules, e.g. *Dot Pattern, Exhibition: Mathematica* or project of the IBM pavilion for the world's fair in New York, demonstrating of the influence of computer programming rules on the architectural design.

### 3. GENERATIVE FORMS: PROTOTYPE AND PROTO-INDIVIDUALITY

Generative form is characterized by the internal algorithm of transformations, similarly to DNA codes of organic forms, which allows for coming into existence the whole range of variations of the same form. Generative form encloses the idea of prototype, being the original pattern of the structure connected with the definite rules of its transformations, expressed in the mathematical language of programming, and the idea of proto-individuality as original form, which is a subject of transformations in the topological space. Generative form is a stream of forces and information, affecting each other and interacting with the surroundings, in which this form is shaped. In regard for the variability of the working forces and the infinite number of combination of mutual interactions in the process of transformation, it can be possible that unique forms, characterized by individual features (multi-individualities), come into existence; forms, belonging to the same family and connected with one prototype at the same time.

Generative forms are based on the access to language of the architectural software, making possible to define the algorithms of forms. These processes are connected with the strategies of the development and evolution of the spatial structures, which allow for transformation, multiplication, combination, mutation or adaptation of forms to the changing environment. The genetic language of forms consists of specific functions of CAD programs, which generate different transformations of the spatial structures. Generative forms differentiate themselves in regard of the ways of mutations or transformations of their structures. It is possible to

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Thames & Hudson, London 2006, pp. 46–49.

<sup>14</sup> *Ibidem*, p. 64.

<sup>15</sup> *Ibidem*, p. 279.

<sup>16</sup> Spiller N., *Visionary architecture: Blueprints of the modern imagination*, Thames & Hudson, London 2006, p. 79.

distinguish the following types of generative forms connected with different methods of their transformations:

- conversional forms: spatial transformations of the structures thanks of using of the modifying functions of CAD programs (*modifiers*);
- animated forms: time transformations of the structures based on computer simulations and animations;
- metamorphic forms: structural transformations of forms thanks of using of the transforming functions of CAD programs (e.g. *NURBS*, *MESHES*, *SPLINES*);
- algorithmic forms: information transformations by using of the algorithmic and parametric programming;
- transgenic forms: substantial transformations of the structures based on morphogenetic simulations.

### **Conversional forms: spatial transformations**

Conversional forms are derived function of data transmission, their modification and mutual interaction of different spatial dimensions, in consequence, it influences on transformation of the architectural structures. Functions of CAD programs, generating particular alterations, are affine transformations, keeping certain features of original structures (e.g. lines' parallelism) and being expressed by using of the algebraic operations or transformation matrix. These functions represent such geometric modifications as, for example, scaling, turning, mirror reflection or moving of the spatial structures along the line.<sup>17</sup> The transformation matrix is not directly accessible for the user of CAD programs. It can be used only for inscription of the individual numerical parameters in relation to definite features and measurements of the spatial structures. The spatial modifiers of CAD programs are more useful; modifiers are "parametric tools of modeling, which influence on alteration of the structure and object's appearance"<sup>18</sup>, such as: bend, taper, flex, push, ripple, skew, smooth, wave, squeeze or stretch of the spatial object etc.

Fundamental advantage of the modifying functions is the possibility of viewing of the effects of structures' transformations directly in the 3D-space. However, degree of the complicatedness of interfering modifications can make occasionally some troubles. And though on the list of history of transformations, one can switch on or off for certain modifications, but sometimes it is not possible to return to the original prototypical form. Additionally, lack of the access to transformation matrix causes the appearing of the impression of fortuity of reached effects in forms' alterations.

Modifiers of CAD programs generate the individual conversional forms, which came into existence based on transformation of the original prototypical form. It seems however that using of the mathematical rules of the transformation leads to the high degree of the repeatability and predictability of conversional forms. In the effect, the symbolic and spiritual meanings disappear in perception of them, because the mathematical rules and modifying tools, connected with them, appear in the foreground; and they are visible at first sight, as for example, one can see the following modifiers in the project of *Metacity Datatown* –

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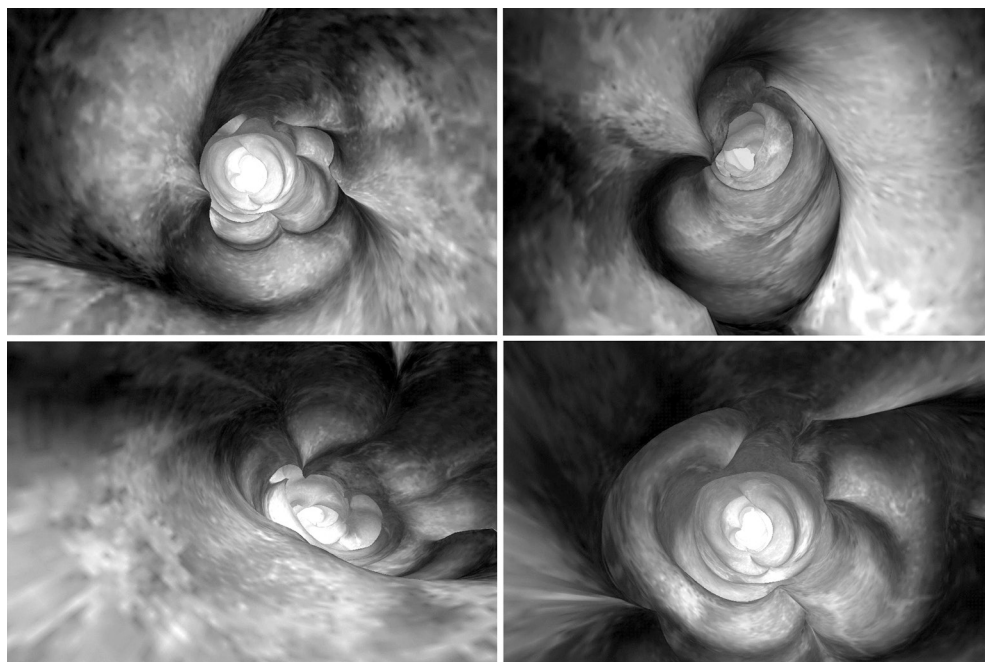
<sup>17</sup> Matossian M., *3D Studio MAX3*, Helion, Gliwice 2000, p. 115.

<sup>18</sup> *Ibidem*, p. 181.

arch. MVRDV<sup>19</sup> – displacement, copy and scale; or in the project of *Taipei Performing Arts Centre* – arch. EMERGENT / Tom Wiscombe<sup>20</sup> – squeeze, flex and stretch.

### **Animated forms: time transformations**

Animated forms are made by applying computer animation techniques in process of creation. These techniques introduce the additional time-dimension to 3D-space; dimension which plays significant role in the perception of the architectural object, because it allows for full control of the designed spatial structure through the possibility of its observation from the perspective of a man being in motion (Ill. 1), and it allows for showing of the form's changeability seeing from different points of view in real time as well. Techniques of the animation consist of the tools making possible to control the observer's movement along the path, to explore the form's variability based on its spatial parameters' change (parametrical animation) or on its displacement, turning or scaling in time (transformation animation).<sup>21</sup> These tools allow for the analysis and transformation of the processes occurring in the spatial structures in the aspect of time, like for example: variables of chiaroscuro projections, energy circulations in architectural objects, dispersals of sound-waves in interiors or the variability of the spatial structures resulting from different influences of the environment.



Ill. 1. Animated forms – time transformations: space flowing through tuboid (author: Ada Kwiatkowska and Tuboid demo version 1.0/notnot)

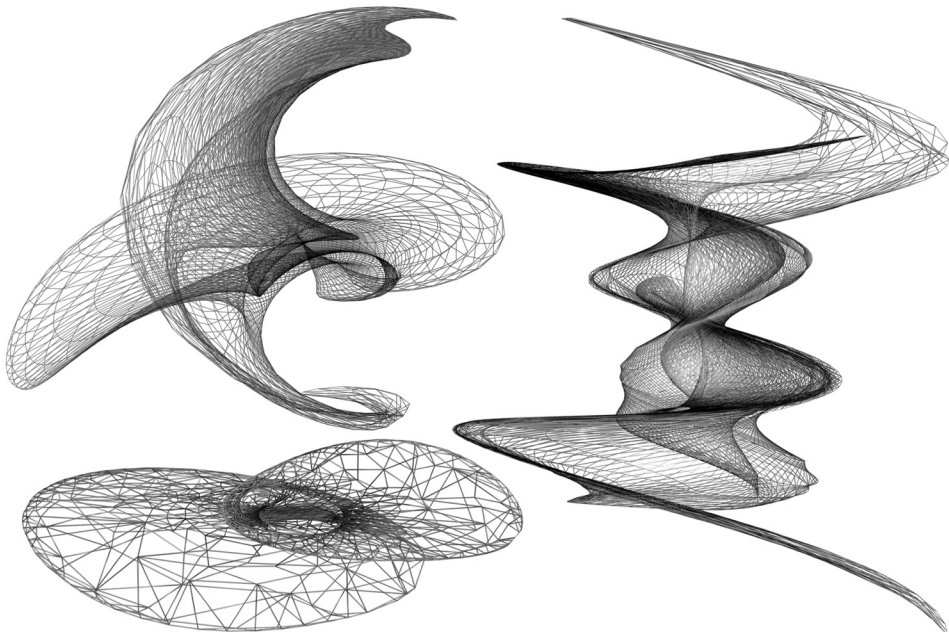
<sup>19</sup> Dunn N., *op. cit.*, p. 36.

<sup>20</sup> *Ibidem*, p. 37.

<sup>21</sup> Matossian M., *op. cit.*, p. 151.

### Metamorphic forms: structural transformations

Metamorphic transformation means converting architectural form from one state into another one, much the same as transformation of the organic form, first of all in the manner, in which it evolves from the primary to the ripe structure (Ill. 2). The mutations of genetic codes allow the structures to take different shapes in particular phases of evolution, keeping simultaneously the structural unity in topological space. Metamorphic transformations are based on certain tools of CAD programs enabling to create and modify forms' shapes based on the acceptance of definite assumptions in relation to their spatial structures. The elementary way of the structure's definition, to which certain transformation modifiers are assigned, is the choice between the concept of object as volume or mesh. Then, the others elements of structure can be modified such as vertex, segment, spline, edge, face, polygon etc.<sup>22</sup>



Ill. 2 Metamorphic forms – structural transformations: evolution of form from the primary to the ripe structure (author: Ada Kwiatkowska)

Modeling and modification of the shapes of metamorphic forms mean the interference in the structure by the changes of splines' parameters, in other words – alterations of the location of Bézier curve's or NURBS (*Non-Uniform Rational B-Splines*) control points or by using different techniques of structural morphing, for instance: embossing, phasing, turning of the volume or mesh.<sup>23</sup> Transformation of the prototypical structure allows for creation of individual forms which belong to one class of related forms according to their structural unity. Structural mutations of the forms, generated on the level of the information codes of computer programs, make possible the better control of working of their structural elements, reaching of

<sup>22</sup> *Ibidem*, pp. 208–209, 214–215.

<sup>23</sup> *Ibidem*, p. 210, 220.

the higher degree of structural complexity and integrating of the creative process with building one, what is especially evident in so complicated forms, as e.g. the project of the curvilinear facade *The Maison Folie* – arch. NOX or construction of the pavilion *H2Oexpo* – arch. NOX.<sup>24</sup>

### **Algorithmic forms: information transformations**

Algorithmic forms come into existence by using of the techniques and tools of algorithmic and parametric design.<sup>25</sup> In contradiction to the traditional way of designing, based on the graphic expression of the spatial structures, these forms refer to the programming language of the matrix of the transformation of CAD programs (information language of scripts and of commands). Tools of the algorithmic design are not directly accessible in the command panel of the computer programs while parametric tools are connected with graphic representation of forms, making possible the immediate observation of the variability of the structure at the change of parameters in toolbars of CAD programs.

Data manipulation requires the logical thinking and also – precise description of the expected features and parameters of designed object, so-called “design the design”<sup>26</sup>, what causes the loss of the intuitiveness and openness of the creative process. In this sense, the information mutations are suitable for designing of the complex structures and systems (e.g. *One North Masterplan* – arch. Zaha Hadid<sup>27</sup>; *Wind-Turbine Factory* – arch. John Dent<sup>28</sup>), subordinated to gaining of definite aims, possible to the later verification by using of the particular criteria of evaluation. The algorithmic design can be a certain trap, especially in case of lack of adaptability of algorithms to changing situation, what makes impossible the achieving of self-corrections of the spatial structures. It also extorts standardization and parameterization of all aspects of shaping of the architectural forms, what is contradictory to such no measurable values as the beauty, harmony or order (e.g. dispute about the phenomenon of the order between the constructivism and deconstructivism).

The algorithmic design allows to create the multifactor and multi-varied matrix of architectural solutions<sup>29</sup>, what is not possible to achieve in comparison with traditional design methods, because the conversion, combination and permutation potentials of the operating systems of computers are significantly greater than human mind’s capacity (e.g. *Crafted Canopy* – arch. Joan Szulda<sup>30</sup>). Therefore the future belongs to algorithmic forms in looking for the prototypical solutions, realizing definite optimization criteria, qualifying certain prototypes to copy. However, this process will be more and more time-consuming, as Jaron Lanier notices in his essay:

„If anything, there’s a reverse Moore’s Law observable in software: As processors become faster and memory becomes cheaper, software becomes correspondingly slower and more bloated, using up all available resources.”<sup>31</sup>

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<sup>24</sup> Dunn N., *op. cit.*, pp. 42, 51.

<sup>25</sup> Burry J., Burry M., *The new mathematics of architecture*, Thames & Hudson, New York 2010.

<sup>26</sup> Dunn N., *op. cit.*, p. 55.

<sup>27</sup> *Ibidem*, pp. 56–57.

<sup>28</sup> *Ibidem*, p. 63.

<sup>29</sup> Terzidis K., *Algorithmic architecture*, Architectural Press, New York 2006.

<sup>30</sup> Dunn N., *op. cit.*, pp. 64–65.

<sup>31</sup> Lanier J., *One half of a manifesto* [in:] J. Brockman (ed.), *The New Humanists: Science at the edge*, pp. 233–263, Barnes & Nobles Book, New York 2003, pp. 251–252.

It seems, that human mind will be better than computer system in looking for the signs of form's individuality because of brain's abilities of the metaphorical and critical thinking.

### **Transgenic forms: substantial transformations**

Transgenic forms are characterized by transformations of their substance, and consequently – by the mutations of their structures and shapes. These forms can pass different states of aggregation of the matter (Ill. 3) and different phases of structural transformations in time. They come into existence in the morphogenetic simulations based on evolutionary processes. It requires to program many phases of the morphogenesis with the elements of self-controllability of the spatial structures. This process is subordinated to such criteria of designing as: structural integrity, reliability of systems, variability of the structural elements or implementation of the self-repair and adaptive mechanisms. It is connected with the creation not only of the forms' genetic codes (prototypes) but also of the morphogenetic algorithms<sup>32</sup> initiating and steering of the evolution of spatial structures toward the greatest degree of differentiation of the growing phases (proto-individualities). It is the most complex process of designing of the architectural forms, which can be realized only the specific range in relation to the chosen aspect of form, e.g. *Morphogenesis and Materialecology: Beast* – arch. Neri Oxman or *Morphogenetic patterns as façade: Airspace* – arch. Faulders Studio + Studio M<sup>33</sup>, because of the limitations of the present computer programs and lack of the accessibility of bio – and nano-materials in architecture.



Ill. 3. Transgenic forms – substantial transformations: forms in different states of aggregation of the matter (author: Ada Kwiatkowska)

<sup>32</sup> Dunn N., *op. cit.*, p. 68.

<sup>33</sup> *Ibidem*, pp. 70–73.

## 4. CONCLUSIONS

In digital architecture, as Branko Kolarevic notices:

“The emphasis shifts from the ‘making of form’ to the ‘finding of form’, which various digitally-based generative techniques seem to bring about intentionally. In the realm of the form, the stable is replaced by the variable, singularity by multiplicity.”<sup>34</sup>

The form’s algorithm, being the specific germ of prototype appeared in the process of „making of form”, is a subject of never-ending modifications influenced by the stream of information, flowing from the surroundings to form and back. Information stream initiates the process of “finding of form” in the meaning of looking for its individuality, and stimulating of the process of growing, differentiation and adaptation of form to the changing context. Creation of form and its transformation take place in information space, passing for the phase of definition of source code of the prototype through formulation of algorithm steering its formal differentiation to materialization of form characterized by its own unique individuality.

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